Manufacturing enterprises are more and more aware of establishing collaborative relationships with the network partners, due to the advantages associated. CN consist of autonomous partners, each one defining its own objectives and formulating its own strategies. The strategies diversity may result in conflict situations, among the enterprises of the same CN, since contradictions between the strategies formulated might emerge. These contradictions appear when the strategies activated in one enterprise negatively influence the objectives defined by other enterprises of the network. The lack of coherence and concordance among the formulated strategies leads to its misalignment. The connotations derived from the strategies misalignments affect the achievement of enterprises objectives, reducing their performance levels, and influencing on the wellbeing of the collaborative relationships established. If the conflicts that arise, derived from the lack of strategies alignment, remain on time and are not tackled, the strategies misalignment could lead, in the long term, to the breakdown of the CN. The success of obtaining higher levels performance in the CN is directly related with the activation of a proper combination of strategies in each enterprise belonging to the network.

This thesis proposes a complete approach, consisting of a model, a method, a guideline and a set of tools, used (i) to identify the degree of alignment of the strategies, from a holistic perspective, and (ii) to propose the activation of the aligned strategies.

The main aim of this thesis is to provide the enterprises appropriate mechanisms to remove the strategies misalignment problem, in order to establish long-term collaborative relationships. The proposed solution is based on a mathematical model, which allows to formally modeling the strategies alignment process, solving it through systems dynamic (SD) method. SD allows representing causal relationships between the strategies and the objectives achievement, within the complex system formed by the enterprises of a CN. A performance measurement scheme is provided to quantitatively measure the influences between the strategies and the objectives. Moreover, a simulation tool is used to automatically solve, in a computer program, the proposed model, assessing and supporting the strategies alignment process.

The contribution of this thesis has been validated in two industrial pilots belonging to the food and automotive industry.

An Approach to support the Strategies Alignment Process in Collaborative Networks

UNIVERSITAT POLITÈCNICA DE VALÈNCIA

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UNIVERSITAT POLITÈCNICA DE VALÈNCIA

AN APPROACH TO SUPPORT THE STRATEGIES ALIGNMENT PROCESS IN COLLABORATIVE NETWORKS

Titulo de Doctor por la UPV

Author: Beatriz Andrés Navarro

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Als meus pares, Adriana i Luis, i a
Tico, el meu company d’aventures

“Let nothing disturb you, let nothing frighten
you. Patience reaches it all”

To the women of my family who instilled in
me this belief.

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Abstract

An Approach to support the Strategies Alignment Process in Collaborative Networks

Manufacturing enterprises are more and more aware of establishing collaborative relationships with the network partners, due to the advantages associated. Especially, the participation of small and medium-sized enterprises (SMEs) in collaborative networks (CN) leads to enhance their competitiveness, by increasing their agility, responsiveness and adaptability to deal with the rapid market evolutions, and the business globalization. Nevertheless, the participation in CN has associated challenges, especially for SMEs, which are derived from the lack of resources and capabilities, and the limitations associated to cultural barriers.

CN consist of autonomous partners, each one defining its own objectives and formulating its own strategies. The strategies diversity may result in conflict situations, among the enterprises of the same CN, since contradictions between the strategies formulated might emerge. These contradictions appear when the strategies activated in one enterprise negatively influence the objectives defined by other enterprises of the network. The lack of coherence and concordance among the formulated strategies leads to its misalignment. The connotations derived from the strategies misalignments affect the achievement of enterprises objectives, reducing their performance levels, and influencing on the wellbeing of the collaborative relationships established. If the conflicts that arise, derived from the lack of strategies alignment, remain on time and are not tackled, the strategies misalignment could lead, in the long term, to the breakdown of the CN. The success of obtaining higher levels performance in the CN is directly related with the activation of a proper combination of strategies in each enterprise belonging to the network.

Despite the fact that the concept of alignment has been studied in different research areas, there is a need to address this topic from the strategies selection perspective, in enterprises belonging to a CN. Thus, there is a gap in the literature to formally represent and solve the strategies alignment process from a holistic view, considering the CN context.

In the light of this, this thesis proposes a complete approach, consisting of a model, a method, a guideline and a set of tools, used (i) to identify the degree of alignment of the strategies, from a holistic perspective, and (ii) to propose the activation of the aligned strategies. The proposed contribution allows considering all the strategies formulated by all the partners, and model the influence that these strategies exert on the wide diversity of objectives defined, regardless of their nature and type, taking into account the CN context. The main aim of this thesis is to provide the enterprises appropriate mechanisms to remove the strategies misalignment problem, in order to establish long-term collaborative relationships. The proposed solution is based on a mathematical model, which allows to formally modelling the strategies alignment process, solving it through systems dynamic (SD) method. SD allows representing causal relationships between the strategies and the objectives achievement, within the complex system formed by the enterprises of a CN. A performance measurement scheme is provided to quantitatively measure the influences between the strategies and the objectives. Moreover, a simulation tool is used to automatically solve, in a computer program, the proposed model, assessing and supporting the strategies alignment process.

The contribution of this thesis (complete approach: model, method, guideline and tools) has been validated in two industrial pilots belonging to the food and automotive industry. The validation has shown that it is possible to model, solve, and assess the strategies alignment process from a collaborative perspective. Allowing the network enterprises to collaboratively make the decision of identifying the aligned strategies to be activated, and the time frame in which to activate them; so that, the performance of the network is maximised. The proposed complete approach allows identifying those strategies that exert positive influences in the majority of objectives defined (or the negative influences are minimum) and deals with potential strategies misalignments, reducing collaborative conflicts.

Key-words: strategies, objectives, performance indicators, alignment, collaborative processes, collaborative networks, system dynamics, simulation.

Resumen

Un Enfoque para apoyar el Proceso de Alineación de Estrategias en Redes Colaborativas

Las empresas de fabricación son cada vez más conscientes de establecer relaciones colaborativas con los socios de la red, debido a las ventajas asociadas a dicha colaboración. De forma especial, la participación de las pequeñas y medianas empresas (PYMEs) en redes colaborativas (RC) las conduce a mejorar su competitividad, mediante el aumento de su agilidad, capacidad de respuesta y capacidad de adaptación, para hacer frente a las rápidas evoluciones del mercado, y a la globalización de los negocios. Sin embargo, la participación en RC conlleva desafíos asociados, especialmente para las PYMEs, que se derivan de la falta de recursos y capacidades, y de las limitaciones ligadas a las barreras culturales.

Las RC están formadas por socios independientes, cada uno definiendo sus propios objetivos y formulando sus propias estrategias. La diversidad de estrategias puede dar lugar a situaciones de conflicto, entre las empresas de una misma RC, debido a que pueden surgir contradicciones entre las estrategias formuladas. Estas contradicciones aparecen cuando las estrategias formuladas en una empresa influyen negativamente en los objetivos definidos por otras empresas de la red. La falta de coherencia y concordancia entre las estrategias formuladas conduce a su falta de alineación. Las consecuencias derivadas de la falta de alineación de estrategias afectan a la consecución de objetivos de las empresas, reduciendo sus niveles de rendimiento, e influyendo en el bienestar de las relaciones colaborativas establecidas. Si los conflictos que surgen, derivados de la falta de alineación de estrategias, se mantienen en el tiempo y no se abordan, la falta de alienación podría conducir, a largo plazo, a la disolución de la RC. El éxito de conseguir niveles de rendimientos más altos en la RC está directamente relacionado con la selección de una combinación adecuada de estrategias, en cada empresa perteneciente a la RC.

A pesar de que el concepto de alineación se ha estudiado en diferentes áreas de investigación, existe la necesidad de abordar este tema desde la perspectiva de selección de estrategias, en empresas pertenecientes a un RC. De forma que, existe un vacío en la literatura sobre la representación formal y la resolución del proceso de alineación de estrategias desde una visión holística, teniendo en cuenta el contexto de RC.

Considerando esto, la presente tesis propone un enfoque completo, que consiste en un modelo, un método, una guía y un conjunto de herramientas, que se utilizan para (i) identificar el grado de alineación de las estrategias, desde una perspectiva holística, y (ii) dar soporte a la selección de estrategias alineadas. La contribución propuesta permite considerar todas las estrategias formuladas por todos los socios de la red, y modelar la influencia que estas estrategias ejercen sobre la gran diversidad de objetivos definidos, independientemente de su naturaleza y tipo, y teniendo en cuenta el contexto RC. El objetivo principal de la presente tesis es proporcionar a las empresas los mecanismos adecuados para abordar el problema de falta de alineación entre las estrategias seleccionadas, con el fin de establecer relaciones colaborativas a largo plazo. La solución propuesta se basa en un modelo matemático, que permite modelar el proceso de alineación de estrategias, resuelto a través del método de dinámica de sistemas (DS). El método de DS permite representar las relaciones causales entre las estrategias y el logro de los objetivos, dentro un sistema complejo como es el formado por las empresas de una RC. Para medir cuantitativamente las influencias entre las estrategias y los objetivos se propone un enfoque de medición del rendimiento. Por otra parte, se utiliza una herramienta de simulación, que permite resolver de forma automática el modelo de alineación de estrategias propuesto.

La contribución desarrollada en la presente tesis, sobre el enfoque completo del modelo, método, guía y herramientas, ha sido validada en dos pilotos industriales pertenecientes a la industria alimentaria y de la automoción. La validación ha demostrado que es posible modelar, resolver y evaluar el proceso de alineación de estrategias desde una perspectiva colaborativa. Permitiendo a las empresas tomar de forma colaborativa la decisión de seleccionar las estrategias alineadas, e identificar el momento en el cual activarlas; de manera que, el rendimiento de la red se maximiza. El enfoque completo propuesto permite identificar aquellas estrategias formuladas que ejercen influencias positivas en la mayoría de los objetivos definidos (minimizando las influencias negativas), abordando la falta de alineación entre estrategias y reduciendo posibles conflictos de colaboración.

Palabras clave: estrategias, objetivos, indicadores de rendimiento, alineación, procesos colaborativos, redes colaborativas, dinámica de sistemas, simulación.

Resum

Un Enfocament per a donar suport al Procés d'Alineació d'Estratègies en Xarxes Col·laboratives

Les empreses de fabricació són cada vegada més conscients d'establir relacions col·laboratives amb els socis de la xarxa, degut als avantatges associats a aquesta col·laboració. De manera especial, la participació de les petites i mitjanes empreses (PIMEs) en xarxes col·laboratives (XC) les condueix a millorar la seva competitivitat, mitjançant l'augment de la seva agilitat, capacitat de resposta i capacitat d'adaptació, per fer front a les ràpides evolucions del mercat, i a la globalització dels negocis. No obstant això, la participació en XC comporta reptes associats, especialment per a les PIMEs, que es deriven de la manca de recursos i capacitats, i de les limitacions lligades a les barreres culturals.

Les XC estan formades per socis independents, cadascun definint els seus propis objectius i formulant les seves pròpies estratègies. La diversitat d'estratègies pot donar lloc a situacions conflictives, entre les empreses d'una mateixa XC, ja que poden sorgir contradiccions entre les estratègies formulades. Aquestes contradiccions apareixen quan les estratègies formulades en una empresa influeixen negativament en els objectius definits per altres empreses de la xarxa. La manca de coherència i concordança entre les estratègies formulades condueix a la seva falta d'alineació. Les conseqüències derivades de la manca d'alineació d'estratègies afecten a la consecució dels objectius de les empreses, reduint els seus nivells de rendiment, i influint en el benestar de les relacions col·laboratives establertes. Si els conflictes que sorgeixen, derivats de la manca d'alineació d'estratègies, es mantenen en el temps i no s'aborden, la manca d'alienació d'estratègies podria conduir, a llarg termini, a la dissolució de la XC. L'èxit d'aconseguir nivells de rendiment més alts en la XC està directament relacionat amb la selecció d'una combinació adequada d'estratègies, en cada empresa pertanyent a la XC.

Tot i que el concepte d'alineació s'ha estudiat en diferents àrees de investigació, existeix la necessitat d'abordar aquest tema des de la perspectiva de selecció d'estratègies, en empreses pertanyents a una XC. De manera que, hi ha un buit en la literatura sobre la representació formal i la resolució del procés d'alineació d'estratègies des d'una visió holística, tenint en compte el context de XC.

Considerant això, la present tesi proposa un enfocament complet, que consisteix en un model, un mètode, una guia i un conjunt de ferramentes, que s'utilitzen per a (i) identificar el grau d'alineació de les estratègies, des d'una perspectiva holística, i (ii) donar suport a la selecció d'estratègies alineades. La contribució proposta permet considerar totes les estratègies formulades per tots els socis de la xarxa, i modelar la influència que aquestes estratègies exerceixen sobre la gran diversitat d'objectius definits, independentment de la seva naturalesa i tipus, i tenint en compte el context XC. L'objectiu principal de la present tesi és proporcionar a les empreses els mecanismes adequats per a abordar el problema de manca d'alineació entre les estratègies seleccionades, per tal d'establir relacions col·laboratives a llarg termini. La solució proposta es basa en un model matemàtic, que permet modelar el procés d'alineació d'estratègies, resolt a través del mètode de dinàmica de sistemes (DS). El mètode de DS permet representar les relacions causals entre les estratègies i la consecució d'objectius, dins d'un sistema complex com és el format per les empreses d'una XC. Per mesurar quantitativament les influències entre les estratègies i els objectius es proposa un enfocament de mesura del rendiment. Per altra banda, s'utilitza una ferramenta de simulació, que permet resoldre de forma automàtica el model d'alineació d'estratègies proposat.

La contribució duta a terme en la present tesi, sobre l'enfocament complet del model, mètode, guia i ferramentes, ha estat validada en dos pilots industrials pertanyents a la indústria alimentària i de l'automoció. La validació ha demostrat que és possible modelar, resoldre i avaluar el procés d'alineació d'estratègies des d'una perspectiva col·laborativa. Permetent a les empreses prendre de forma col·laborativa la decisió de seleccionar les estratègies alineades, i identificar el moment en el qual activar-les; de manera que, el rendiment de la xarxa es maximitza. L'enfocament complet proposat permet identificar aquelles estratègies formulades que exerceixen influències positives en la majoria dels objectius definits (minimitzant les influències negatives), abordant la manca d'alineació entre estratègies i reduint possibles conflictes de col·laboració.

Paraules clau: estratègies, objectius, indicadors de rendiment, alineació, processos col·laboratius, xarxes col·laboratives, dinàmica de sistemes, simulació.

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PART I. INTRODUCTION

Chapter 1

Introduction

The main aim of this chapter is to present an overview of the research work developed in this thesis. In the light of this, the problem to be studied, the strategies alignment process, and the motivation that led to address this collaborative process are described. It follows a brief description of the research context, in which this thesis is developed, collaborative networks (CN) and non-hierarchical manufacturing networks (NHN). Afterwards, the research questions defining the main research objectives of this thesis are raised. The research method considered to address the problem of strategies alignment is identified and described. Finally, the structure, in which this thesis is organised, is presented.

1.1 Problem definition and Motivation

The concept of collaborative networks (CN) has been widely studied over the last years due to the positive effects undergone by the enterprises that collaborate (Poler et al., 2012). In an effort to gain a better understanding on the ways of managing collaboration, various studies have been developed (Bititci et al. 2004) (Camarinha-Matos and Afsarmanesh, 2005) (Camarinha-Matos and Afsarmanesh, 2008) (Camarinha-Matos et al., 2009).

Camarinha-Matos and Afsarmanesh (2008), in their work of consolidating a new discipline in CN, define collaborative networks as a network consisting of a variety of autonomous, geographically distributed, and heterogeneous entities that collaborate to better achieve common or compatible goals, to jointly generate value, and whose interactions are computer network supported.

The processes carried out by the enterprises belonging to a CN are characterised by being collaborative. Collaborative processes have been widely studied over the last years due to their decisive contribution in the proper operation of the CN. There is a wealth of knowledge available in the research area of collaborative processes and a need to consolidate this knowledge was detected. Accordingly, a comprehensive analysis has been carried out with the main aim of identifying the most important collaborative processes. The identified processes have been discussed in the literature for addressing the establishment of collaborative relationships among networked partners. The models, methods, guidelines and tools proposed in the literature to support these collaborative processes were reviewed. Moreover, the performed analysis allowed to arrange the identified collaborative processes according to the decision making level: strategic (S) tactical (T) and operational (O). Following this, a classification of the identified processes is shown in Table 1.1. Amongst all the collaborative processes identified, this thesis particularly focuses on the strategies alignment process, highlighting its influence on the success of a CN. The proposal of proper mechanisms supporting the strategies alignment process results on the elimination of conflicts between the strategies activated by the companies that belong to the network. Favouring the increase of performance of the CN and generating more stable cooperation relations, ensuring the good operation and sustainable relationships within the network.

Table 1.1. Collaborative Processes arranged according to the decision making level (Andres and Poler, 2015)

STRATEGIC	TACTICAL	OPERATIONAL
• Decisions System Design • Partners' Selection • PMS Design • Coordination Mechanisms Design • Network Design • Partners' Coordination and Integration • Product Design • Strategies Alignment	• Forecast Demand • Operational Planning • Performance Management • Contracts' Negotiation • Coordination Mechanisms Management • Knowledge Management • Replenishment • Share Costs and Profits • Uncertainty Management	• Information Exchange • Interoperability • Orders' Promising • Inventory Management • Process Connection • Scheduling • Lotsizing

Enterprises willing to collaborate must overcome a set of barriers not only associated with the establishment of identified collaborative processes (Andres and Poler, 2013) (e.g. products design, demand forecasting, operations planning, replenishment, uncertainty management, share costs and profits, scheduling, information exchange, interoperability, etc.), but also when defining compatible goals, activating complementary strategies (Andres and Poler, 2014) or aligning their core values (Bititci et al., 2007) (Macedo, Abreu, and Camarinha-Matos, 2010). Focusing on the strategies alignment process, the mere consideration of all the enterprises' objectives when deciding which strategies are the best ones to carry out will allow achieving higher levels of adaptability, agility, and competitiveness (Poler et al., 2012), strengths that are specially valued in current turbulent contexts and dynamic markets.

The autonomy and heterogeneity that characterises the enterprises, belonging to a CN, implies that each one defines its own objectives, which are also characterised by being heterogeneous. The objectives' heterogeneity is extended to the high diversity of strategies, which are formulated as set of actions to be performed in order to fulfil the objectives defined. The strategies diversity may result in conflict situations among enterprises of the same CN, since contradictions among the strategies formulated might emerge. These contradictions appear when a strategy activated in one enterprise has a negative effect on the objectives defined by other network partners. This lack of coherence and concordance among the formulated strategies leads to its misalignment. The strategies misalignments, in addition to negatively influence the objectives attainment of each enterprise, influence on the wellbeing of the collaborative partners' relationships. Ultimately, strategies misalignments could lead to the breakdown of the collaborative partnership if the conflicts that arise remain on time and are not tackled.

Considering this, the strategies alignment process is hereafter addressed with the main aim of dealing with the conflicts appearing with misalignments, in the CN context. Intuitively, as the activation of strategies has a direct influence on the objectives achievement, it can be understood that the strategies will be characterised by being aligned when: each activated strategy not only promotes the achievement of the objectives defined by the enterprise that formulates such strategy, but also positively influences the accomplishment of the objectives defined by the rest of the network partners. The strategies alignment concept is linked with the strategies *complementarity*, in which two or more strategies, apart from being able to harmoniously co-exist and be simultaneously activated (*compatibility*), enhance the performance levels of the associated objectives. Along this thesis, the strategies alignment process will be characterised, modelled and solved, considering the CN context.

It is well know that the agility, adaptability and alignment (Lee, 2004) are key factors that must constantly wrap up the CN structures, allowing increasing the performance level at both, enterprise and network level. Accordingly, the success of CN largely depends on achieving higher degrees of strategies alignment, reducing the appearance of conflicts between the strategies formulated and the objectives defined.

The strategies alignment process has been treated in the literature proposing some models, guidelines and tools. From its analysis, it can be highlighted that, some of the identified contributions are focused on the alignment of two types of strategies within the same enterprise. As regards the strategies alignment at network level, some contributions are provided to deal with the alignment of specific strategies such as supply strategies (Cousins, 2005), sourcing strategies (Ashayeri and Selen, 2008), marketing strategies (Green, Whitten and Inman, 2012) or product design strategies (Dell'Era and Verganti, 2010). It can be concluded that, the contributions, provided so far, reefer to the alignment of particular network strategies (i.e. supply, sourcing, marketing or product design), with the aim of obtaining competitive advantages or enhancing the performance. The main weakness of the works addressing this process, from the network level, is that the provided solutions only focus on the alignment of pairs of strategies. Moreover, the contributions proposed so far only deal with particular and specific strategies, making difficult its adaptation to more general scenarios of CN, in which highly different strategies are formulated by individual and heterogeneous enterprises.

Despite the importance of aligning strategies, in terms of avoiding partnership conflicts, to the best of our knowledge, it can be stated that there is a gap in the literature as regards contributions providing a holistic approach that allows considering all the strategies formulated by all the partners and modeling the influence that these strategies exert on the wide diversity of objectives defined. In order to fill this gap, the aim of this research is to propose an integrated approach to identify the aligned strategies from a holistic perspective, regardless of their nature and type, taking into account the CN context. The main aim of this thesis is to provide enterprises an appropriate model, method, tools and guidelines to allow them success in the establishment of long-term collaborative relationships using the strategies alignment mechanism.

1.2 Research Questions

Considering the importance of aligning strategies, among the enterprises of the same network, in terms of improving the CN relationships, there is a lack of an integrated approach to support enterprises on the modelling, assessment and solution of the strategies alignment process from a collaborative perspective.

The following research questions are raised to support the strategies alignment process, in order to solve them as the objective of this research.

A general question is considered:

> ***GenQ.*** What would be a complete approach to adequately support enterprises on the modelling, assessment and resolution of the strategies alignment process from a collaborative perspective?

This general question is next decomposed in five specific research questions. These research questions arise with the main aim of providing a solution to the strategies alignment process from a CN perspective.

RQ1. How to model the impact that each strategy, formulated by one enterprise, has on the objectives defined by the other network enterprises? That is, how to model the impact of the strategies at the inter-enterprise level?

RQ2. What would be an adequate model to support the process of identification of aligned strategies, through modelling the strategies impact in the objectives, in CN context?

RQ3. What would be an adequate method to support the process of identification of aligned strategies, and to represent causal relationships (impacts) between the strategies and the objectives, in CN context?

RQ4. What would be an adequate tool to support the process of identification and assessment of aligned strategies, and to compute the strategies impact on the objectives performance at enterprise and network level, in CN context?

RQ5. What would be an adequate guideline to support the process of identification and assessment of aligned strategies, and to analyse the strategies impact on the objectives and identify misalignments, in CN context?

1.3 Research context

The increasing research interest in collaboration, in supply chain context, has resulted in the emergence of a wide variety of CN topologies – i.e. virtual organisations, virtual laboratories etc. (Camarinha-Matos et al., 2009). This thesis specifically considers the classification of hierarchical and non-hierarchical network topologies (Andres and Poler, 2013). Both structures can acquire collaborative or non-collaborative behaviours. Particularly, the research context of this thesis considers that enterprises, belonging to any of these two topologies, establish collaborative relationships. Thus, this dissertation focuses on collaborative hierarchical manufacturing networks (HN), and more specifically, it focuses on the study of collaborative non-hierarchical manufacturing networks (NHN). Giving the reader a better understanding of the research context, Table 1.2 describes the most important concepts as regards collaboration, and hierarchical and non-hierarchical networks.

Research motivation in collaborative NHN has its starting point in the call funded by the European Commission, “FP7-NMP-2008-SMALL-2”, activity code “NMP-2008-3.3-1: Supply chain integration and real-time decision making in non-hierarchical manufacturing networks” (European Commission, 2008). Regarding the topic under study, different projects where funded by the European Commission,

(REMPLANET, 2009), (CONVERGE, 2009), (NET-Challenge, 2009)and (InTime, 2009), all of them associated with the iNet-IMS initiative (INet-IMS, 2009) (Poler et al., 2012).

In recent years, researchers from various disciplines have shown an increasing interest in the structure and strength of the relationships in the manufacturing networks, currently embedded in dynamic and globalised environments. In fact, in today's global market, industry competitiveness and growth largely depends on the movement towards highly innovative industrial systems and networks of agile enterprises. Through the creation and consolidation of collaborative NHN, SMEs will be able to cope with networks based on large companies and participate in innovative and agile industrial systems (Poler et al., 2012).

In this way, traditional supply networks (HN), characterised by having a centralized decision-making (CDM) perspective, evolve to a decentralized approach of decision-making (DDM), typical of NHN. More specifically, in HN the objectives of the dominant nodes are taken into account to a greater extent, while secondary ones must adapt to the requirements defined by the dominant partners. Considering the characteristics of current highly dynamic markets, HN models can lead to a reduction of the network performance, as in the decision-making process only takes into account the objectives of the dominant partner, regardless the objectives defined by other enterprises of the network. An example of a collaborative HN is the automotive supply chain in which the first tier suppliers are fully dedicated to the car assembly, and CDM efficiently work. Nevertheless, for other manufacturing networks closer to the collaborative NHN topology, such as technology components, electronics, clothing, tile, furniture, machinery and equipment networks, etc. (Lyons et al., 2013), CDM generates significant inefficiencies due to the more powerful firms do not consider the other companies' limitations (Poler et al., 2013). In this type of networks, DDM are more feasible. The performance of HN is significantly improved through applying collaborative DDM, in which the NHN are based. Accordingly, NHN transforms the way SMEs do business in a network of enterprises; thus, the enterprises evolve from centralised collaboration to decentralised collaboration, improving profits and reducing costs (Rodríguez et al., 2008).

This new conception of networks, collaborative NHN, requires a greater exchange of information and a greater commitment of all enterprises; more specifically collaborative NHN requires shared responsibility, active participation of all the network partners in the decision-making process to jointly address the problems, the consideration of all the objectives defined by all the partners and the equally consideration of all nodes of the CN.

Despite the benefits associated to the participation of collaborative NHN, enterprises will find some limitations that should be taken into account when establishing collaborative relationships in the NHN context. These limitations are more evident when small and medium enterprises (SMEs) collaborate (Matopoulos et al., 2007). Generally, these limitations must be overcome in order to efficiently develop collaborative relationships and apply DDM within the collaborative NHN structure. Accordingly, all the requirements appearing when participating in collaborative NHN must be properly addressed by the enterprises in order to establish good relations and, definitely, create sustainable CNs. In spite of the importance and growing attention of the posed topic (collaborative NHN), there is still a lack of a framework that relates the drawbacks, likely to emerge among collaborative partners belonging to NHN, and solutions to support these problems/limitations.

The developed research aims to provide a better understanding on the ways of establishing sustainable collaborative relationships within the partners of a NHN. This thesis specifically focuses on the strategies alignment process proposing a set of solutions consisting of a model, a method, a tool and a guideline to deal with this process in the CN context.

Table 1.2. Main Concepts Definition (Andres and Poler 2015)

Concept	Definition	Authors
Collaboration	A process in which the entities share information, resources, responsibilities risks, and rewards for planning, implementing and evaluating, jointly, a program of activities to achieve a common goal. This concept is derived from the Latin *collaborare* and means "working together" and is seen as a process of jointly creation, whereby a group of entities enhances the capabilities of each other. Collaboration involves the mutual commitment of the participants to solve a problem together, implying mutual trust and therefore time, effort and dedication.	Camarinha-Matos, Afsarmanesh, and Ollus (2008a)
Collaborative Networks (CNs)	Networks consisting on a variety of autonomous entities, geographically distributed and heterogeneous in operational terms and objectives, which collaborate to achieve common or compatible goals. In CNs the network partners can achieve goals that would not be possible, or would be more costly if organisations individually work	Camarinha-Matos and Afsarmanesh (2005)
Collaborative Processes	Processes involving multiple partners, each one playing a different role. The processes are defined based on business interaction protocols, commonly agreed by the involved partners. Multiple entities collaboratively participate in these processes. Therefore, collaborative mechanisms are required	Dyal, Hsu, and Ladin (2001)
Centralised Decision System (CDS)	Centralised decision-making models in which a single partner (or central node) is familiarised with all the information systems. The central node is in charge of the system planning and owns the power to manage the operations performed by all the network partners. The central node performs the decision-making in terms of optimising the objectives of the entire network	Schneeweiss (2003) Li and Wang (2007) Alemany et al. (2011)
Decentralised Decision System (DDS)	Decentralised decision-making models in which each individual independent network entity makes its own decisions, trying to optimise its own objectives. More than one decision maker is identified. Depending on the collaboration degree, the nodes will take into account, in a lesser or larger extent, the decisions of other nodes. Collaborative mechanisms are needed to coordinate the partners' decisions and exchange the information	Schneeweiss (2003) Li and Wang (2007) Jung, Chen, and Jeong (2008) Alemany et al. (2011)
Collaborative Hierarchical Networks (HN)	A network characterised by having an "X" structure, in which a central node, usually located in the middle, separates the network into two parts: upstream (suppliers) and downstream (customers). The decision-making is done in a centralised way (CDS), having a single decision unit within the network. Accordingly, the majority of the network partners have to adapt to the decisions made by the minority of dominant/central firms	Andres and Poler (2013)
Collaborative Non-Hierarchical Networks (NHN)	A network characterised by the balance of power and equally consideration of partners, creating no concentration of decision-making in the hands of a sub-group of actors. All the members are involved in the identification and definition of problems and solutions, and the common management of the processes collaboratively established. Different collaboration degrees are identified depending on the degree of cooperation, the alignment objectives/strategies defined in each decisional unit, and the amount of shared information. The decision-making is done in a decentralised way (DDS) in which several decision units participate	CONVERGE (2009) Andres and Poler (2013) Poler et al. (2012)

1.4 Research Method

The research method is used as a set of accepted and applied rules that govern the research work. Näsi (1980) proposes a classification of four research methodologies based on *Nomothetic*, *Decision-Oriented*, *Action-Oriented*, and *Conceptual* approach. In addition to these four approaches, (Kasanen, Lukka, and Siitonen, 1993) proposed a fifth research method named *Constructive Research Approach* (CRA). These approaches are classified in Figure 1.1 according to two types of characteristics: (i) theoretical or empirical and (ii) descriptive or normative.

	Theoretical	**Empirical**
Descriptive	Conceptual Approach	Nomothetical Approach Action-oriented Approach
Normative	Decision-oriented Approach	Constructive Approach

Figure 1.1. Position of Constructive approach (Kasanen et al., 1993)

The CRA has recently received a lot of attention in business administration and engineering fields. CRA is characterised as empirical and normative. Normative models correspond to optimisation or heuristic mathematical models. In the empirical characteristic, the direct and pragmatic empirical connections, and the application of case study method to solve a specific problem, play a major roles; entailing always an attempt to explicitly test the practical usability of the designed solution (Metodix, 2015).The main aim of CRA is to solve a relevant problem through constructing innovative artefacts. The proposed solution must be demonstrated, and both theoretical and practical knowledge is accumulated. CRA has similarities with the decision-oriented and action-oriented research methods (Kihn and Näsi, 2012):

- In decision-oriented approach and constructive approach new entities/artefacts are created. These two approaches differ in that decision-oriented method uses the method of deduction whereas CRA uses heuristic innovations. Besides decision-oriented method is more theoretical while CRA is more empirical, applying the solutions in particular cases.
- Action-oriented approach and constructive approach have in common the empirical part. Nevertheless, action-oriented approach does not aim to create any explicit managerial constructs.

Engineering is based on how to create new entities (Lázaro and Marcos, 2005), taking into account this, the constructive research method is considered as a proper method to be applied in the context in which this thesis is developed.

CRA is more focused on providing solutions to relevant problems, these solutions are proposed in a novel way considering previous existing knowledge. In the CRA, the practical application of the proposed solution has to be demonstrated (Crnkovic, 2010). In order to deal with this, five are the phases identified in CRA, listed next and showed in Figure 1.2 : (i) identify a relevant problem subject to study, (ii) consider the background of the problem to be solved, therefore understand the problem and the context in which it is embedded, (iii) propose a solution to the problem in an innovative way, (iv) identify the theoretical relevance of the solution and the theoretical contribution (v) validate the solution and determine the applicability of the solution (Kasanen et al., 1993).

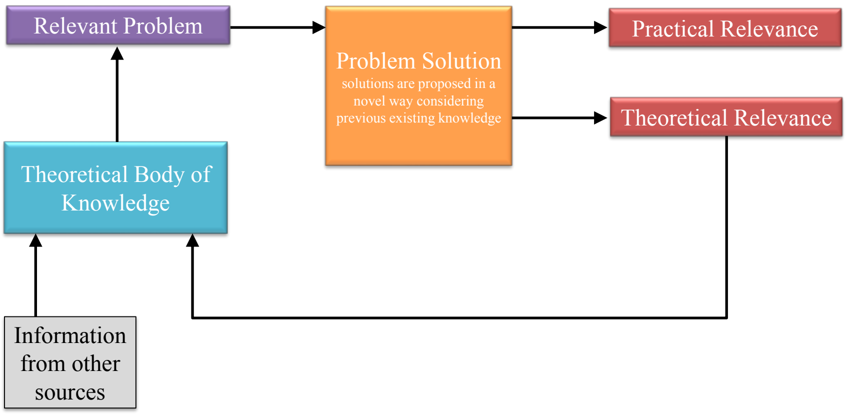

Figure 1.2. Constructive Research Approach (CRA) (Kasanen et al., 1993)

Considering the application of the constructive research method to develop this thesis, each phase is briefly described next:

Relevant Problem

Misalignments among the strategies defined by the CN partners lead to the reduction of performance and ultimately to the collaboration failure. The strategies alignment process must be addressed proposing a model, a method, a tool and a guideline to support the enterprise decision makers of a CN; with the main aim of dealing with the strategies misalignments and obtaining higher levels of alignment, as well as assessing the strategies influences in the objectives attainment.

The enterprises belonging to a CN define a set of objectives and formulate strategies to achieve these objectives. Each strategy has a cost of activation, and the enterprises have to decide which strategies activate depending on the activation costs and the influences that each strategy has on the objectives defined. Therefore, when dealing with the decision of which strategies to activate, amongst all the strategies previously formulated, the CN enterprises must consider not only how the activated strategies affect its own objectives, but also have to consider, in the decision making, how the activation its strategies influence on the objectives defined by the rest of network partners. This consideration will be known as *inter-enterprise influence*: the influence that the strategies of one network enterprise has on the objectives of the other enterprises of the CN.

The lack of consideration of inter-enterprise influences in the decision-making, as regards which strategies activate, can lead in most of the cases to the strategies misalignment. Accordingly, the strategies that are not aligned and are activated will generate negative influences in the objectives of some of the enterprises belonging to the CN. These negative influences will result on the reduction of the performance at enterprise and network level. Consequently, it can be stated that the strategies misalignment will influence on the collaborative relationship, leading to the partnership expiration, and ultimately, dissipating the CN.

Theoretical Body of Knowledge

In order to deal with the strategies alignment problem, this doctoral thesis is based on a theoretical body of knowledge regarding:

- <u>Collaborative Networks</u> (CN) discipline contributes with the theoretical base concepts about virtual organisations, consortium formation and collaboration, in general. It provides methods and tools for its application in the CN perspective, and modelling CNs (Camarinha-Matos and Afsarmanesh, 2005-2008) (Camarinha-Matos, Afsarmanesh, and Ollus, 2008).
- <u>Non-hierarchical Production Networks</u> (NHN) topology emerged as an evolution of the traditional hierarchical networks (HN), providing important contributions to the enterprises networks whose nature does not fit the HN structure (Teich, Fischer, and, Käschel, 2002)(Wirth S. et al., 1999)

(Bölt and Freitag, 2001)(Baum, Dammann, and Enderlein, 2000)(Carneiro, Almeida, and Azevedo, 2010) (Poler et al., 2012).

- Collaborative processes and its treatment in the literature to support enterprises to properly establish them and reduce the appearing drawbacks, specially in SMEs (Forrester, 1961) (Lambert, Emmelhainz, and Gardner, 1996) (Cooper, Lambert, and Pagh, 1997) (Beamon, 1998) (Dyal et al., 2001) (Li and Wang, 2007)
- Industrial Management, contributes with the main concepts dealing with Performance Indicators, Performance Measurement and Performance Management (Rodriguez et al., 2008) (Alfaro et al., 2010)(Piedade, Azevedo, and Bastos, 2010)
- System Dynamics (SD) contributes with the representation of causal relationships established among the objects of the modelled system, as well as simulation and optimisation methods (Forrester, 1961; Martin, 2006; Gary, Kunc, and Morecroft, 2009; Campuzano and Mula, 2011)
- Alignment as a background of models, guidelines and tools proposed in the literature to deal with problems related with the alignment (Lee, 2004; Dudek and Stadtler, 2005; Martinez and Bititci, 2006; Piedade et al., 2010; Macedo and Camarinha-Matos, 2013; Dao, Abhary, and Marian, 2014)

Problem Solution

An innovative integrated approach will be proposed in order to support enterprises on addressing the strategies alignment process in the context of CN. The integrated approach will consist of a:

- Model that will allow to formally represent, in a mathematical notation, the influences that the strategies activated in one enterprise have on the performance indicators (KPI) defined to measure the achievement of the objectives, in other enterprises.
- Method, based on SD that will allow to graphically represent and solve the proposed mathematical model, from a CN perspective. SD will enable to characterise the causal relationships between the strategies and the objectives; modelling the influences that the objectives experience when certain set of strategies are activated. Moreover, SD will favour to understand the structure and dynamics of complex systems, such as the CN.
- Tool that will be used to solve and represent the strategies alignment model, based on SD rigorous method. The use of computational tools will allow to automatically solve the strategies alignment process. Allowing to identify the strategies to activate and the time instant at which activate them, optimising the global performance of the CN. Supporting tools to automatically generate the flow diagram of the model, in SD notation, will be required; besides, a Database Management System must be generated in order to gather the data required to feed and solve the proposed alignment model.
- Guideline will be considered as a complementary mechanism to the model, method and tool, with the main aim of supporting the enterprises, which belong to a CN, on addressing, assessing and solving the strategies alignment process. The guideline will propose negotiation processes in order to enable the enterprises to negotiate the solution that best fits to all the netework enterprises.

Theoretical Relevance

The proposed contribution will allow presenting an integrated approach that consist of a model, a method, a tool and a guideline to empower the generation of automatic solutions, as regards the decision of which strategies activate, achieving higher levels of alignment and obtaining higher levels of network performance. This complete approach is proposed by considering the CN context and the areas of contribution are related with the Collaborative Networks, Strategies Alignment and System Dynamics.

The mathematical notation model would represent the process of strategies alignment as well as the causal relationships established between the strategies activated and the objectives attainment, at this stage the inter-enterprise influences will also be considered in order to model the problem of strategies alignment from a collaborative perspective. The use of SD method enables the representation of the strategies alignment process from an aggregated view. The use of tools based on SD simulation approach will allow the automated resolution of the proposed model.

Practical Relevance

The proposed contribution would be relevant to support the network enterprises when facing the decision of which strategies activate, from a collaborative perspective, so that looking for the wellbeing of the network. The lack of strategies alignment could lead to non-collaborative behaviours.

A tool integrating the model and the method will be developed and a guideline will be considered as a complementary mechanism to support the network enterprises on the estimation of all the data required and the data to be exchanged for the tool implementation. The contribution proposed would allow identifying which of the formulated strategies must be activated, among all the strategies formulated by the CN, to achieve higher levels of alignment, depending on the restrictions characterising each problem.

The practical relevance will be examined through the application of the theoretical contribution to two pilots, which will consist of two networks belonging to the food and automotive industry. The implementation of the proposed contribution will allow identifying critical points of application. The pilots will allow showing the use that the enterprises give to the proposed contribution to deal with the strategies alignment process. Besides, the pilots will determine the practical relevance after applying the strategies alignment model in the networks, in which they are embedded.

1.5 Outline of the Thesis

The main aim of this thesis is to support the strategies alignment process in the context of CN. An integrated approach consisting of a model, method, tool and guideline is proposed. The thesis is distributed as follows considering the five phases in which the constructive research method is divided (Figure 1.3).

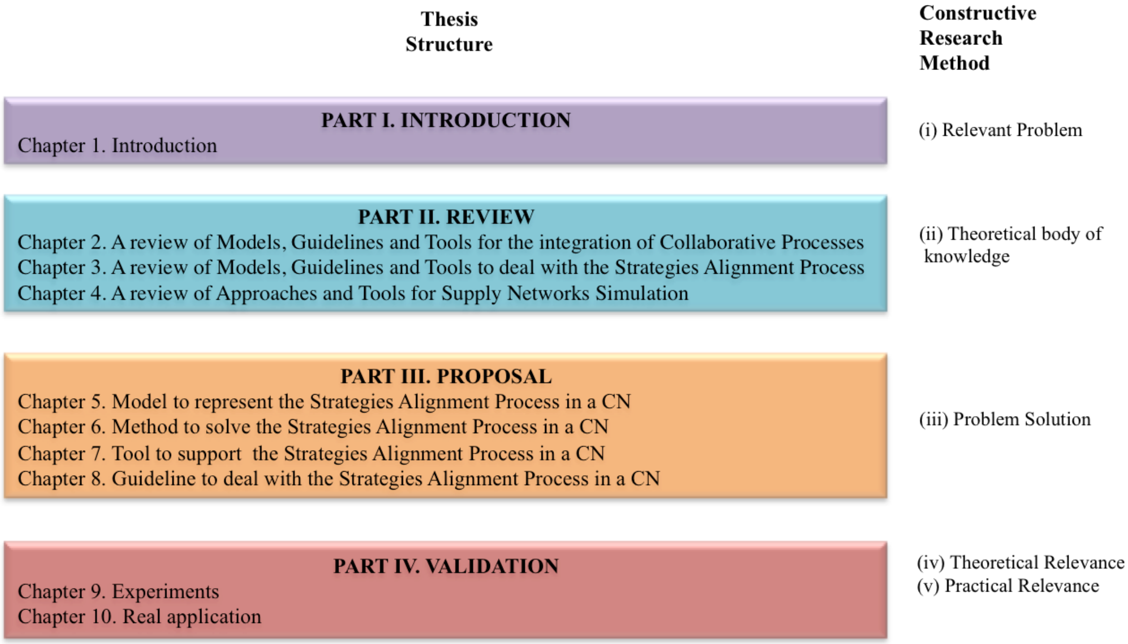

Figure 1.3. Thesis Structure and parallelism with the CRA

The work developed and proposed in each chapter is briefly described next:

PART I

Chapter 1. Introduction

An introduction of the problem to be treated in this thesis is given: the strategies alignment process. Besides, the importance of studying the problem and proposing solutions to solve it is discussed. A brief insight of the context, CNs, in which the research carried out is embedded, is given. The main concepts related to the research are introduced, as regards collaboration and CN. The research method used for the development of the thesis is also presented.

PART II. REVIEW

The literature review work is presented in this part of the thesis. The state of the art, treating the topics of this thesis, is divided in three research areas: (i) collaborative processes, (ii) strategies alignment process and (iii) supply network simulation approaches.

Chapter 2. A review of Models, Guidelines and Tools for the integration of Collaborative Processes

In this chapter a detailed review of the processes performed in a collaborative context, is developed. A set of processes are identified and a review on how these processes are treated in the literature, from the collaborative perspective, is made. In order to classify both the processes and the approaches proposed in the literature to solve them, two characteristics are considered (i) the decision making level to which the collaborative process belongs (ii) and the type of contribution proposed in the literature to treat the collaborative process (models, guidelines and tools). Afterwards, the existing contributions are discussed in terms of identifying which ones are designed from the NHN perspective and which ones are proposed, only, from the HN perspective. Finally, a detailed classification is proposed, identifying those collaborative processes that need to be studied from the NHN perspective. The collaborative processes, whose contributions are not proposed from a NHN perspective, are potential to be further addressed through designing contributions applicable from the NHN perspective.

Chapter 3. A review of Models, Guidelines and Tools to deal with the Strategies Alignment Process

This chapter focuses on the strategies alignment process, identified in Chapter 2 as potential to provide solutions in the NHN. The concept of strategies alignment, considering the CN perspective, is introduced. A detailed review on how this process has been treated in the literature is presented. In the light of this, some models guidelines and tools are identified and briefly described. The gaps and trends related to the strategies alignment process from a collaborative perspective are identified.

Chapter 4. A review of Approaches and Tools for Supply Networks Simulation

In this chapter the simulation approaches that can be used to simulate supply networks are identified. As supply networks are characterised by being complex systems, analytical techniques are considered complex, costly and timely. Simulation approaches are considered as complementary techniques, to the analytical ones, to solve the supply network models. Different simulation paradigms are identified and compared each other. The most used tools for each simulation approach are identified. A discussion of tools supporting multi-method simulation approaches is also presented.

PART III. PROPOSAL

Chapter 5. Model to represent the Strategies Alignment Process in a CN

The strategies alignment problem is modelled in a formal mathematical notation, considering the collaborative perspective. The strategies alignment concept is mathematically defined. The strategies alignment model is parameterised and the decision variables are defined. This mathematical model allows representing the causal relationships between the strategies formulated and the objectives defined by the collaborative partners. The two main contributions of the strategies alignment model are (i) the mathematical representation of the influences that the formulated strategies exert on the performance indicators, defined to measure the attainment of the objectives by the network partners, and (ii) the consideration that the activation of one strategy in a particular enterprise influences on the objectives attainment of other enterprises of the CN; the concept of intra and inter-enterprise influences is consolidated. Intra-enterprise influences refer to the influences that the strategies of one enterprise have on the objectives in the same enterprise. Whilst Inter-enterprise influences allow to model the influences that the strategies of one enterprise have on the objectives defined in other enterprises of the network.

Chapter 6. Method to solve the Strategies Alignment Process in a CN

In this chapter the method used to solve the strategies alignment model is described. Considering as a base the work proposed in Chapter 4, the System Dynamics method is selected. A justification on why SD method is used and how it fits with the strategies alignment model resolution is presented. The mathematical model proposed in Chapter 5, modelling the strategies alignment model, is rewritten considering the variables defined by the SD method (parameters, auxiliary, stock and flow variables). The strategies alignment model is represented in the causal diagram and the flow diagram, according to the SD notation.

Chapter 7. Tools to support the Strategies Alignment Process in a CN

This chapter presents the tools used to support the implementation of the strategies alignment model presented in Chapter 5. Three are the tools considered, a simulation software based on SD method, a Database Management System (DMS) to gather the information required to feed the model and an application to automatically generate in XML format the strategies alignment model, from the information stored in the DMS. The XML definition of the strategies aligment model is then sent as input to the simulation software. The simulation software will allow to automatically obtain the optimal solutions of the decision variables described in the model, simulation and optimisation experiments will be carried out.

Chapter 8. Guideline to deal with the Strategies Alignment Process in a CN

This chapter proposes the steps required to support enterprises in the implementation of the model, method and tools, proposed in Chapters 5, 6 and 7. The guideline is considered as a complementary mechanism used by the enterprises to deal with the strategies alignment process. The guideline also supports enterprises on the assessment of the optimal solutions, obtained through the optimisation experiments carried out in the simulation software, by the development of sensitivity analysis. Three different collaborative scenarios are considered, which are characterised by having different degrees of information exchange. Besides this, the proposed guideline provides enterprises negotiation procedures to achieve agreements on the solutions obtained from the application of the strategies alignment model.

PART IV. VALIDATION

This part of the thesis focuses on the validation of the contribution proposed to deal with the strategies alignment process.

Chapter 9. Experiments

A set of experiments are carried out in order to validate the model, method, tool and guideline proposed to solve and assess the strategies alignment process. A set of illustrative cases are generated simulating different scenarios with different restrictions in order to encompass a wide rage of possible cases, depending on the nature of the strategies modelled in the strategies alignment process.

Chapter 10. Real application

Tow real-case study are considered in order to validate the proposed model, method, tool and guideline. The strategies alignment process is modelled in two different networks: Pilot 1 corresponds to a network belonging to the food industry; and Pilot 2 corresponds to a network belonging to the automotive industry.

PART V. CONCLUSIONS

Chapter 11. Conclusions

This chapter is devoted to discuss the original proposal developed along the thesis with the main aim of solving the strategies alignment process. A list of conclusions and limitations as regards the developed contribution is presented. The research work of this thesis finishes with the identification of future research lines of the original proposal developed in this dissertation.

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PART II. REVIEW

Chapter 2

A review of Models, Guidelines and Tools for the establishment of Collaborative Processes

Collaborative practices among partners of manufacturing networks require the support of models (M) guidelines (G) and tools (T), which should take into account the network topology. Most of the M, G and T proposed in the literature were developed for hierarchical manufacturing network (HN) topologies, but most of the real manufacturing networks, mainly composed by SMEs, are closer to non-hierarchical manufacturing network (NHN) topologies. This section focuses its research on the collaborative processes and the way in which the contributions proposed to address them deal with the NHN requirements. Firstly, a comprehensive literature review is conducted, allowing identifying a set of relevant collaborative processe, in manufacturing networks (both HN and NHN), as well as the M, G and T designed to address each of them. Secondly, an analysis is carried out in order to determine how these M, G and T, designed for HN and/or NHN, adjust to the needs of the NHN. The assessment carried out, reveals that some of the proposed M, G and T do not entirely fill the requirements demanded in NHN contexts. Each collaborative process is classified into a satisfactory, acceptable or unacceptable degree of coverage, depending on the extent into which the provided M, G and T can be applied in NHN. On this basis, it is concluded that some of the identified collaborative processes have a clear lack on the M, G and T for its properly application in NHN. Finally, potential research lines are suggested in terms of providing solution approaches, missing in the literature, to adequately support the collaborative processes in NHN contexts.

2.1 Introduction

The benefits perceived by the enterprises that participate in a collaborative network (CN) have triggered an increased interest for research in this discipline, being a challenge for both practitioners and researchers. In this context, creating appropriate conditions to support enterprises on establishing collaborative processes with the network partners is a key issue (European Commission, 2008). Nowadays, the industries competitiveness depends on their evolution towards innovative systems and agile networks in order to stand up to companies based on powerful large-scale economies. This scenario can be achieved through the enterprises' participation in collaborative *Non-Hierarchical manufacturing Networks* (NHN) (Poler et al. 2013), characterised by the establishment of collaborative processes, and the implementation of decentralised decision making models (DDM) (Schneeweiss 2003).

Unlike NHN, traditional Hierarchical Manufacturing Networks (HN), are based on centralised decision models (CDM) in which the majority of the network companies have to adapt to the decisions made by the minority of dominant firms. DDM in NHN involves equally powered partners that collaboratively participate in the business processes and decision-making; therefore, no individual partner leads the network (Andres and Poler 2013). The enterprises participation in NHN enhances their competitiveness, specially SMEs, by increasing the their agility and adaptability to deal with rapid evolutions of existing and future markets (European Commission, 2008).

The significance of establishing collaborative processes among networked members is cross-examined and widely studied (Dyal, Hsu and Ladin 2001; Camarinha-Matos and Afsarmanesh 2005; Andres and Poler 2013). In order to contribute in this study area, this section focuses its research on the analysis of collaborative processes in the particular context of NHN.

Given this, the research objective of this chapter is led to (i) review the literature in order to identify the most important collaborative processes, (ii) examine the contributions provided in the literature to deal with the establishment of the identified collaborative processes, (iii) analyse the extent into which these contributions can be applied into the NHN context, and (iv) from the encountered shortcomings, suggest potential contributions to fill the gaps on the research field to support the establishment of collaborative processes in NHN. In the light of this, section 2.2 describes the research methodology used to conduct the literature review. The set of collaborative processes identified are described in section 2.3. In section 2.4 a matrix classifying the collaborative processes and its associated solutions is provided. Taking into account the results from the matrix, each collaborative process is categorised in a satisfactory, acceptable or unsatisfactory degree of coverage, considering that those classified as satisfactory have associated contributions that can be applied in NHN while the unsatisfactory ones only present solutions in the HN contexts. Finally, the conclusions of the developed study are discussed in section 2.5

2.2 Problem Formulation and Literature Review Methodology

Collaboration has an important influence on SMEs agility and responsiveness. Nevertheless, the establishment of collaborative processes has associated challenges, especially for SMEs (Matopoulos et al. 2007). In NHN contexts, in which basically participate SMEs, these challenges become even more noticeable.

In an effort to gain a better understanding on the ways of managing collaborative processes in NHN, chapter 2 focuses on the literature review methodology with the main aim of identifying the most significant collaborative processes, and analysing the contributions proposed to address each process, attending the NHN features. Accordingly, two questions are formulated to review the literature

- what are the most important processes for establishing collaborative relationships – Section 2.3 – and
- into which extent the collaborative processes are treated in the literature from the NHN context – Section 2.4.

In the literature reviewed, papers that develop solutions to support the establishment of collaborative network processes within network partners are considered. Due to the wide range of works carried out in the literature dealing with collaboration issues, a refinement process is carried out in order to synthesise the literature. The search work is restricted to publications between 1963 and 2014. The initial round of search is based on a broad meaning of keywords to ensure that papers adopting alternative nomenclature are identified. The used keywords are: *supply chain*, *networks*, *collaborative networks*, *cooperation*, *collaborative processes*, *SMEs*, *collaborative problems*, *collaborative solutions*, *distributed decision making*, *non-hierarchical networks* and *partners' collaboration*. Provided the broadness of the topic under research, 200 papers are considered, addressing collaborative processes in both HN and NHN context. The majority of the citations are found in journals (66,5%), conferences proceedings (20%) and books (9%). The three most cited journals are *European Journal of Operations Research* (6%), *Expert Systems with Applications* (8,5%) and *International Journal Computer Integrated Manufacturing* (10%) that accounted for 24,5% of the citations (Table 2.1).

The collected works are analysed considering this two variables:

- the *decision making level* the collaborative process belongs to: strategic (S), tactical (T) or operational (O) and
- the way how the collaborative process is addressed, that is the *solution proposal typology*: model (M), guideline (G) or tool (T).

Regarding the first variable, a decision is classified as strategic, tactical or operational depending on the time horizon affected and the degree of reversibility (Schneeweiss 2003). Concerning the second variable, a model is a representation and description of the structure and processes of an enterprise. A guideline is a statement by which to determine a course of action in order to achieve or improve a process. And a tool is a mechanism in which some decision rules and calculation processes have been implemented in order to take automated decisions (e.g. software for demand forecasting). The collected papers propose models, guidelines and tools for dealing with the barriers appearing when SMEs decide to establish collaborative processes. Figure 2.1 shows the distribution of the reviewed papers according to (i) the solutions scope provided to manage the collaborative process (M, G, T) and (ii) the year of publication. The chart shows that, in early papers, solutions are mostly based on models or guidelines. In recent years, the tools approaches have been increased due to the deep development of technology-based solutions and the Internet (FInES 2013). As regards the tools solution approaches, 62 papers were published from 2003 to 2014, constituting approximately the 25% of the total papers. Indicating a growing concern, over the last decade, in the tools design to support SMEs in collaboration.

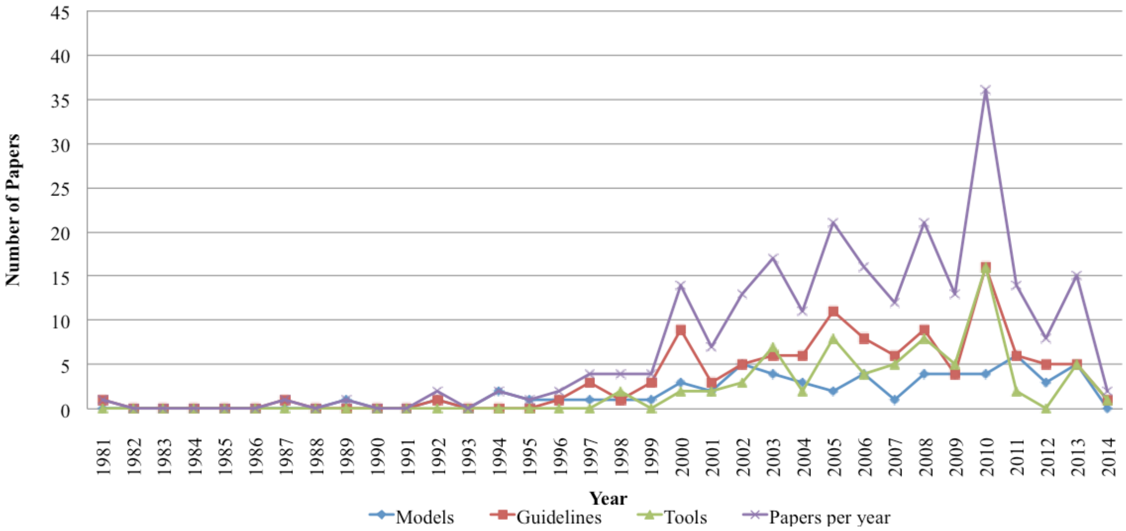


Figure 2.1. Papers Distribution according to year of publication and solution approach type

In collaborative networks context, there is available a wealth of knowledge, but this knowledge needs to be consolidated through developing a classification framework containing both the whole range of relevant collaborative processes and the approaches designed to efficiently carry them out.

Table 2.1. Summary of citations

SOURCE	**Nº Citations**	**%**
Book	4	2,00%
Books Chapter	14	7,00%
Deliverables	6	3,00%
Proceedings of Conferences	40	20,00%
Web	1	0,50%
Work Studies	2	1,00%
Journals	**Nº Citations**	**%**
Advanced Engineering Informatics	1	0,50%
Annual Reviews in Control	2	1,00%
Business Process Management Journal	1	0,50%
Computer Science	2	1,00%
Computers & Chemical Engineering	1	0,50%
Computers & Industrial Engineering	1	0,50%
Computers in Industry	6	3,00%
Computers Industry Engineering	1	0,50%
Decision Science	1	0,50%
European Journal of Operational Research	*12*	*6,00%*
Expert Systems with Applications	*17*	*8,50%*
IBM Systems Journal	1	0,50%
IEEE Transactions	1	0,50%
IEEE Transactions on Engineering Management	1	0,50%
IEEE Transactions on Robotics and Automation	1	0,50%
IIE Transactions	3	1,50%
Industrial & Engineering Chemistry Research	2	1,00%
Industrial Management & Data Systems	1	0,50%
Industrial Marketing Management	1	0,50%
Information and Software Technology	1	0,50%
INNOVAR Gestión de Operaciones y Tecnología	1	0,50%
International Journal Computer Integrated Manufacturing	*20*	*10,00%*
International Journal of Electronic Commerce	1	0,50%
International Journal of Networking and Virtual Organisations	1	0,50%
International Journal of Operations & Production Management	1	0,50%
International Journal of Production Economics	11	5,50%
International Journal of Production Research	6	3,00%
Journal of Business Logistics	1	0,50%
Journal of Intelligent Manufacturing	3	1,50%
Journal of Knowledge Management	1	0,50%
Journal of Operations and Logistics	1	0,50%

SOURCE	Nº Citations	%
Management Science	4	2,00%
Omega	1	0,50%
Operations Research	1	0,50%
Or Spectrum	2	1,00%
Production Planning & Control	8	4,00%
Robotics and Computer-Integrated Manufacturing	3	1,50%
Scientific Programming	1	0,50%
Service Business	1	0,50%
Supply Chain Management: An International Journal	5	2,50%
Technovation	1	0,50%
Transportation Research Part E: Logistics and Transportation Review	2	1,00%
TOTAL	*200*	*100%*

2.3 Collaborative Processes in Manufacturing Networks: A Literature Review

As a result of the literature reviewed, in this section, a set of twenty-four collaborative processes is identified. An overview concerning the research subjects covered in each collaborative process is given in Table 2.2. The identified collaborative processes are classified according to the decision-making level to which they belong (strategic, tactical or operational); besides, in each level the processes are placed in alphabetical order (see Table 2.2). Eight of the twenty-four encountered processes are classified at the strategic decision making level, characterised by long term decisions. At the tactical decision-making level nine processes are identified. These processes are characterised by making decisions at the intermediate level, between the strategic and operational decision making levels, helping to achieve the strategic goals so that, there are subject to strategic decisions. Processes at the operational decision-making level are characterised by repetitive decisions made in the short term, so that the information needed in the decision-making must be available; seven processes are classified at this level. Following this classification, three more tables are provided; each one brings together the collaborative processes corresponding to a particular decision-making level, previously classified in strategic (Table 2.3), tactical (Table 2.4) and operational (Table 2.5) levels. In each table, a list of authors that provide models, guidelines and tools to specifically treat each particular process, is given. The contributions provided by the authors are characterised by being solutions designed to deal with specific barriers that can appear when a particular collaborative process is carried out. In order to have a deeper knowledge, much information can be identified on each specific paper.

Table 2.2. Relevant Collaborative Processes: identification and research topics

	Collaborative Processes	**Overview of the researched topics**
Strategic	Coordination Mechanisms Design	Consideration of the type of network, the decision-making system, the collaborative partners, the relationships and behaviour, and knowledge of the networked partners. Design of operational plans to coordinate decisions; platforms to share information and incentive schemes to allocate the benefits of derived from collaboration (Li and Wang 2007).
	Decision System Design	Generation of flexible decision making systems based on decentralised decision models (DDM) and distributed decision-making systems (Schneeweiss 2003). Integration of decisions within the nodes and equally consideration of all the networked partners (Shafiei, Sundaram, and Piramuthu 2012)
	Network Design	Identification of optimal alternatives as regards network structure, business processes, partners selection, location, planning, logistics, inventory, information and material flows, leadership structure and network externalities (Johnson and Pyke 1999; Lambert and Cooper 2000). Consideration of the all objectives defined by all the partners when designing the network (Chen and Xu 2012)
	Partners' Coordination and Integration	Encouragement of communication and collaboration among network partners to deal with current dynamic and competitive environments (Vernadat and Kosanke 1992). Introduction of interoperable information systems (Chen, Doumeingts, and Vernadat 2008). In CN there are different decisional units, so, coordination is necessary to align individual actions and plans of two or more partners, in an effort to adapt to a joint decision-making.
	Partners' Selection	Analysed factors: logistics, materials acquisition, technological development, human resources, suppliers and customers number of levels, financial statement, satisfaction degree, due date and cost (Cardoni, Saetta, and Tiacci 2010). Partners' selection to facilitate the establishment of collaborative processes. Search of partners with aligned strategies, willing to build long-term collaborative relationship (Huang, Gao, and Chen 2011).
	PMS Design	Integrated Performance Management System capable of satisfying the complexity associated to CN (Alfaro et al. 2010). Consideration of Key performance indicators (KPIs) to measure the results derived from the collaboration (Camarinha-Matos and Abreu 2007). Design of platforms to support the exchange of data between network collaborative partners, and properly measure the performance of the entire network (Alfaro et al., 2010).
	Product Design	Consideration of multiple collaborative partners in order to improve the product efficiency (Zheng, Shen, and Sun 2011). Technological platforms to collaboratively deal with the product development (Germani et al. 2010)
	Strategy Alignment	Selection of partners that are already aligned with the network strategy (Verdecho, Rodríguez, and Alfaro 2010). Definition of the strategic network goals as result of potential opportunities derived from collaboration (Cardoni, Saetta, and Tiacci 2010). Consideration of performance measurement methodologies to identify the aligned strategies (Andres and Poler, 2014b). Alignment of all the strategies defined by the network partners.
Tactical	Contracts' Negotiation	Achievement of higher levels of cooperation between partners so that all the nodes achieve the maximum degree of agreement in their decisions (Kebriaei and Majd 2009). Effective mechanisms to achieve partners' satisfaction and build partnerships (Cachon 2003). Definition of negotiation protocols, auctions, models and methodologies to manage contracts in collaborative networks (Camarinha-Matos and Afsarmanesh 2005).
	Coordination Mechanisms Management	The networks' evolution towards collaboration is a fact; and *coordination mechanisms management* have become vital to cope with global solutions customers demand (Smith and Randall 1981). The management of coordination mechanisms allows the networked partners to manage operations in a coordinated way (Camarinha-Matos and Afsarmanesh 2005).
	Demand Forecasting	Increase network visibility, reduce of inventory levels and improve forecasts in product requirements (Yue and Liu 2006). Coordination mechanisms and contracts to share credible forecasts and reduce the demand uncertainty (Cachon 2003). Conduct dependent demand forecasting. Collection of internal and external information to obtain accurate demand forecasts. Platforms to integrate the demand applications of the network partners (Poler et al. 2007).
	Knowledge Management	Management of intangible assets. Promotion of the exchange and creation of specific knowledge. Uncertainty management (Malhotra 2005). Knowledge management in distributed and collaborative environments (Zhen, Song and He 2012). Management of collaborative processes in parallel with the knowledge creation process. Management of public and private knowledge (Dargahi, Pourroy, Wurtz 2010)
	Operation Planning	Management of contradictory objectives among partners; development of scenarios that integrate all the nodes (Gupta and Maranas 2003). Jointly planning production, inventory and distribution activities. Extend the planning process, initially local, towards different planning domains (Stadler 2009). Get beneficial plans every network partner (Wang and

	Collaborative Processes	Overview of the researched topics
		Chen 2009). Decentralised planning supported by coordination mechanisms, pre-agreed business rules, and assessment and comparison of alternatives using performance measurement techniques (Goetschalckx and Rleischmann 2005; Pibernik and Sucky 2007)
	Performance Management/Measurement	Storage, gathering and processing of performance data in a meta-repository (network level) (Alfaro et al. 2007). KPIs definition (Gunasekaran, Patel, and McGaughey 2004; Camarinha-Matos and Abreu 2007). Evaluation and monitoring the network decisions, strategies and objectives (Andres and Poler, 2014b). Improvement of knowledge and visibility in terms of network information and decisions (Verdecho, Rodríguez and Alfaro 2011).
	Replenishment	Planning, execution and control procurement, inventory management and logistic operations. Reduction of inventory levels, lead-time and transport costs. Increase the accurancy of demand forecasts and customer service levels (Wu et al. 2010). Collaborative Replenishment jointly done with the demand forecasting process and the operational planning process (VICS 2011).
	Share Costs and Profits	Computation of net profits generated in the network. Mechanisms to equitable share the benefits among network partners (Chen, Wang, and Lee 2003). Management of sharing benefits when decentralized and collaborative relationships are established (Andres and Poler, 2014a)
	Uncertainty Management	Addressing the lack of transparency and commitment, and incomplete information disclosure. Management of information and knowledge asymmetry (Ho and Chi, 2005; Kwon, Im and Lee 2007). Handling uncertainty in demand forecasting or operational planning processes (Mula, Poler, Garcia-Sabater 2008)
Operational	Information Exchange Management	Strong support of information technologies (IT). Data storage in distributed information systems (Seng and Wong 2012). Integrated solutions providing interoperability within the network information systems. Platforms to exchange data among the partners that establish collaborative processes (Garita, Afsarmanesh, and Hertzberger 2001; Rabelo 2008, Astorga et al. 2010; Li et al. 2011)
	Interoperability	Platforms, methodologies or methods for exchanging information and services in a heterogeneous organisational and technological environment (Chen, Dassisti, and Elvesæter 2006). Transfer of information flows at data, processes and services levels. Deal with conceptual, organisational and technological barriers affecting interoperability (Boza, Navarro, and Lario 2008; Jung 2008).
	Inventory Management	Management multiple suppliers and customers' inventories in innovative ways (Johnson and Pyke 1999). Management of products in the time domain to maintain appropriate and balanced stock levels within the network (Giannoccaro and Pontrandolfo 2002). Traditional approaches in inventory management have been led to maintain stock levels, but nowadays the trend is to reduce lead times and change stocks for information.
	Lotsizing	Negotiation processes related to inventory management. Negotiation mechanisms to identify the optimum batch size according to the partners' skills, demands and internal needs (Ertogral and Wu 2001). Models to determine optimal order quantities to improves the order promising process (Corbett and Groote 2000)
	Order Promising Process	Deal with the requirements and orders made by the customer, through coordinating activities of the different involved companies (Alarcón, Alemany, and Ortiz 2009). Promotion of collaborative actions to exchange information as regards companies' availability (Makatsoris, Chang, and Richards 2004; Kirche, Kadipasaoglu, and Khumawala 2005). Allocation of orders to the best possible suppliers (Haleh and Hamidi 2011).
	Process Connection	Management of processes from the distributed perspective. Connection between collaborative processes (Hepp et al., 2005). Increase agility and interoperability among different communication, information and knowledge sharing systems. Platforms to deal with information exchange (Bénaben et al. 2010)
	Scheduling	Definition and implementation of incentive mechanisms and coordination mechanisms (Hall and Potts 2003). Extended and collaborative scheduling processes (Gómez et a., 2009). Communication and information exchange for production scheduling. Integration of production scheduling with operations planning, forecast and replenishment processes

Table 2.3. Collaborative Processes at the Strategic decision-making level

Collaborative Processes		Authors
STRATEGIC	Coordination Mechanisms Design	Simatupang, Wright, and Sridharan (2002); Sahay (2003); Ortiz, Anaya, and Franco (2005); Fugate, Sahin, and Mentzer (2006); Shen et al. (2006); Li and Wang (2007); Camarinha-Matos, Afsarmanesh and Ollus (2008); Alemany et al. (2010); Neves and Guerrini (2010)
	Decision System Design	Chen and Doumeingts (1996); Lanzenauer and Pilz-Glombik (2002); Poler, Lario, and Doumeingts (2002); Lario et al. (2003); Schneeweiss (2003); CONVERGE Project (2010); Shafiei, Sundaram, and Piramuthu (2012)
	Network Design	Johnson and Pyke (1999); Lambert and Cooper (2000); Sabri and Beamon (2000); Persson and Olhager (2002); Miranda and Garrido (2004); Bhatnagar and Sohal (2005); Camarinha-Matos and Afsarmanesh (2005); Goetschalckx and Rleischmann (2005); Camarinha-Matos, Afsarmanesh, and Ollus (2008); Carneiro et al. (2013); Hajlaoui, Boucher, and Boussaid (2010); Camarinha-Matos, Afsarmanesh and Koelmel (2011); Everington, Lyons, and Li (2011); Chen and Xu (2012); Saetta, Tiacci, and Cagnazzo (2013); Shamsuzzoha et al. (2013)
	Partners' Coordination and Integration	Zachman (1987); Vernadat and Kosanke (1992); Williams (1994); Chen and Doumeingts (1996); Bernus and Nemes (1997); Open Group (2000); Marquez, Bianchi, and Gupta (2004); Nahm and Ishikawa (2005); Ortiz, Anaya, and Franco (2005); Vernadat (2007); Pearcy, Parker, and Giunipero (2008); Shamsuzzoha et al. (2013)
	Partners' Selection	Davidrajuh and Deng (2000); Lau et al. (2000); Lee, Ha and Kim (2001); Ko, Kim and Hwang (2001); Huang, Wong, and Wang (2004); Bittencourt and Rabelo (2005); Feng and Yamashiro (2006); Jarimo and Salkari (2006); Camarinha-Matos, Afsarmanesh and Ollus (2008); Angulo and Martin (2009); Biennier, Aubry, and Maranzana (2010); Cardoni, Saetta, and Tiacci (2010); Paszkiewicz and Picard (2010); Verdecho, Rodríguez, and Alfaro (2010); Ertay, Kahveci, and Tabanlı (2011); Huang, Gao, and Chen (2011); Beckett and Jones (2012); Shamsuzzoha et al. (2013)
	PMS Design	Beamon (1998); Lee and Wang (1999); Alfaro, Ortiz, and Poler (2007); Pinto and Lucas (2010)
	Product Design	Parker (2000); Pappas et al. (2007); Germani et al. (2010); Schumacher et al. (2010); Zheng, Shen, and Sun (2011); Khan, Christopher, and Creazza (2012); Houshmand and Valilai (2013); Kim et al. (2013); Lu et al. (2013); Saetta, Tiacci, and Cagnazzo (2013); Shamsuzzoha et al. (2013)
	Strategy Alignment	Martinez and Bititci (2006); Cardoni, Saetta, and Tiacci (2010); Macedo, Abreu, and Camarinha-Matos (2010); Piedade-Francisco, Azevedo, and Bastos (2010); Verdecho, Rodríguez, and Alfaro (2010), Andres and Poler (2014b)

Table 2.4. Collaborative Processes at the Tactical decision-making level

Collaborative Processes		Authors
TACTICAL	Contracts' Negotiation	Griffel et al. (1998); Greunz, Schopp, and Stanoevska-Slabeva (2000); Ertogral and Wu (2001); Angelov and Grefen (2003); Cachon (2003); Camarinha-Matos and Afsarmanesh (2005); Gupta and Weerawat (2006); Jiao, You, and Kumar (2006); Oliveira and Camarinha-Matos (2008); Kebriaei and Majd (2009)
	Coordination Mechanisms Management	Smith and Randall (1981); Adacher, Agnetis, and Meloni (2000); Ertogral and Wu (2000); Zimmer (2002); Cachon (2003); Luh et al. (2003); Fink (2004); Marquez, Bianchi, and Gupta (2004); Schneeweiss and Zimmer (2004); Camarinha-Matos and Afsarmanesh (2005); Fugate, Sahin, and Mentzer (2006); Gupta and Weerawat (2006); Sarmah, Acharya, and Goyal (2006); Shen et al. (2006); Li and Wang (2007); Xu et al. (2010)
	Demand Forecasting	Lee, Padmanabhan, and Whang (1997); Raghunathan (1999); Caridi, Cigolini, and Marco (2005); Yue and Liu (2006); Poler et al. (2007); Rodriguez et al. (2008); Poler and Mula (2011); VICS (2011)
	Knowledge Management	Malhotra (2005); Ortiz, Anaya, and Franco (2005); Bénaben et al. (2010); Choudhary et al. (2010); Dargahi, Pourroy, Wurtz (2010); Fiumara et al. (2010); Neves and Guerrini (2010); Tramontin, Rabelo, Hanachib (2010); Capó-Vicedo, Mula, and Capó (2011); Zhen, Song, He (2012)
	Operation Planning	Sabri and Beamon (2000); Sadeh et al. (2001); Poler, Lario, and Doumeingts (2002); Chen, Wang, and Lee (2003); Gupta and Maranas (2003); Lario et al. (2003); Dangelmaier, Heidenreich, and Pape (2005); Dudek and Stadtler (2005); Goetschalckx and Rleischmann (2005); Shen et al. (2006); Pibernik and Sucky (2007); Boza,

Collaborative Processes		Authors
		Navarro, and Lario (2008); Camarinha-Matos, Afsarmanesh, and Ollus (2008); Jung, Frank, and Jeong (2008); Selim, Araz, and Ozkarahan (2008); Hernández et al. (2009); Stadler (2009); Wang and Chen (2009); Alemany et al. (2010); Bonfatti, Martinelli, and Monari (2010); Alemany et al. (2011); Phanden, Jaina, and Vermaa (2011); Xu, Wang, and Newman (2011)
	Performance Management	Gunasekaran, Patel, and McGaughey (2004); Bititci et al. (2005); Alfaro, Ortiz, and Poler (2007); Camarinha-Matos and Abreu (2007); Peters, Odenthal, Schilick (2008); Alfaro et al. (2010); Pinto and Lucas (2010); Verdecho, Rodríguez, and Alfaro (2011); Shamsuzzoha et al. (2013)
	Replenishment	Holmström et al (2002); Moinzadeh (2002); Caridi, Cigolini, and Marco (2005); Sari (2008); Wu et al. (2009); VICS (2011)
	Share Costs and Profits	Chen, Wang, and Lee (2003); Giannoccaro and Pontrandolfo (2004); Corbett, de Croix, and Ha (2005); Frisk et al. (2006); Sarmah, Acharya, and Goyal (2006); Jähn (2010); Audy et al. (2010), Andres and Poler (2014a)
	Uncertainty Management	Belloum et al. (2003); Ho and Chi (2005); Kwon, Im, and Lee (2007); Mula, Poler, Garcia-Sabater (2008)

Table 2.5. Collaborative Processes at the Operational decision-making level and

Collaborative Process		Authors
OPERATIONAL	Information Exchange Management	Rezgui et al. (2000); Garita, Afsarmanesh, and Hertzberger (2001); Camarinha-Matos and Afsarmanesh (2005); Egri, Karnok, Vancza (2007); Camarinha-Matos, Afsarmanesh and Ollus (2008); Chen et al. (2008); Rabelo (2008); Astorga et al. (2010); Jiang, Mair, and Yuan (2010); Kazem and Wentland (2010); Perin-Souza and Rabelo (2010); Świerzowicz and Picard (2010); Li et al (2011); Seng and Wong (2012); Cheikhrouhou, Pouly, and Madinabeitia (2013)
	Interoperability	AWG (1998); IDEAS (2002); NEHTA (2005); ATHENA (2006); Chen, Dassisti, and Elvesæter (2006); Elvesæter, Hahn, and Berre (2006); Poler et al. (2007); Boza, Navarro, and Lario (2008); Chen, Doumeingts, Vernadat (2008); Jung (2008); Mykkänen and Tuomainen (2008); Chituc, Azevedo, and Toscano (2009); Franco, Ortiz, and Lario (2009); Alemany et al. (2010); Bénaben et al. (2010); Camara, Ducq, and Dupas (2010); Lemrabet et al. (2010); Camarinha-Matos, Afsarmanesh, Koelmel (2011); Cretana et al. (2012); Grilo et al. (2013); Jardim-Gonçalves et al. (2013); Lu et al. (2013); Pazos Corella, Chalmeta Rosaleñ, and Martínez Simarro (2013)
	Inventory Management	Goyal and Gupta (1989); Hoeskstra and Romme (1992); Lu (1995); Van der Heijden, Diks, and de Kok (1997); Johnson and Pyke (1999); Moses and Seshadri (2000); Giannoccaro and Pontrandolfo (2002); Moinzadeh (2002); Sari (2008); Gumus and Guneri (2009)
	Lotsizing	Gupta and Brennan (1994); Thomas and Griffin (1996); Lee, Padmanabhan, and Whang (1997); Corbett and Groote (2000); Ertogral and Wu (2001); Hall and Pots (2003); Mohammadi and Fatemi Ghomi (2011)
	Order Promising Process	Cakravastia and Nakamura (2002); Abid, D’amours, and Montreuil (2004); Makatsoris, Chang, and Richards (2004); Kirche, Kadipasaoglu, and Khumawala (2005); Alarcón, Alemany, and Ortiz (2009); Schuh et al. (2008); Gómez et al. (2009); Haleh and Hamidi (2011)
	Process Connection	Hepp et al. (2005); Osório and Camarinha-Matos (2008); Bénaben et al. (2010); Berasategi, Arana, Castellano (2010); Lemrabet et al. (2010)
	Scheduling	Karimi and McDonald (1997); Hall and Potts (2003); Nishioka, Kasai, and Kamio (2003); Gómez et al. (2009); Guillaume, Thierry, Grabot (2010); Phanden, Jaina, and Vermaa (2011)

Having identified and grouped the most relevant processes, in terms of collaboration; next section provides a classification matrix giving researchers a more comprehensive view on the solution approaches provided to deal with the identified collaborative processes when they are applied in both HN and NHN. In the light of this, an interesting factor to consider is whether the collaborative processes have been treated from the decentralised perspective in order to be applied to NHN, or conversely there have been addressed from a centralised perspective of HN.

2.4 Collaborative Processes Matrix: Classification and Analysis

Many authors have highlighted the research need of designing and providing models, guidelines and tools to support the establishment of collaborative and decentralised processes to improve the information integration, product and transport flows, and decision-making processes, among others, with the main aim of obtaining higher levels of performance (Camarinha-Matos and Afsarmanesh 2005- 2007; Osório and Camarinha-Matos 2008; CONVERGE 2010; Shamsuzzoha et al. 2010; Poler et al. 2013; Andres and Poler 2013). In order to contribute to this research area, this section focuses its efforts on identifying the most relevant contributions (M, G and T) provided in the literature to assist enterprises to carry out collaborative processes from the decentralised perspective; that is to say, contributions that are specifically designed, or that can be applied, in the NHN context.
A large number of network topologies can be found in the literature, making difficult to find a generic topology that covers most of the problems associated with the establishment collaborative processes in SMEs. This section has narrowed the network topologies down to two in order to better classify the contributions designed to deal with the barriers, appearing when SMEs decide to establish collaborative relationships within the networked partners. These topologies are the hierarchical manufacturing networks (HN) and non-hierarchical manufacturing networks (NHN). In the topic under study, hierarchical networks (HN) topologies are more examined than the non-hierarchical ones (NHN) due to the first ones can be easily represented and solved, despite being less close to reality. The difficulty of representing non-hierarchical collaborative networks (NHN) makes them to be less studied in the literature. However, as networks often consist of multiple independent actors, many authors have studied the collaborative processes considering decentralised decision models and solutions, making them applicable to NHN environments. Besides this, the analysis performed to the reviewed M, G and T shows that some contributions initially designed from the centralised perspective (HN) can be occasionally adapted to the decentralised view (NHN). This situation, allows researchers to consider centralised approaches as a base for future developments of M, G and T, adapting them to NHN contexts. Considering the aforementioned, the contributions identified in the literature can be widely classified according to the *classification criterion* described in Table 2.6 (*HN*, *HN→NHN* and *NHN*). For each classification criterion, is given an example of a contribution, provided in the literature, to solve a particular collaborative process.

Afterwards, a matrix (Table 2.7) is constructed in order to classify the contributions found in the literature, according to each collaborative process identified. Two different perspectives are considered when proposing this taxonomy: (i) the *solution proposal typology*, that consist of models (**M**), guidelines (**G**) and tools (**T**) proposed to diagnose and mitigate the barriers appearing when SMEs establish a collaborative process, and (ii) the *solutions classification criterion* (**HN**, **HN →NHN**, **NHN**). The consideration of these two perspectives gives researchers an insight of how the models, guidelines and tools provided in the literature are applied or can be adapted in the specific network topology of NHN.

Table 2.6. Solution classification criteria

Solution Classification Criteria	**Description**	**Example of a solution used to deal with a collaborative process**
HN	Solutions that are provided only from the Hierarchical Networks perspective (centralised approaches)	To deal with the *operational planning* process, a solution based on a non-linear mixed integer programming multi-objective model is provided from the centralised perspective (Chen, Wang, and Lee 2003). In this case, the data required to feed the model is to be public and is controlled by the central node of the network making it only applicable in HN. The central node manages the decision-making as regards the network planning.
HN→NHN	Solutions that are initially designed for Hierarchical Networks (centralised approaches) but there are partially applicable,	*DGRAI tool* (French acronym that can be translated into: Graph showing Interrelations between Results and Activities) is provided from a centralised perspective (Poler, Lario, and Doumeingts 2002). Nevertheless, this tool can be adapted to decentralised scenarios of collaborative networks

Solution Classification Criteria	Description	Example of a solution used to deal with a collaborative process
	considering modifications, to Non-Hierarchical Networks (decentralised approaches)	to deal with the collaborative *decision system design* process. Adaptations, such as using platforms to share the needed data, can be carried out in order apply this tool in NHN scenarios. The main aim is to model the decentralised decision-making process carried out among different network partners.
NHN	Solutions that have the appropriate characteristics to be applied in Non Hierarchical Networks or that are specifically designed for Non Hierarchical Networks (decentralised approaches)	As regards the *order promising process* (OPP), *myOpenFactory* (Schuh et al. 2008) is a platform to collaboratively deal with this process. *myOpenFactory* tool connects all software and individual interfaces from one platform to a normalised data model, promoting the access to updated information in the OPP. The decentralised features offered by this platform make it directly applicable to the NHN topology.

Table 2.7. Collaborative Processes & Contributions Matrix

Collaborative Processes	**HN**	**NH → NHN**	**NHN**
Coordination Mechanisms Design	***G:*** logistics synchronisation, information exchange, incentives alignment, collective learning (Simatupang, Wright, and Sridharan 2002), strategic, outsourcing, in-House and convenience involvement, strategic alliances, clusters, industrial districts, VO, virtual labs, joint ventures, cooperation agreements (Sahay 2003)	***M:*** IE-GIP (Ortiz, Anaya, and Franco 2005), Decoupling Point, CPFR, VMI, collaborative manufacturing model, hybrid coordination, decentralised system (Li and Wang 2007) ***G***: EKD (Neves and Guerrini 2010), ARCON, ECOLEAD (Camarinha-Matos, Afsarmanesh and Ollus 2008)	***G***: coordination mechanisms principles (Li and Wang 2007), Coordination Protocols (Alemany et al. 2010) ***T***: MASCOT (Shen et al. 2006)
Decision System Design	***M:*** MILP (Lanzenauer and Pilz-Glombik 2002) ***G***: GRAI (Chen and Doumeingts 1996)	***M:*** DDM, MCDM, Reference Model VO (Lario et al. 2003) ***G***: DAROMS (Poler, Lario, and Doumeingts 2002) ***T***: DGRAI (Poler, Lario, and Doumeingts 2002)	***G***: GRAI-PROJECT (CONVERGE Project 2010), MECDSS (Shafiei, Sundaram, and Piramuthu 2012) ***T***: MAS (Schneeweiss 2003), CONVERGE platform (CONVERGE Project 2010)
Network Design	***M***: stochastic multiobjective programming (Goetschalckx and Rleischmann 2005), multi-objective decision analysis is adopted to allow use of a performance measurement system (Sabri and Beamon 2000) ***G***: Supply chain management (Johnson and Pyke 1999), integration and management of business processes in SC (Lambert and Cooper 2000)	***M***: DNDRP model (Miranda and Garrido, 2004) ***G***: VBE, VOmap (Camarinha-Matos and Afsarmanesh 2005), ARCON, ECOLEAD (Camarinha-Matos, Afsarmanesh and Ollus 2008), RCEDcrf (Carneiro et al. 2013), REMPLANET (Everington, Lyons and Li 2011), VDO (Saetta, Tiacci and Cagnazzo, 2013), GloNet project (Camarinha-Matos, Afsarmanesh and Koelmel 2011), Net-Challenge Framework (Shamsuzzoha et al 2013) ***T***: performance simulation (Persson and Olhager 2002), PSL, WfMC, XML, VENabledTM, MASIF, UEML (Camarinha-Matos and Afsarmanesh 2005), UNICOMP (Hajlaoui, Boucher and Boussaid 2010)	***M:*** GP to solve the SMONDP models (Chen and Xu 2012) ***G***: location KPIs (Bhatnagar and Sohal, 2005) ***T***: e-services, SOA (Camarinha-Matos and Afsarmanesh 2005)
Partners' Coordination and Integration	***G***: Zachman (Zachman, 1987), CIMOSA (Vernadat and Kosanke 1992), PERA (Williams 1994), GRAI/GIM (Chen and Doumeingts 1996), GERAM (Bernus and Nemes 1997), TOGAF (Open Group 2000)	***G***: IE-GIP methodology (Ortiz, Anaya, and Franco 2005) ***T***: CIMOSA, BPMN, UML, UEML, XML, OWL-S, BPMS, iFlow, ebXML, RosettaNet, CaseWise, Popkin, Rational (Ortiz, Anaya, and Franco 2005)	***T***: e-collaboration (Marquez, Bianchi, and Gupta 2004), MAS (Nahm and Ishikawa 2005), SOA, e-HUBS, web portals, orquestation (Vernadat, 2007), e-procurement (Pearcy, Parker, and Giunipero 2008), Net-Challenge ICT platform (Shamsuzzoha et al 2013)

Collaborative Processes	**HN**	**NH → NHN**	**NHN**
Partners' Selection	***M:*** minimise manufacturing cost (Ko, Kim and Hwang, 2001), MILP (Jarimo and Salkari 2006), qualitative analysis (Feng and Yamashiro, 2006)	***M:*** Trust in networks (Beckett and Jones 2012), index of satisfaction degree, PSO algorithm (Huang, Gao, and Chen 2011) ***G***: NOLAPS (Lau et al. 2000), SSMS (Lee, Ha, and Kim 2001), VPA, MOP, DEA, ANP, Two-stage Manufacturing PS (Huang, Wong, and Wang, 2004), SCOR model metrics (Bittencourt and Rabelo 2005), VBE (Angulo and Martin 2009), performance measurement (Verdecho, Rodríguez, and Alfaro 2010), evaluation potential pool of partners (Cardoni, Saetta, and Tiacci 2010) QFD, AHP, PGP (Ertay, Kahveci, and Tabanlı 2011) ***T***: VMS (Davidrajuh and Deng 2000), PSS (Camarinha-Matos, Afsarmanesh and Ollus 2008), SOVOBEs (Angulo and Martin 2009), service registries (Biennier, Aubry, and Maranzana 2010)	***G***: MAPSS (Paszkiewicz and Picard 2010), ***T***: ESB, SOA, cloud computing infrastructures for enterprises registry (Biennier, Aubry, and Maranzana 2010), Net-Challenge ICT platform (Shamsuzzoha et al 2013)
PMS Design	–	***G***: KPIs (Beamon 1998), PMS features (Lee and Wang 1999), integral PMS (Alfaro, Ortiz and Poler, 2007)	***G***: PMS design Key elements (Pinto and Lucas 2010)
Product Design	-	***M***: VDO (Saetta, Tiacci and Cagnazzo 2013) ***G***: R&D agreements, technology exchange and license agreements (Parker 2000), product design/supply chain alignment adopting a "design centric" approach (Khan, Christopher, and Creazza 2012), CPLM (Kim et al. 2013), STEP-PDM standard (Lu et al., 2013) ***T***: CO-Design Platform (Germani et al. 2010), Aided VTB System (Schumacher et al. 2010), DiCoDEv platform (Pappas et al. 2007)	***T***: web 2.0 (Germani et al. 2010), CoAutoCAD (Zheng, Shen, and Sun 2011), Net-Challenge ICT platform (Shamsuzzoha et al 2013), platform that exchanges the product data between different distributed CAx software packages Distributed-LAYMOD (Houshmand and Valilai 2013)
Strategy Alignment	-	***G***: causal models and graph theory for values alignment (Macedo, Abreu, and Camarinha-Matos 2010), Business Strategy & IT Strategy (Cuenca, Boza and Ortiz, 2011) linking vision and mission (Cardoni, Saetta, and Tiacci 2010)	***M:*** network modelling, maximisation of the KPIs improvement when certain strategies are activated (Andres and Poler, 2014b) ***G***: Fuzzy Logic and KPIs (Piedade Francisco et al., 2010), degree of strategy alignment (Verdecho, Rodríguez, and Alfaro 2010)

Collaborative Processes	HN	NH → NHN	NHN
Contracts' Negotiation	***M:*** negotiations (Cachon 2003), quantity discount, volume discount, return policy, revenue sharing contracts (Gupta and Weerawat 2006)	***M:***-4W Framework (Angelov and Grefen 2003) ***G:*** negotiation protocols, SPE (Ertogral and Wu 2001) ***T:*** COSMOS platform (Griffel et al. 1998), e-contracts (Camarinha-Matos and Afsarmanesh 2005)	***G:*** SeCo (Greunz, Schopp, and Stanoevska-Slabeva 2000) ***T:*** MAS multiple contract negotiations (Jiao, You, and Kumar, 2006), WizAN TOOL (Oliveira and Camarinha-Matos 2008), Agent-based simultaneous negotiation method for bilateral contracts in a multi agent market (Kebriaei and Majd 2009)
Coordination Mechanisms Management	***G:*** game theory, tasks distribution (Smith and Randall 1981), auction theories (Ertogral and Wu, 2000), executed-oriented with control-oriented decision (Zimmer 2002), updating pricing policies (Luh et al. 2003), contracts negotiation (Cachon 2003), negotiation rules (Fink 2004), procurement policies and inventory control (Schneeweiss and Zimmer 2004), revenue-sharing policy (Gupta and Weerawat 2006)	***M:*** quantity discount models, profit-sharing models, supply chain game models (Sarmah, Acharya and Goyal 2006; Li and Wang 2007) ***G:*** distributed workflow, WfMC, Modelling, PSL and WS-Coordination (Camarinha-Matos and Afsarmanesh 2005), two part tariffs, return policy repurchase, flexible order amount, allocation rules, exclusive agreements, VMI, QR, CPFR, ECR and Postponement (Fugate, Sahin, and Mentzer 2006) ***T:*** Autonomous Agents (Adacher, Agnetis, and Meloni 2000)	***T:*** e-collaboration (Marquez, Bianchi, and Gupta 2004), MASCOT, Grid Computing (Shen et al. 2006), IST Project CO.OPERATE, web 2.0, Mashup (Xu et al. 2010)
Demand Forecasting	***M:*** Information Distortion and Bullwhip Effect (Lee and Padmanabhan, 1997), demand forecasting sharing (Yue and Liu 2006)	***M:*** forecast model selection through out-of-sample rolling horizon weighted errors *(*Poler and Mula 2011*)* ***G***: CFAR (Raghunathan 1999) CFM (Rodriguez et al. 2008), CPFR (VICS 2011), MVC, *Collaborative Forecasting in networks* (Poler et al. 2007), ***T***: V-collab Forecast Management (Poler et al. 2007)	***T***: MAS (Caridi, Cigolini, and Marco 2005), e-colaboration (Rodriguez et al. 2008)
Knowledge Management	***M:*** CSM (Choudhary et al. 2010)	***G:*** IE-GIP knowledge view (Ortiz, Anaya, and Franco 2005), EKD (Neves and Guerrini 2010), customising knowledge search in CNOs (Tramontin, Rabelo, Hanachib 2010) ***T:*** plug-and-play tools (Malhotra, 2005), MUVEs (Fiumara et al. 2010), DIMOCODE (Dargahi, Pourroy, Wurtz 2010)	***G:*** MISE (Bénaben et al. 2010), social network-based model (Capó-Vicedo, Mula, and Capó 2011), Personal knowledge management (PKM) (Zhen, Song, He 2012) ***T:*** WS, Web 2.0 (Fiumara et al. 2010)

Collaborative Processes	HN	NH → NHN	NHN
Operation Planning	***M:*** non-linear mixed integer programming multi-objective models (Chen, Wang, and Lee 2003), integrated multi-objective supply chain (SC) model (Sabri and Beamon 2000)	***M:*** multiobjective planning models under uncertainty (Gupta and Maranas 2003), collaborative planning process modelling view (Boza, Navarro, and Lario 2008), algorithm for solving a set of non-linear mixed integer programming models (Wang and Chen 2009), IPPS (Phanden, Jaina, and Vermaa 2011) ***G:*** OPS (Lario et al. 2003) ***T:*** DGRAI (Poler, Lario, and Doumeingts 2002), MASCOT (Sadeh et al. 2001), MASCOPP (Dangelmaier, Heidenreich, and Pape 2005), eXPlanTech, ProPlanT (Shen et al. 2006), SCAMM-CPA (Hernández et al. 2009), ACI (Bonfatti, Martinelli, and Monari 2010), CAPP (Xu, Wang, and Newman 2011)	***M:*** decentralised planning (Pibernik and Sucky 2007; Stadler 2009) ***G:*** performance measures (Goetschalckx and Rleischmann 2005), non-hierarchical negotiations (Dudek and Stadtler 2005), FGP (Selim, Araz, and Ozkarahan 2008), ADSCP (Jung, Frank, and Jeong 2008), interoperability (Alemany et al. 2010), ***T:*** COC PLAN TOOL (Camarinha-Matos, Afsarmanesh and Ollus 2008) application to support temporal and spatial distributed decision-making process (Alemany et al. 2011)
Performance Management	***G:*** Supply Chain Performance Measurement (Gunasekaran, Patel, and McGaughey 2004), EPMM (Bititci et al. 2005), PMS–VE (Peters, Odenthal, Schilick 2008)	***G:*** KPIs to measure collaboration (Camarinha-Matos and Abreu 2007), PMS-BP (Alfaro, Ortiz, and Poler 2007), PmColNet (Pinto and Lucas 2010), GPM-SME (Alfaro et al. 2010), *PMS in Collaborative Networks (*Verdecho, Rodríguez, and Alfaro 2011*)*	***G:*** ANP (Verdecho, Rodríguez, and Alfaro 2011*)* ***T:*** GPM-BUS (Alfaro et al. 2010), Net-Challenge ICT platform (Shamsuzzoha et al 2013)
Replenishment	***M:*** (Q, R) policy (Moinzadeh 2002), TOC-SCRS (Wu et al. 2010)	***G:*** VMI, QR, CPFR (Sari 2008; VICS 2011) ***T:*** VICS CPFR XML Messaging Model (VICS 2011)	***T:*** virtual hubs, SOA (Holmström et al. 2002), MAS (Caridi, Cigolini, and Marco 2005)
Share Costs and Profits	***M:*** simple/two revenue-sharing contract (Giannoccaro and Pontrandolfo 2004)	***M:*** shared-savings contracts, *doublé moral hazard* (Corbett, de Croix, and Ha 2005), cost allocation (Frisk et al. 2006), equitable division of benefits (Sarmah, Acharya and Goyal 2006), surplus calculation (Jähn 2010), economic model (Audy et al. 2010), Multiobjective Optimization for a Multienterprise Supply Chain Network (Chen, Wang, and Lee 2003) ***G:*** cash flow based on a predefined incentive rules, Equal Profit Method (Audy et al. 2010)	***G:*** SP-NHN methodology, share profits in non-hierarchical networks (Andres and Poler, 2014a)
Uncertainty	***G:*** Supply-Chain Uncertainty Scale (Ho and Chi 2005)	***M:*** *capacity and material requirement planning under uncertainty* (Mula, Poler, Garcia-Sabater 2008) ***T:*** Grid-based distributed analysis VLAM-G (Belloum et al. 2003)	***T:*** MACE-SCM (Kwon, Im, and Lee 2007)

Collaborative Processes	HN	NH → NHN	NHN
Information Exchange Management	***G:*** OSMOS (Rezgui et al. 2000)	***M:*** VEAC architecture (Chen, et al. 2008), Trust categories and impacts on information (Cheikhrouhou, Pouly, and Madinabeitia, 2013) ***G:*** federated information management, visibility, access rights (Camarinha-Matos and Afsarmanesh 2005), ECOLEAD (Camarinha-Matos, Afsarmanesh and Ollus 2008) ***T:*** PRODNET platform (Garita, Afsarmanesh and Hertzberger 2001), EDIFACT, XML, RosettaNet, ODMG, WebDAV, SAML, XML, (Camarinha-Matos and Afsarmanesh 2005), Logistic Platform (Egri, Karnok, Vancza 2007), Computer Supported Cooperative Work, “My” System, Application Service Provider, Component-Based Model, Knowledge Search & Sharing, (Rabelo 2008), DRACO MODEL, AVISPA (Astorga et al. 2010)	***M:*** Intelligent XML-based multidimensional data exchange model (Seng and Wong 2012) ***T:*** hub portals, e-marketplace, VPN, GRID security, (Camarinha-Matos and Afsarmanesh 2005), Net-Challenge ICT Platform, ITC –CBI (Rabelo 2008), Web 2.0, SOA, OSOA (Astorga et al. 2010), IOIS (Kazem and Wentland 2010), UDDI (Świerzowicz and Picard 2010), Saas (Perin-Souza and Rabelo 2010), MAS, SoBeNet (Jiang, Mair, and Yuan 2010), platform for business–IT alignment of an enterprise in the CCE (Li et al. 2011)
Interoperability	–	***M:*** Conceptual Framework for the Interoperability Requirements of Collaborative Planning Process (Alemany, 2010), barriers identification (Boza, Navarro, and Lario 2008), BIQMM (Grilo et al. 2013), funStep (Jardim-Gonçalves et al. 2013) ***G:*** LISI (AWG 1998), IDEAS (IDEAS 2002), EIF, INTEROP (Chen, Dassisti, and Elvesæter 2006), E-health (NEHTA, 2005), ATHENA (ATHENA 2006), guidelines for systematic evaluation of interoperability (Mykkänen and Tuomainen 2008), Architectures for Enterprise Integration and Interoperability (Chen, Doumeingts, Vernadat 2008), CIbFw (Chituc, Azevedo, and Toscano 2009), MISE (Bénaben et al. 2010), orchestration of business processes (Lemrabet et al. 2010), GloNet project (Camarinha-Matos, Afsarmanesh and Koelmel 2011), intra/inter-alignment of taxonomy (Jung 2008), ONTO-PDM (Lu et al., 2013) ***T:*** CIM, PIM, J2EE, P2P, PSM, ontologies, UEML (Bénaben et al. 2010; Cretana, et al. 2012), Interop platform to implement collaborative demand forecasting V-collab Forecast Management (Poler et al. 2007)	***M:*** MDI (Cretana et al. 2012) ***G:*** KPIs, previous evaluation (Camara, Ducq, and Dupas (2010), SCIF-IRIS (Pazos Corella, Chalmeta Rosaleñ, and Martínez Simarro 2013) NEGOSEIO (Cretana et al. 2012) ***T:*** WebService, net, MAS, EBS, (Elvesæter, Hahn, and Berre 2006), SOA (Franco, Ortiz, and Lario 2009), ColNet platform, UEML and PSL, SAWSDL, OWL-S WSMO,SWS (Bénaben et al. 2010)

Collaborative Processes	**HN**	**NH → NHN**	**NHN**
Inventory Management	***G***: Supply chain management (Johnson and Pyke 1999); (Q, R) policy (Moinzadeh 2002),	***M:*** Integrated Inventory Models (Goyal and Gupta 1989), decoupled point, Postponement (Hoeskstra and Romme 1992), Integrated Inventory Model (Lu 1995), Balanced Stock Rationing and Consistent Appropriate Share Rationing (Van der Heijden, Diks, and de Kok 1997), negotiations on credit terms (Moses and Seshadri 2000) SMART algorithm, coordination of the inventory policies (Giannoccaro and Pontrandolfo 2002) ***G:*** VMI, CPFR (Sari 2008) ***T:*** NIMISs (Giannoccaro and Pontrandolfo 2002)	***M:*** inventory management framework and deterministic/stochastic-neuro-fuzzy cost models (Gumus and Guneri 2009)
Lotsizing	***M:*** algorithms that apply back-order lot-sizing (Gupta and Brennan 1994), policy (Q, R) (Thomas and Griffin 1996), quantity optimal discount (Corbett and Groote 2000), scheduling of batch jobs (Hall and Pots 2003), Genetic algorithm-based heuristic for capacitated lotsizing problem (Mohammadi and Fatemi Ghomi 2011)	***M:*** repeated bargaining game, SPE (Ertogral and Wu 2001) ***G:*** JIT (Lee, Padmanabhan, and Whang 1997)	–
Order Promising Process	***M:*** ATP, CTP, DTP (Kirche, Kadipasaoglu, and Khumawala 2005) ***G:*** Interactive Weighted-Tchebycheff (Cakravastia and Nakamura 2002)	***M:*** Distributed Order Promising System (Makatsoris, Chang, and Richards 2004), fuzzy MCDM (Haleh and Hamidi 2011) ***G:*** Guidelines to design and characterise the OPP ECOSELL (Alarcón, Alemany, and Ortiz 2009), ***T:*** MAS NetMan (Abid, D'amours, and Montreuil 2004), ECOSELL platform (Gómez et al. 2009)	***T:*** SOA, myOpenFactory (Schuh et al. 2008)
Process Connection	***G:*** framework and a reference model for implementing the innovation processes (Berasategi, Arana, Castellano 2010)	***T:*** CIM, PIM, .net, MAS, P2P, PSM, UEML, PSL, SBPM, BPEL4WS, BPML, WSCI, and WSFL, WSMO, ASICOM, XML (Lemrabet et al. 2010)	***T:*** BPEL, CNO-OSB distributed process execution in CN (Osório and Camarinha-Matos 2008), SOAP, WSDL, WS (Hepp et al. 2005), distributed platforms (Bénaben et al. 2010*)*
Scheduling	***M:*** MPI (Karimi and McDonald 1997; Hall and Potts 2003), negotiation of deliver capacity risk, requirements model (Guillaume, Thierry, Grabot 2010)	***M:*** IPPS (Phanden, Jaina, and Vermaa 2011) ***T:*** PSLX SUPREM (Nishioka, Kasai, and Kamio 2003), ECOSELL Platform (Gómez et al. 2009)	***T:*** MAS (Gómez et al. 2009)

<u>Legend:</u> HN: applicable only to Hierarchical Networks / **HN → NHN**: designed for Hierarchical Networks but partially applicable to Non Hierarchical Networks / **NHN**: specifically designed for Non Hierarchical Networks / **M**: models / **G**: guidelines / **T**: tools

A classification scheme of the literature review on the contributions proposed to support the establishment of the identified collaborative processes is shown in Table 2.8. This classification scheme is based on the results obtained from the classification performed in Table 2.7. In Table 2.8 the number of contributions in each solution proposal typology (M, G and T) is given in brackets for each particular collaborative process. Moreover, the total number of models, guidelines and tools proposed in each *solution classification criterion* (**HN**, **HN →NHN**, **NHN**) is also given. The last column indicates the number of works found in the literature treating each specific process. In some of the processes it can be observed that the sum of the given solutions does not necessarily correspond with the number of references, this is because the same author can sometimes give two types of solutions for the same process. For example, in the *decision system design* process Poler, Lario, and Doumeingts (2002) provide two types of solutions: a guideline (DAROMS) and a tool (DGRAI). Table 2.8 provides a broad view of the results obtained from the reviewed literature, in terms of the M, G and T proposed considering the NHN perspective. In the light of this, it can be highlighted that:

- Most of the proposed solutions focus on the *HN classification criterion*, approximately the 70% of contributions,
- Although most of the contributions are treated from centralised scenarios, some of them can be carried out in NHN contexts after certain modifications or adaptations, what it is named *HN→ NHN* (52% of contributions);
- Amongst all the solutions, models and guidelines are more used than tools (i.e. tools count with 87 contributions in comparison with the 187 works proposing models and guidelines) this is due to the *tools* are considered more complex as regards its design and implementation;
- Models and guidelines are in some of the cases specifically generated for the HN topology (*HN: M[16], G[36]*). However, there are large number of contributions (*HN→ NHN: M[39], G[62]*) that can be subject to certain adjustments and can be adapted and applied in the NHN scenarios
- In the *NHN classification criterion* some gaps can be found, especially with respect to models and methodologies; however, the design of tools applicable, or directly conceived, to NHN context is more common (*NHN: M[9], G[25], T[45]*). Note that all the tools provided in the HN context can be adapted for its use in NHN (*HN: T[0]* and for *HN→NHN: T[42]*). This adaptation is possible through mechanisms in which the information exchange is not managed by a central network node, what means that all the nodes have available public information, and can keep certain information in the private sphere. Furthermore, when adapting these tools, there is a chance to include negotiation mechanisms, which will allow enterprises to obtain acceptable solutions for themselves, while generating optimal results for the network to which they belong.

Table 2.8. Classification Scheme for collaborative processes according to the classification criteria and the type of solution

Level	Contributions Classification / Collaborative Process	Classification Criteria									Number of References
		HN [53]			HN→NHN [143]			NHN [79]			
		M [16]	G [36]	T [0]	M [39]	G [62]	T [42]	M [9]	G [25]	T [45]	
Strategic	Coordination Mechanisms Design	-	G [2]	-	M [2]	G [2]	-	-	G [2]	T [1]	9
	Decision System Design	M [1]	G [1]	-	M [1]	G [1]	T [1]	-	G [2]	T [2]	7
	Network Design	M [2]	G [2]	-	M [1]	G [7]	T [3]	M [1]	G [1]	T [1]	16
	Partners' Coordination and Integration	-	G [6]	-	-	G [1]	T [1]	-	-	T [5]	12
	Partners' Selection	M [3]	-	-	M [2]	G [8]	T [4]	-	G [1]	T [2]	18
	PMS Design	-	-	-	-	G [3]	-	-	G [1]	-	4
	Product Design	-	-	-	M [1]	G [4]	T [3]	-	-	T [4]	11
	Strategy Alignment	-	-	-	-	G [3]	-	M [1]	G [2]	-	6
Tactical	Contracts' Negotiation	M [1]	-	-	M [1]	G [1]	T [2]	-	G [2]	T [3]	10
	Coordination Mechanisms Management	-	G [8]	-	M [2]	G [2]	T [1]	-	-	T [3]	16
	Demand Forecasting	M [2]	-	-	M [1]	G [4]	T [1]	-	-	T [2]	8
	Knowledge Management	M [1]	-	-	-	G [3]	T [3]	-	G [3]	T [1]	10
	Operation Planning	M [2]	-	-	M [4]	G [1]	T [7]	M [4]	G [5]	T [2]	23
	Performance Management/Measurement	-	G [3]	-	-	G [5]	-	-	G [1]	T [2]	9
	Replenishment	-	G [2]	-	G [2]	-	T [1]	-	-	T [2]	6
	Share Costs and Profits	M [1]	-	-	M [6]	G [1]	-	-	G [1]	-	8
	Uncertainty Management	-	G [1]	-	M [1]	-	T [1]	-	-	T [1]	4
Operational	Information Exchange Management	-	G [1]	-	M [2]	G [2]	T [5]	-	G [1]	T [7]	15
	Interoperability	-		-	M [4]	G [13]	T [2]	M [1]	G [3]	T [3]	23
	Inventory Management	-	G [2]	-	M [6]	G [1]	T [1]	M [1]	-	-	10
	Lotsizing	-	G [5]	-	-	-	-	M [1]	G [1]	-	7
	Order Promising Process	M [1]	G [1]	-	M [2]	G [1]	T [2]	-	-	T [1]	8
	Process Connection	-	G [1]	-	-	-	T [2]	-	-	T [2]	5
	Scheduling	M [2]	-	-	M [1]	-	T [2]	-	-	T [1]	6

2.4.1 Discussion of the findings

So far, the most relevant collaborative processes and their associated solutions (M, G and T) have been identified and classified. The solutions that support the establishment of each collaborative process are classified from both the HN and the NHN perspective. For those contributions that were originally provided for HN but can be applied to the NHN context (HN → NHN), the main aim is to analyse the magnitude to which the centralised approaches can be applied in decentralised contexts. Considering the *solution classification criterion* (***HN***, ***HN→NHN*** and ***NHN***), this subsection aims to classify the collaborative processes, identified in section 3, through the variable *"degree of coverage"*. The degree of coverage will give researchers an insight of the extent into which the identified processes are treated from the NHN perspective (Table 2.9).

Table 2.9. Solutions Degree of Coverage

Degree of coverage		**Description**	**Association with the solutions classification criteria**
Satisfactory	**A**	Processes whose M, G and T are specifically designed to fill the requirements needed from the decentralised and collaborative perspective of NHN.	Most of the solutions are provided from the **NHN** perspective. These solutions are considered very relevant to deal with barriers SMEs find when participate in NHN
Acceptable	**B**	Processes whose M, G and T are outlined for HN scenarios but that can be applied, through adaptations, to NHN.	Most of the solutions are provided from the **HN →NHN** perspective
Unsatisfactory	**C**	Processes whose M, G and T are only provided from the centralised perspective and these cannot be applied to NHN because there are subject to a HN features	Most of the solutions are provided from the **HN** perspective

Each process is classified according the *degree of coverage* variable (Table 2.10). In order to provide a better insight of why the processes have been classified in each degree of coverage, Table 2.10shows in the last column the justification of why the processes have been classified in each degree of coverage. This justification is given taking into account the literature reviewed and the contributions found for each collaborative process.

Table 2.10. Collaborative Processes, Degree of Coverage associated and Justification

Level	Collaborative Processes	Degree of Coverage	Justification
Strategic	**Coordination Mechanisms Design**	B	Most of the coordination mechanisms are supported by models and methodologies, which are designed to be controlled by a dominant enterprise. Although MAS mechanisms are provided from the NHN perspective (MASCOT, Shen et al., 2006), its application needs expert knowledge. Methodologies are mostly provided from the centralised perspective but can be applied to the NHN with certain considerations in the information exchange (IE-GIP, CPFR, VMI, EKD). There is a lack of models designed for its application in decentralised scenarios.
	Decision System Design	A	The decision system in NHN is characterised by the DDM involving multiple decision makers. GRAI methodology and DGRAI tool, initially designed from the centralised perspective, can be implemented in NHN due to all the network partners can be represented through the "decision centres" involved in the decision-making. As an extension of GRAI methodology, the GRAI-PROJECT framework is proposed in the specific context of NHN (CONVERGE Project, 2010). MAS (Schneeweiss, 2003) or distributed platforms (CONVERGE Project 2010) consider different criteria and agents in the decision-making, allowing solving conflicts that arise from participation of different agents.
	Network Design	B	Several European projects propose reference models for designing a CN, i.e. ECOLEAD or ARCON, although there are focused to design the network from a centralised perspective considering a virtual planner. From the tools perspective, Camarinha-Matos and Afsarmanesh (2005) propose a summary of technologies and standards for supporting the collaborative network design problem. Tools such as SOA can be applied in this process. Nevertheless, the provided guidelines partially solve the network design process by mostly focusing on the facility location problem. In order to deal with this process, models, guidelines or tools are needed to be designed considering (i) the decentralised network structure, (ii) the collaborative business processes established, (iii) the management of components -location, forecast planning, logistics, inventory structure, organisation structure, product flow, information flow, power and leadership structure, risk and reward structure, culture and performance metrics-, (iv) the social structure and (v) the network externalities (Johnson and Pike, 1999; Lambert and Cooper, 2000).
	Partners' Coordination and Integration	B	The use of tools such as e-collaboration, SOA, web portals, MAS enable decision makers to cope with the enterprises' integration process in terms of information integration and exchange among nodes (Marquez et al., 2004). Nevertheless, the guidelines are provided from the HN perspective, i.e. enterprise integration architectures (Ortiz, Anaya, and Franco 2005). Besides this, there is a lack of models solution typology
	Partners' Selection	A	Several frameworks and methodologies are developed in the literature for its application in HN considering a centralised perspective, i.e. VBE managed by a VO planner with a centralised role (Angulo et al. 2009). Nevertheless, these methodologies and frameworks can be applied in the partners' selection process in NHN; through making available all the information required for selecting the partners to all the pool of potential network partners. Besides this, SOA and cloud infrastructures are also provided as tools that consider the decentralised perspective. On the other hand, the majority of models provided require private information such as location, price, processing time, production costs and distribution time. However, these models can be used as a base for future model contributions to be applied in NHN.
	PMS Design	A	The characteristics that define an integrated PMS and the *multi criteria decision making methodology* allows considering of all the elements that influence the design of a PMS in a collaborative NHN (Verdecho et al., 2011). Besides this, Pinto and Lucas (2010) identify a set of key elements that should be considered to fill the requirements needed when designing a PMS in a NHN: (i) a methodology, (ii) a process management structure, (iii) tools to collect, process and analyse information, (iv) theoretical guidelines on how to manage the actions and (v) a review process to constantly update KPIs.
	Product Design	B	Collaborative design of new products involves the establishment of cooperative partnerships between networked partners. In NHN, the creation of collaborative products requires the definition of models and methodologies to optimise tasks assignments, from a decentralised view, taking into account the capabilities and skills of human resources. With this regard, there is a lack on models and guidelines to deal with the product design process in NHN. Nevertheless, technologies such as web 2.0 or distributed platforms are proposed in the literature giving support to this process from the decentralised perspective of NHN (Germani et al. 2010; Shamsuzzoha et al 2013).

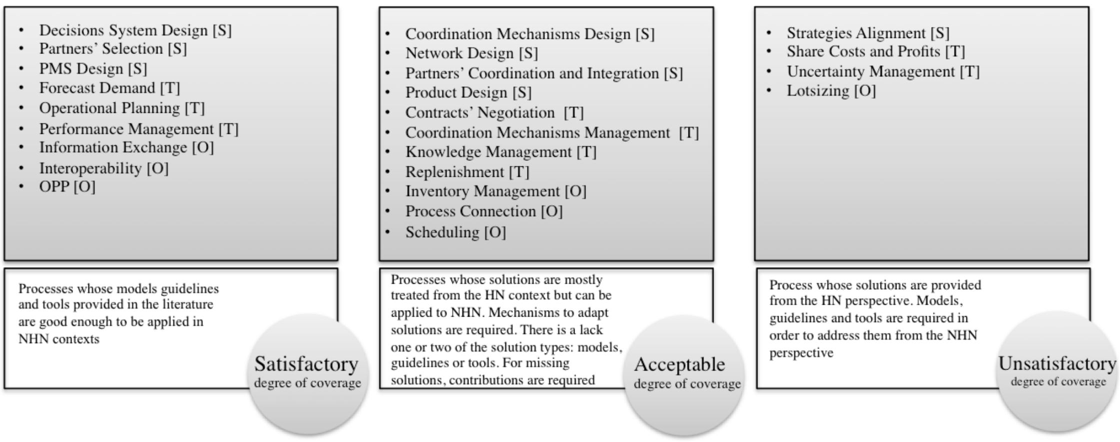
Level	Collaborative Processes	Degree of Coverage	Justification
	Strategy Alignment	C	Solutions are provided from the centralised perspective, in which the majority of partners have to adapt to the strategy formulated by the minority of dominant firms. The guidelines proposed in the literature just calculate the degree of the strategies alignment (Verdecho, Rodríguez and Alfaro 2010) and only consider the alignment of pairs of strategies within the same enterprise (Cuenca, Boza and Ortiz, 2011). Values alignment research has been widely studied (Macedo, Abreu and Camarinha-Matos, 2010). Research in strategies alignment process is aimed to provide models guidelines and tools in the same way as it has been done in the values alignment. In the light of this, Andres and Poler (2014b) have initiated a series of solutions, providing a model that measures the KPIs maximisation when certain strategies are activated. Continuing with this research line, models, guidelines and tools are required to help enterprises to identify what strategies to activate in order to be aligned. Analyse the degree of alignment, identify imbalances and eliminate or minimise them are some of the actions to be performed. Future work is lead to formally identify the aligned strategies, in order to improve the enterprises' objectives and, consequently, the network performance. Besides this, the main aim is not to focus on pairs of strategies; unlike, identify the aligned strategies formulated by all the collaborative partners.
Tactical	**Contracts' Negotiation**	B	An extensive review on network coordination contracts is given by Cachon (2001), from the centralised perspective. In the contracts field various approaches and initiatives are provided to resolve or reduce coordination drawbacks and uncertainties when organisations collaboratively work. The management of contracts in collaborative networks is supported through negotiation protocols and modelling approaches; nevertheless, there is a common limitation in the provided contributions: the main node determines the partners to which negotiate. Amongst the found solutions, only the tools solution type deals with this process from a decentralised perspective: e-contracts (Camarinha-Matos and Afsarmanesh 2005), e-based platforms for transactions and commercial contracts (Griffel et al., 1998), and multi-agent systems (Jiao et al., 2006) since they allow multiple contract negotiations. Models and guidelines are required from the decentralised perspective, taking into account all the parts (network partners) in the negotiation process.
	Coordination Mechanisms Management	B	Most of the coordination mechanisms are built through models and methodologies designed from the centralised perspective. Nevertheless, the literature proposes several tools that support coordination mechanisms from the decentralised perspective, such as autonomous agents (AA), MAS or Grid computing (Shen et al., 2006). Manufacturing networks evolution towards collaboration is a fact and collaboration has become a vital mechanism to cope with the global solutions that customers demand. Therefore, organisations must implement collaboration mechanisms instead of coordination mechanisms to establish collaborative relationships (Sahay, 2003). Models and guidelines are required supporting solutions in order to complement the tools solutions line.
	Demand Forecasting	A	CFAR, CPFR, V-CFM, and web service solutions can be applied in NHN through linking decentralised platforms or interoperable IS to gather and manage the exchanged information required in the demand forecasting process. The guidelines provided in the literature can also be applied in NHN context, such as the *Collaborative Demand Forecasting* conceptual model (Rodriguez et al. 2008) that uses e-collaboration practices, or the Model View Controller (Poler et al., 2007) an architecture that allows network partners to have multiple views of the shared data of the demand. Tools such as MAS enables to link the intelligent agents, which represent the network enterprises, in the demand forecasting process (Caridi, Cigolini, and Marco 2005).
	Knowledge Management	B	The consideration of the knowledge view in modelling architectures enables the network to get a more analytical perspective of partners that own knowledge. The main limitation is that these modelling architectures are provided from the centralised perspective (IE-GIP; Poler eta l., 2002a). Other methodologies can be used such as the *social network-based* for improving knowledge management in multi-level supply chains formed by SMEs (Capó –Vicedo eta l., 2011). The barriers appearing in knowledge management raise on the public and private knowledge treatment but methodologies such as Mediation Information System Engineering (MISE) can be used to deal with it (Bénaben et al., 2010). Note the importance of ICT in knowledge management process to support knowledge generation and sharing among partners; web services facilitate this knowledge exchange (Fiumara et al. 2010). Although there are tools specifically designed for the NHN contex, the provided guidelines are needed to be adapted and there is a lack of models defined from the decentralised perspective characterising the NHN.

Level	Collaborative Processes	Degree of Coverage	Justification
	Operation Planning	A	Decentralised planning involves all the partners and takes into account the objectives of all the network nodes. Special attention has to be paid to the "A Decentralised Supply Chain Planning methodology" (ADSCP) that allows partners to create network plans by the simple exchange of information (Jung et al. 2008). From the tools perspective, the COC PLAN TOOL (Collaboration Opportunity Characterisation &VO Rough Planning) can be underlined, supporting the collaborative business planning process (Camarinha-Matos et al., 2008). Besides, agent-based contributions such as the SCAMM-CPA (Hernández et al., 2009) designed for assisting the collaborative planning modelling process within the network and can be applied to NHN scenarios.
	Performance Management/Measurement	A	PMS initially designed from the centralised perspective, can be applied in NHN environments through employing methodologies and tools for exchanging information among network enterprises. An example is GPM-SME and its associated information architecture that enables the data exchange among the variety of SMEs information systems (Alfaro et al., 2010).
	Replenishment	B	Mathematical models generate optimal decisions as regards the amount of orders for replenishment between the retailer and the manufacturer, both in sharing and non-sharing information scenarios. Models in this process are constructed from the centralised perspective (CDM) and need private information, i.e. (Q,R) policy (Moinzadeh, 2002). Technological solutions may vary depending on the implementation complexity; SOA or MAS are proposed. On the other hand, methodologies such as CPFR, initially designed considering CDM, can be adapted to its application in NHN. In spite of the range of tools provided, methodologies and specially models are required to be designed from the decentralised perspective in order to add new ways to efficiently deal with this process
	Share Costs and Profits	C	According to the literature reviewed, few solutions are encountered from the decentralised perspective, i.e. the methodology SP-NHN (Andres and Poler, 2014a). As regards methodologies, this type of solutions requires a strong support on data management tools to properly apply them in decentralised contexts. In order to deal with the SMEs exchange information, the information architecture using *enterprise bus services* can be used in the same way as is done in the performance management process (Alfaro et al., 2010). Some of the contributions classified as models and guidelines can be adapted to the NHN topology; however, mechanisms to adapt the solutions, initially provided from the HN perspective, have to be designed in order to use them from the decentralised view. In the light of this, future contributions must be designed to integrate all the network partners as regards their negotiation mechanisms and decentralised decision-making systems, and obtain fair distributions of the benefits obtained. Some contributions of the literature review follow these principles, but are characterised by a single agent that owns all the bargain power (Giannoccaro and Pontrandolfo 2004). Negotiation mechanisms are required in order to agree the quantity that gives an equitable sharing of costs and profits within all the collaborative partners.
	Uncertainty Management	C	Tools such as MACE-SCM (Kwon, Im, and Lee 2007) are proposed to deal with the uncertainties that appear in the specific processes of demand forecasting and supply. In terms of models, uncertainty has been also faced in the specific process of *capacity and material requirement planning* (Mula, Poler, Garcia-Sabater 2008). Nevertheless, the collaborative uncertainty management is a problem to be solved in other processes, such as partner's collaboration, contracts, coordination mechanisms, information sharing management, interoperability and connection between the processes of network partners. Particularly, the uncertainty management requires methodologies for the uncertainty measurement and tools to diagnose and eliminate information asymmetry barriers, and properly manage the public and private information. Accordingly, models, guidelines and tools are required with the main aim of reducing uncertainty in all the processes in which enterprises collaboratively participate.

Level	Collaborative Processes	Degree of Coverage	Justification
Operational	**Information Exchange Management**	A	Useful tools, to be applied in NHN, are (i) the PRODNET platform (Garita et al., 2001) that allow supporting the exchange of information through a Distributed Information Management System (DIMS), (ii) the Net-Challenge ICT Platform, (iii) MAS, or (iv) Open Service Oriented Architectures (OSOA) (Astorga et al., 2010). Technological infrastructures provided in the literature enable the exchange of information in a flexible, scalable, interoperable and embeddable way; providing privacy, confidentiality and information integrity within the collaborative applications. Although there is a lack of models and methodologies in the NHN context, the proposed tools are considered sufficient enough to support this process in collaborative and decentralised scenarios.
	Interoperability	A	Methodologies and tools are provided, in the literature, to cope with interoperability; applying different standards and standardised architectures, in order to control and make interoperable the whole range of information systems owned by the network enterprises. Tools that allow data exchange and information management to support interoperability are basically based on SOA, ESB, web services, UEML, Process Specification Language (PSL) and semantic Web Services (SWS) (Elvesæter et al., 2006; Bénaben et al., 2010). This process is assisted in the literature from all the solution proposal typologies: models, guidelines and tools.
	Inventory Management	B	The model provided by Gumus and Guner (2009) considers the decentralised perspective, proposing a multi-echelon approach using fuzzy methods. The multi-echelon structure gives a broad view of the network, but it must be considered how the information that feeds the model is gathered. On the other hand, most of the contributions encountered to collaboratively manage the inventory, are provided from the HN perspective. Although these contributions can be applied from a decentralised scenario there is a long path to cover in order to make them applicable in NHN. Future solutions can be based on the centralised models, guidelines and tools, extending their features and considering a wide view of the network in order to manage the inventory. A platform to show the information related the inventories of each of partners or solutions similar to VMI may be a useful tool in order to deal with the inventory management from a decentralised perspective.
	Lotsizing	C	For overcoming the lotsizing problem, centralised mathematical models are proposed, in which all the data needed to feed the model is known by a central/dominant network partner. Policies, based on CDM, such as quantity optimal discount, joint economic lot size, arrangement of joint policies and optimal ordering policy (Q, R) are very common to deal with lotsizing process (Corbett and Groote, 2000). As regards lotsizing of multilevel networks, Gupta and Brennan (1994) considered several algorithms that apply back-order lot-sizing algorithms but only adjustable in HN. Accordingly, models, guidelines and tools are needed to be designed to deal with the requirements of the NHN in the process of lotsizing negotiation.
	Order Promising Process	A	The tools solution typology identifies *myOpenFactory* platform (Schuh et al. 2008), enabling collaborative enterprises to integrate all the software and interfaces from one platform to a normalised data model, promoting the access to updated information in the OPP. Besides this, the models, guidelines and tools initially designed from the centralised perspective, can be applied to NHN. These models and guidelines can make use of the platform *myOpenFactory* in order to manage the information required in the OPP, and adapt them to the requirements needed from the NHN perspective.
	Process Connection	B	The tools provided in the literature, from a centralised perspective, are more focused on the process modelling, i.e. BPEL or XML (Osório and Camarinha-Matos 2008; Lemrabet et al. 2010); nevertheless, these tools can be applied to decentralised scenarios. Osório and Camarinha-Matos (2008) state that collaborative processes should be executed and coordinated in a distributed computational platform where computers are connected through heterogeneous networks and systems. This network of services and processes is to be orchestrated via BPEL, allowing processes to establish an integrated and collaborative environment. The definition and design of a platform will allow having a broad view of the processes collaboratively performed and the connections established among individual enterprises, which take part of the collaborative process execution. Models and guidelines represent a gap in the process connection solutions. Therefore, apart from distributed platforms, decentralised models and guidelines are required to orchestrate the set of collaborative processes performed in a network.

Level	Collaborative Processes	Degree of Coverage	Justification
	Scheduling	B	MAS methods can be usefully implemented from the decentralised and collaborative perspective. The agents are used to represent the enterprises that collaboratively perform the scheduling process (Gómez et al. 2009). MAS allow synchronising product flows and simultaneously consider all the resources of the network partners. Integrated solutions such as IPPS (Phanden, Jaina and Vermaa 2011) can be usefully applied in the NHN, although being initially applied in centralised scenarios. Models and guidelines are required to supplement the tools solution typology. Negotiation mechanisms to deal with scheduling process have to be considered in order to improve the scheduling flexibility within the collaborative partners. The scheduling process is characterised by repetitive decisions made in the short term, so that the information needed must be available. Therefore, the establishment of information exchange platforms are required to gather the proper data in the proper time. To the support the scheduling process, decentralised models to generate optimum solutions that satisfy the demanded orders are required. As the production scheduling is directly related with the operations planning, demand forecasting and replenishment processes, solutions integrating all this processes will be very useful, too.

According to Table 2.10, the processes classified in the ***satisfactory degree of coverage** (A)* concur in that most of the contributions (M, G and T) are provided from the decentralised perspective. In general terms, the processes grouped in the ***acceptable degree of coverage** (B)* coincide in that the models and guidelines proposed do not usually satisfy the needs of the decentralised contexts (NHN). As regards the tools solution type, there are mostly applicable to NHN contexts; i.e. web services, distributed platforms, MAS or SOA. The strength associated to these tools is that the same tool can serve to support different collaborative processes though adaptations. Nevertheless, this generality may sometimes lead to a trouble when specific requirements in a particular collaborative process are needed, and the tool is so general that cannot cover them. Thus, for collaborative processes belonging to the acceptable degree of coverage, models and guidelines and specific tools should be provided, giving greater levels of customisation for the NHN context. The processes classified in the ***unsatisfactory degree of coverage** (C)* present a lack of M, G and T to be applied from the NHN perspective. The solutions provided in the literature are not expected to efficiently work from the decentralised point of view that characterises the NHN. Accordingly, new approaches must be generated, considering the features that characterise NHN, in order to bridge this gap, converting the processes with unsatisfactory degree of coverage into satisfactory degree of coverage. Considering the analysis performed to the contributions given in the literature, it can be stated that some of the collaborative processes have not been treated from the decentralised perspective (NHN). In order to enhance collaborative behaviours in NHN, researchers must focus their attention on the processes whose solutions are not designed from the collaborative and decentralised perspective (Figure 2.2) providing solutions to address the collaborative processes in NHN.



***Legend**: Collaborative process [decision making level] →[S] strategic, [T] tactical, [O] operational*

Figure 2.2. Summary of collaborative processes classified according to the degree of coverage

Figure 2.2 allows identifying at a glance what are the processes that need to be addressed from the NHN perspective through proposing new contributions to fill the decentralized and collaborative features that characterise NHN. The identified pattern follows the idea that NHN are being less accessible to researchers mainly in the difficulty of representation in models, the definition of guidelines and the complexity on tools construction. Nevertheless, the reviewed studies reveal that the generation of solutions from the NHN is an upward trend.

2.5 Conclusions

A comprehensive analysis on the literature in the research area of collaborative processes in manufacturing networks has been developed. The analysis performed allowed to identify a set of collaborative processes and the associated solution' approaches classified into models (M), guidelines (G) and tools (T) developed to support such collaborative processes. The research objective is to achieve a better understanding on the ways that SMEs can address collaborative processes, and identify solutions applicable to NHN context. In doing so, a matrix that relates the collaborative processes (arranged in the strategic, tactical and operational decision making levels) with the M, G and T to support them, is proposed. Besides, the contributions are grouped, in each collaborative process, according to their applicability in collaborative contexts according to the solution classification criteria (HN, HN→NHN and NHN).

Collaborative processes tackled from the HN perspective are more frequently provided in the literature, assuming simple structures of networks. Unlike, in the NHN context, collaborative processes are not completely addressed due to the fact that these networks are more complex, and being modelled efficiently implies higher levels of difficulty. Purely in NHN context a small number of models and guidelines were identified and the majority of solutions provided were based on tools. However, it must be considered that these tools are often not specific for each collaborative process, and are identified in a more general way, i.e. web services, distributed platforms, MAS or SOA. Thus, from the literature analysis it is concluded that a set of collaborative process have not received sufficient attention in the NHN context, due to the provided solutions cannot be directly implemented in decentralised decision making processes. In the light of this, the degree of coverage is analysed for each collaborative process, identifying the extent into which the provided M, G and T, for each process, can support collaborative processes in NHN contexts.

According to the degree of coverage it can be stated that the most significant processes in which is needed to provide solutions in NHN, are those classified in the acceptable and unsatisfactory degrees of coverage (see Figure 2.2). On the one hand, for those processes classified in the *unsatisfactory degree of coverage*, the current M, G and T proposed are subject to several gaps for their application in NHN. These gaps encourage designing design new contributions focused on supporting the collaborative processes considering the specific needs of NHN. On the other hand, for those processes classified in the *acceptable degree of coverage*, the solutions initially proposed from the HN perspective (see columns HN and HN→NHN, of Table 2.7, can be used as a base, adjusting or extending them to adequately support the collaborative processes in NHN contexts. The design of new solutions or adaptation of existing ones would reduce the barriers concerning collaboration among SMEs belonging to NHN.

This thesis focuses on the specific collaborative process of *strategies alignment*, classified in the *unsatisfactory degree of coverage*. This process is considered due to its decisive contribution, among other processes, for the CN success. Taking into account the results obtained from the comprehensive analysis carried out, and to the best of our knowledge, it can be highlighted the importance of addressing the collaborative process of aligning the strategies, in the CN context. This importance is given by the consolidation of the partnerships established within the CN, avoiding conflicts among the network members when aligning their strategies. The success of the CN is determined by the increase of the performance level, the reduction of strategies misalignments, and the generation of more stable and sustainable collaborative partnerships. The elimination of misalignments and conflicts, in terms of strategies and objectives achievement, and the improvement of relationships established among the network partners are two advantages obtained from addressing the collaborative process of strategies alignment from the CN perspective.

The heterogeneity associated to the CN may foment that the activation of some of the strategies formulated are inconsistent with the objectives defined by other network enterprises, preventing its achievement. Therefore, if these discrepancies are not addressed on time and strategies misalignments remain, the negative influences between the strategies activated and the objectives formulated within the enterprises of the CN will increase, leading to the collapse of the collaborative partnership. The heterogeneous nature of the enterprises belonging to the CN makes that each enterprise defines its own objectives and formulates its own strategies. This heterogeneity could lead to a situation in which the strategies activated are inconsistent with the objectives defined. The consideration of all the objectives and strategies, as well as their causal relationships, makes that the collaborative process of strategies alignment is complex to solve. This chapter has allowed finding a gap, in the literature, as regards contributions providing a holistic approach to deal with the alignment of strategies by considering all the strategies formulated by all the partners in the CN context. Therefore, an integrated approach is needed in order to deal with the equal consideration of objectives and strategies of all the enterprises of the CN. Accordingly, a set of artifacts, such as models, guidelines and tools, will be developed, along this thesis, in order to support enterprises on the achievement of higher degrees of strategies alignment, considering all objectives and strategies proposed by all the members of the CN. The contribution proposed will allow to fill the gap found in the literature as regards the strategies alignment and create theoretical knowledge and practical contributions within the domain of the studied collaborative process.

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Annex 2.1. Acronyms

Accessible in: https://goo.gl/Tb91vI

Chapter 3

A review of Models, Guidelines and Tools to deal with the Strategies Alignment Process

In this chapter the strategies alignment process is analysed, giving a better insight of the collaborative process analysed and addressed in this thesis. Firstly, the strategies alignment concept is defined giving a better comprehension of the research performed along this thesis. In order to have a broader view of how the strategies alignment process has been treated in the literature so far, some relevant contributions, proposing models, guidelines and tools, are reviewed. Finally, gaps and potential trends are identified, in the topic under study. The research questions formulated in Chapter 1, are compared with the found gaps and trends in order to show their analogy.

3.1 Introduction

The literature review carried out in Chapter 2 has allowed identifying, firstly, the most important processes to perform in a CN, and secondly, amongst all these processes, those that have a lack of contributions from the collaborative non-hierarchical manufacturing network (NHN) context. This last group of processes are characterised by requiring more attention in terms of providing solutions to address them from the collaborative and decentralised decision-making perspective. The strategies alignment process is included in the group of potential processes to propose solutions in collaborative decentralised scenarios. According to the analysis carried out in Chapter 2 it can be concluded that, to the best of our knowledge, the strategies alignment process is a collaborative process that requires to be studied, proposing models, guidelines and tools for its analysis, assessment and resolution, in the CN context.

Current business environments force enterprises to be more agile and flexible in order to deal with constant quickly changes, volatile markets, high of complexity of customised products, shorter time-windows to respond to business opportunities, higher levels of competitiveness, globalisation, rapid evolution of information and communication technologies. In the light of this, the strategies alignment is considered a key process to allow enterprises achieve the required levels agility and flexibility, being aware that the strategies alignment process leads to the improvement of collaborative relationships between the enterprises, increasing the CN sustainability.

Unlike Chapter 2, that has a more widespread vision of analysis of all the collaborative processes, this chapter focuses on the strategies alignment process, as it is the collaborative processes selected for research in this thesis. Thus, the concept of strategies alignment is defined in Section 3.2. Afterwards, in Section 3.3 some contributions, proposed by different authors between 2003 and 2014, are gathered and analysed. The strategies alignment concept is studied, from different perspectives, in order to know how this process has been treated so far in the literature. Models, guidelines and tools for strategies alignment assessment have been considered from the literature. The analysis made upon the gathered works, which shape the background of the analysed topic, has allowed to identify not only the gaps of the topic under review but also define some trends related with the strategies alignment process, considering its importance in the context of CN (Section 3.4). In Section 3.5, the research questions to be solved along this dissertation, and proposed in Chapter 1, are compared with the identified gaps and trends. Finally, the developed work is discussed and concluded in Section 3. 6.

3.2 Strategies Alignment Concept

The concept of strategies alignment is not frequently used in the literature; having related other terms with similar meanings, such as collaborative decision design, collaborative decision making, collective decision, or alignment of decisions, amongst others.

Focusing, first, on the term *alignment*, it can be stated that it has a very broad meaning, involving terms such as consistency, fit, affinity, similitude, or compatibility (Macedo, 2011). In a network of enterprises, the alignment can be defined as a proper or desirable coordination or relationship of the components of this network. More concretely, in the management field, the concept of alignment can be considered as a situation in which the strategies, formulated by the entities belonging to the network, are strictly combined under a set of functions to achieve the objectives (Piedade, Azevedo, and Bastos, 2010).

According to Camarinha-Matos and Afsarmanesh (2005) CN are characterised by the enterprises heterogeneity, each one defining its own objectives, heterogeneous too. Consequently a high diversity of strategies is formulated, in order to reach the objectives defined. The strategies diversity may result in conflict situations among enterprises of the same CN, since contradictions among the strategies formulated might emerge. The strategies misalignment may, ultimately, lead to the failure of the collaborative partnership if the conflicts that arise are not tackled. In order to deal with these conflicts, the strategies alignment is considered a powerful mechanism to implement among enterprises of the same CN (Piedade, Azevedo, and Almeida, 2012).

When an enterprise has to face the decision-making of the strategies to activate, in order to achieve its objectives, can opt for making the decision from an isolate perspective (non-collaborative scenario), or, on the contrary, from a common perspective (collaborative scenario). When considering the collaborative alternative, each enterprise decides which set of strategies activate, by not only taking into account the extent into which its own activated strategies influence its own objectives, but also considering how the activated strategies influence the objectives defined by other network enterprises. Generally, the strategies that, on the whole, positively influence the objectives defined by the majority the network enterprises will be characterised by being aligned.

The strategies alignment leads a situation in which the strategies formulated by the network partners are strictly combined and activated, being complementary one another. The collaborative strategies alignment enables to adequately coordinate the network objectives and appropriately identify those strategies that maximise positive impacts, minimising the negative ones, on the objectives defined by all the networked partners, so that the best solution coincides with the one that leads to maximise the network performance, even though some strategies have negative influences on some definite objective.

CNs consist of autonomous and heterogeneous enterprises each one defining its own objectives. The strategies are the set of actions raised to achieve the defined objectives; therefore, each enterprise of the CN formulates its own strategies with the main aim of achieving the defined objectives. There will be times in which all the strategies formulated are activated. Nevertheless, sometimes only a few of the formulated strategies will be activated, due to, for example, a restriction associated with the budged. Assuming that, the strategies alignment concept is defined next as:

"*the set of strategies, formulated by the enterprises belonging to the CN, whose activation positively influence, on the whole, the objectives achievement of the majority of the enterprises participating in the CN; obtaining the best performance at the network level, although some of the strategies negatively influence any of the defined objectives* "

The fully alignment of strategies is considered when all the strategies activated have positive influences in all the objectives defined by each enterprise of the CN. Nevertheless, the set of aligned strategies will not only be restricted to the strategies that exclusively have positive influences in all the objectives defined by each enterprise. If this was the case, it could happen that some of the objectives defined would not be achieved due to only few strategies (those that exert positive influences) would be activated. Thereby, the set of aligned strategies will include the strategies whose activation involves the attainment of all the defined objectives, maximising the positive influences and minimising the negative ones (in case some of the strategies negatively influence any of the defined objectives), so that the performance at network level is maximised. Accordingly, the best set of aligned strategies leads to maximise the network performance, even though some strategies have negative influences on some definite objective.

The ideal situation would be one in which the (Figure 3.1a):

- The objectives of one enterprise promote the achievement of the objectives defined by other companies
- The strategies defined by one network partner are aligned with the strategies of other networked partners
- The strategies defined by one network partner promote the achievement of the objectives defined in the same enterprise and the objectives defined in other enterprises.

Nevertheless, it must be considered that (i) individual enterprises take part in several networks and, it is very likely that some of these networks have contradictory objectives and consequently contradictory strategies, and (ii) the enterprises belonging to one specific CN are heterogeneous and contradictory objectives and strategies might arise. Therefore, for enterprises belonging to a CN, the defined objectives and the strategies formulated by one enterprise could favour, or not, the objectives defined by other enterprises (Figure 3.1b). In order to achieve the ideal situation, enterprises belonging to a CN should be able to identify those aligned strategies whose activation promotes the improvement of the objectives defined by the majority of the networked enterprises, or at least the activated strategies do not negatively influence on the objectives attainment (Andres and Poler, 2014).

a) b)

Figure 3.1. a) Ideal situation in strategies formulation and objectives accomplishment. b) Strategies whose activation do not favour all the objectives defined by the CN enterprises

Example 3.1. Lets consider two enterprises; each one defines one objective and formulates one strategy. Each objective has associated a KPI to measure its achievement.

- *enterprise1*: defines *objective1*, which has associated the *KPI1,* and formulates *strategy1*
- *enterprise2*: defines *objective2*, which has associated the *KPI2,* and formulates *strategy2*.

The strategies formulated, *strategy1* and *strtrategy2,* are considered to be fully aligned when (i) the activation of *strategy1* exerts a positive influence in both *objective1* and *objective2*. What means that the activation of *strategy1* exerts an increase on the KPIs defined to measure the objectives: $\Delta^{+}KPI1$ and $\Delta^{+}KPI2$; and (ii) simultaneously, the activation of *strategy2* exerts a positive influence in both *objective1* ($\Delta^{+}KPI1$) and *objective2* ($\Delta^{+}KPI2$). Accordingly, the strategies are aligned when the total benefit obtained is higher than the sum of the benefits obtained by the activation of each strategy individually.

The term *strategies alignment* must not be confused with the concept *strategies compatibility*. The strategies are compatible when there can be performed at the same time, but do not have positive influences with each other. Consequently, the total benefit corresponds to the sum of the benefit obtained by the activation of each strategy. Therefore, the compatibility between strategies does not ensure its alignment. The compatibility does not implies that the joint activation of a group of strategies generate higher benefits than the sum of the benefits obtained from the activation of each strategy in isolation; thus the strategies are compatible but not aligned. An example showing the difference between the two concepts, strategies alignment and strategies compatibility, is shown in Table 3.1.

Table 3.1. Strategies Alignment vs. Strategies Compatibility

		Increase of *KPI1*	**Increase of *KPI2***	**Total Performance Increase *KPI1*+ *KPI2***
	strategy1	10	-	10
	strategy2	-	9	9
Alignment	***strategy1***	10	(5)	
	strategy2	(3)	9	
		13	14	27
Compatible	***strategy1***	10	0	
	strategy2	0	9	
		10	9	19

In order to achieve higher levels of integration within the CN, the strategies alignment process becomes crucial in terms of establish common and compatible strategies and goals.

3.3 Background of topic under study: Strategies Alignment Process

The enterprises' participation in CN allows them to increase their competitive advantages. Nevertheless, the participation in CN itself does not ensure the enterprises to obtain the associated benefits (Lee, 2004) and achieve better positions than the competitors. Linked with this topic Lee (2004) goes further and claims that three are the key elements to achieve sustainable and competitive supply networks: agility, adaptability and alignment. Accordingly, with the appearance of the concept of supply chain and later the concept of CN, the term "alignment" has gained an increased importance.

It can be stated that, the strategies alignment process has its very first background in the *Games Theory* discipline (Von Neumann and Morgenstern, 1947), drawn from its research into the *MiniMax* Theorem. Games Theory for decision-making is applied in competitive situations, in which more than one decision maker intervenes, and each player look for its individual benefit. In game theory players are self-interested, there is no cooperation, and seek the way that each player loss at least as possible, by computing the equilibrium point. The equilibrium point is non-collaborative as both players always seek the maximum individual benefit. Later, and as a result of the contributions of the Optimal Control Theory, Games Theory branched off into differential games and into the study of cooperative games. In this case, the game resolution becomes more complex due to the players do not only have to decide about how to distribute the current benefits, but also have to decide how to distribute the external benefits derived from the cooperation. Afterwards, the *Nash equilibrium* was defined as a way to obtain an optimal strategy for games involving two or more players (Nash, 1950).

Nevertheless, the specific concept of alignment referring to enterprises' strategies has its origins in the work developed in the term *fit* (Venkatraman, 1989) and in the concept of *strategy coalignment* (Venkatraman and Prescott, 1990). In order to have a broad perspective as regards the *alignment* concept, some definitions are collected in Table 3.2.

Table 3.2. Definition of the *alignment* concept

Author	Definition of Alignment
Nadler and Tushman (1980)	Adjustment of one component in relation to another component so that the arrangement leads to an optimal consequence of the relationship between the components
Miles and Snow (1984)	The process of achieving fit, by aligning the company to its marketplace. The process of alignment defines the company's strategy
Venkatraman (1989)	Introduces the similarities with the fit concept and the perspectives of alignment: moderation, mediation, matching, gestalt, profile deviation, and covariation
Anand and Ward (2004)	Strategic fit as the alignment between the requirements of the business environment and the strategy applied by the organisation
Lee (2004)	Coordination of each member's interests with overall interests through a redefinition of relationships and agreements in such a way that risks, costs and rewards are shared fairly
Piplani and Fu (2005)	The common interest and goal-seeking in order to synchronise and coordinate processes, activities and decisions among the network partners
Urh et al. (2008)	Adjustment between the planned performance indicators and the real performance indicators in business process management context
Piedade et al. (2010)	A situation where inter-organisational enterprises in a business environment, are strictly combined under strategic decisions to achieve specific objectives and goals
Piedade et al. (2012)	Adjusted relationship between the performance achieved by participants and the strategic goals of the CN considering that each partner must contribute with self-operation efficiency in order to achieve inter-organisational alignment. The partner's capacity to achieve the expected performance in a collaboration strategy

As it has been stated, the concept of alignment is closely related with the concepts of agility and adaptability, that if achieved, leads the network to attain higher levels of performance and obtain enhanced competitive advantages (Lee, 2004). The positive association between the alignment and the increase on the network performance is derived from the improvement on the quality of relationships among the network partners. The increase of network performance is interpolated to the improvement of the enterprises performance (Green, Whitten, and Inman, 2012). Besides the effectiveness of alignment has associated the enhancement of supply network resilience and responsiveness (Khan, Christopher, and Creazza, 2012). However, due to the features that characterise the CN, such as wide variety of entities, diversity, heterogeneity, misalignments are prone to appear, creating inefficiencies in the network competitiveness leading to a reduction of its possibilities to survive (Piplani and Fu, 2005).

One of the reasons of misalignments could be the lack of collaboration mechanisms among CN partners when making their decisions. In order to avoid these misalignments the literature provides some contributions that allow decision makers to deal with this lack of coordination among the decisions made within the enterprises belonging to a CN. In order to have a better knowledge on how the strategies alignment process has been treated in the literature, a review has been carried out considering the models, guidelines and tools developed.

When carrying out this research the author realised that there is broad meaning of keywords referring to the alignment concept, i.e. values alignment (Macedo, Abreu, and Camarinha-Matos, 2010), participants' alignment (Piedade et al., 2010), strategic alliance (Cante et al., 2004), or collaborative strategy (Campos, Brazdil, and Mota, 2013).

Research on strategies alignment anecdotally leads to papers that address a different problem *Strategic Alignment* (Kaplan and Norton, 2006) and *Strategic Fit* (Anand and Ward, 2004). (Kaplan and Norton, 2006) define *strategic alignment* as the internal consistency of the activities that implement the different attributes of strategy. The research in strategic alignment is focused on aligning individual strategies of the enterprises with the strategy defined in the global supply chain (Fisher, 1997) (Lyons and Ma'aram, 2014). Therefore, the main troubles found in the topic under study were related to the keywords used to carry out the research. In the light of this, it must be clarified that the strategies alignment concept treated in this thesis must not be confused with the *strategic alignment* (Henderson and Venkatraman, 1999) in which strategic goals, business model and processes, and enterprise culture is aligned with the business purpose and core values.

Different works have been analysed, by considering in most of the cases the alignment of two particular strategies (Table 3.3), having their background in the concept of *strategic alignment*. Amongst them, most of the papers consider the alignment between business strategy and IT strategy in the same enterprise.

Table 3.3. Summary of works considering the alignment of specific strategies

Alignment of specific strategies	Authors
Business Strategy & IT Strategy	Cuenca, Boza, and Ortiz (2011)
Business Strategy & Information Assurance Efforts	Ezingeard, Mcfadzean, and Birchall (2007)
Business Strategy & e-Business	Raymond and Bergeron (2008)
Supply Strategies	Cousins (2005)
Global Sourcing Strategies	Ashayeri and Selen (2008)
Marketing Strategy & Sourcing Strategy	Green et al. (2012)
Supply Chain Configuration & Distribution Channels	Wu et al. (2008)
Product Design Strategies	Dell'Era and Verganti (2010)
Product & SC characteristics	Lyons and Ma'aram (2014)
Product & SC Processes	Stavrulaki and Davis (2010)
Green SCM & Business Strategy	Whitelock (2012)

In order to make an accurate research of the topic under study, strategies alignment (leaving aside the research on strategic alignment), next keywords were considered: collaborative decisions align, collective decisions align decisions and alignment in supply chain. In the light of this, research on strategies alignment is seen as the creation of decisions in a collaborative way, or, the alignment of decisions that have been previously defined and created by the network partners. In this last case, each collaborative partner, as an autonomous enterprise, define its own decisions, which are pooled, and amongst them the more "aligned decisions" are identified. The papers addressing the problem of carrying out decisions from a collaborative perspective, considering the different decision making levels (strategic, tactical and operational), look for achieving higher performance levels derived from the "alignment of the decisions" or at least generating minimum amount of losses.

Considering this, the initial round of search was based on a broad meaning of keywords and contexts (enterprise and network levels) to ensure that papers adopting an alternative nomenclature were identified. *Alignment of strategies*, *alignment of actions*, *alignment of decisions*, *collaborative decisions design*, *collective decisions* and *alignment in supply chain* where the keywords used. The result of looking for these terms was a set of relevant contributions in the topic under research, strategies alignment. The found works proposed models, guidelines and tools to deal with the alignment of decisions from different decision making levels and different perspectives of application (i) one in which the decisions are collaboratively made and from the beginning of the decision making the decisions are aligned, and (ii) another one in which the each partner define its own decisions and then these are pooled in order to identify those that are more aligned with the decisions of other network partners.

Considering the reviewed works, Table 3.4 is generated, in which the authors are listed and a brief description of the approaches proposed to deal with the collaborative decision-making is given. After that, the Table 3.4 focuses on identifying if the proposed approaches are designed considering that (i) the decisions are collaboratively made or, unlike, (ii) the decisions are previously and separately made by each CN partner and after that the decisions are aligned. Finally, the collaborative process in which the approaches proposed are applied is identified. The decision-making level, (strategic “S”, Tactical “T” or Operational “O”) to which the collaborative process tackled correspond, and the type of the proposed solution (model “M”, guideline “G” or tool “T”) are also presented.

Some works have been proposed in the literature applying the alignment concept in order to improve the collaborative relationships. Worth to mention are Braun and Hoolick (2008) that study the alignment in the tourism sector requirements, and links it with the establishment of best practice examples aimed at achieving sustainable networks.
Enterprises involved in virtual organizations face the barrier of the lack of success in achieving the intended goals. Martins and da Silva (2008) recognise that the most critical problems occur during project activities, and strongly believe that both, the development of collaborative process and project alignment can be the best practice to get better project results and improve organizations’ development processes. The authors propose a methodology that allows the definition, evaluation and improvement of an organisation software development process, called a Process and Project Alignment Methodology (ProPAM) that allows for a general vision on the current state of an organization development process, as well project alignment with the development process.
Figueiredo (2008) reviews the actor-network theory (ANT), usually intended as a conceptual tool to study socio-technical systems. ANT supports the alignment of interests of heterogeneous networks, by the negotiation of actors, in order to achieve common objectives. The author treats the concept of alignment as the assumption of all the roles to work in the same direction of goals, actions, and strategies.
The Balanced Scorecard approach is analysed by Kettunen (2008) as a powerful tool to accomplish targets, through studying cause-and-effect relationships and different perspectives for achieving the performance from the whole network rather than concentrating on just improving performance in isolated enterprises’ measures. In the light of this, the strategies of all such units should be aligned and linked with one another to obtain the maximum effectiveness.
Finally, Jackson and Klobas (2008) proposes the virtual alignment model (VAM) for envisioning virtualisation, which permits the evaluation of the alignment of the organization’s goals, state and capabilities for virtualization. Two definitions are proposed: (i) virtualization alignment: Alignment between a firm’s strategy for virtuality current level of virutality and capability to operate virtually, and (ii) Virtual Alignment Model (VAM): A model of the elements of alignment accompanied by the likely effects of alignment or misalignment between a firm’s strategy for virtuality, current level of virtuality, and capability to operate virtually at different levels
An application as regards alignment and performance is carried out in Kern et al. (2005) that use feedback information on the objectives achieved and those not met, allowing enterprises to assess the efficiency of their own performances and determine the need for any adjustment to the strategies formulated in an enterprise.

Other works have been analised, highlighting the importance of alignment in collaborative networks, this analysis has been extracted in most, from the book "Encyclopedia of Networked and Virtual Organizations":

A survey conducted by Geary and Zonnenberg (2000) suggests that the best-in-class performers align their supply chain strategy with their overall business objectives and customer requirements.

Strategic fit is a process of aligning an enterprise with its business environment, arranging strategies, objectives and resources internally to support that alignment. Miles and Snow (1984) highlight the improvement of performance achieved by companies when align their strategies with the business environment, improving also their flexibility. Moreover, Kidd (2008) talks about the principle of dynamic alignment within enterprises, as the essence of achieve agility in dynamic, uncertain and unpredictable business environments. Concluding, enterprises must constantly adapt to the business environment by seeking to continually reconfigure their strategies, technology, organization, and people, being all of them aligned with the business environment.

Pithon and Putnik (2008) study the importance of the strategies alignment within the concurrent engineering process objectives.

Eraslan et al. (2008) matches the concept of strategies and activities alignment with the concept of smart organizations. Defining smart organizations as companies that have strong principles, respects the environmental and safety concerns of the public and has a focused activity by aligning the activities of its constituents.

Garrido and Lemahieu (2008) address in their work the concept of collective intelligence. The authors state that a network topology, based on a hierarchical structure, is a source of trouble and a factor of diminishing overall intelligence of the network. The reason of this is because individual entities led to exploit their position in the hierarchy for private ends, increasing the misalignments interests of the collective network. This leads to power games and fights for maintaining one's own position in the hierarchy and consequently the network operation failure, in the long term.

Camarinha-Matos and Afsarmanesh (2008) describe the concept of collaboration, in the context of enterprise networks, as the process in which entities share information, resources, and responsibilities to jointly plan, implement, and evaluate a program of activities to achieve a common goal. In addition, collaboration involves aligning activities so that the enterprises achieve more efficient results. In collaboration, enterprise entities are closely aligned for "working together" to reach the desired outcome and objectives.

Rodrigues and Dorrego (2008) highlight the importance of aligning the core competences of the enterprises, based on knowledge assets and intellectual capital, with the key success factors of the market; giving them competitive advantages, better performance and better market position.

Rittgen (2008) defines the concept of process integration emphasizing that the alignment improves collaboration through the adaptation of internal processes of the different networked entities.

Cunha and Putnik (2008) deal with the virtual enterprises (VE) integration concept. The authors stress the importance of the alignment between the market requirements and the independent enterprises, for the proper operation of the VE; where each participant contributes with her best practices and core competencies to the success and competitiveness of the structure as a whole. As stated in Carlsson (2002) a new VE paradigm claims for new effective methods for intelligent support to virtual teams and for supporting the process of alignment between the enterprises and the market changing environment, being this alignment crucial.

Gall and Burn (2008) infers that the alignment of strategies and values across organizational boundaries is a key factor for the enterprises readiness for virtual collaboration.

Lasnik (2008) analyses the basic constructs of fostering collaborative network creativity, based on the work of Robinson and Stern (1997), and highlights that the alignment and its importance in the organization performance. As defined by Robinson and Stern (1997) the alignment principle in collaborative networks refers to the degree to which the interests and actions of every network enterprise mutually supports key goals of both the network and other enterprises taking part. The organization cannot be consistently creative unless it is strongly aligned. Moreover, the most critical step in aligning an organization is recognizing the value of alignment and that it has to be done.

The selection and activation of aligned strategies can be performed from a (i) short term perspective, e.g. a virtual organization that is dissolved once a specific market opportunity is achieved, or (ii) long-term perspective, similar to a strategic alliance in which a long-term alignment of the collaborative partners must be achieved. In this long-term view, *Allied Business Processes* are defined as processes of enterprises that have agreed on a strategic alliance (Werth, 2008). They are characterized by an alignment of the processes in order to foster its shared objectives and to avoid any impeding.

Table 3.4. Contributions dealing with the research issue: decisions alignment

Author	**Proposal**	**Create decisions Collaboratively**	**Created decisions separately and align them**	**Application**	**Decision Level**			**Solution Type**		
					S	**T**	**O**	**M**	**G**	**T**
Lau et al. (2003)	A fuzzy multi-criteria decision support (FMCDS) procedure to improve information delivery. Fuzzy principle is considered allowing decision-makers generate suitable decisions under uncertainty	Extended enterprise. Hierarchical multi-criteria decision-making	-	Selection of information receiver	✓			✓		
Dudek and Stadtler (2005)	A non-hierarchical, negotiation-based scheme is proposed to synchronise plans between two independent supply chain partners linked by material flows. Mathematical programming models are used to asses material orders and generate counter-proposals. An iterative negotiation process allows to suggest order/supply patterns	-	Non-hierarchical negotiation based scheme for decentralised partners. Each partner proposes its plans that are modified in iterative negotiation process	Collaborative Planning		✓	✓	✓		
Piplani and Fu (2005)	Coordination framework, called Alignment of Supply Chain Executions and Decisions (ASCEND) that consist of multi-agent technology, coordination theory, and optimisation technology. A decentralised constraint satisfaction optimisation problem (DCSOP), solved through using a genetic algorithm-based coordination process, is proposed. The main principle is establishing a proper incentive alignment mechanism considering the associated dependencies	Solving the DCSOP entails determining the optimal inventory control parameters for each node simultaneously	-	Inventory management			✓	✓	✓	
Martinez and Bititci (2006)	Value Chain Tool Kit is presented as a tool for the analysis of value creation in supply networks. The network members, skills and capacities and value propositions are identified. The value propositions are assigned to one of 6 proposals of the value matrix (innovation, brand management, price minimisation, simplification, technological integration and socialisation). An analysis of alignment and determination of mismatches of value propositions of the partners is performed		Each enterprise holds its own values. A framework to analyse the (mis)alignment among the values is proposed	Partners' Values	✓		✓		✓	
Derrouichea, Neuberta, and Bourasa (2008)	Collaborative strategies to establish specific collaborations are proposed, such as quick response (QR), efficient consumer response (ECR), vendor managed inventory (VMI) or collaborative planning, forecasting and replenishment (CPFR)	The decision of establishing a collaborative strategy is collaboratively performed	-	Inventory management			✓		✓	
Selim, Araz, and Ozkarahan (2008)	A multi-objective linear programming model is developed to deal with the collaborative production–distribution planning problem in a SC. Fuzzy Goal Programming (FGP) allows decision makers' incorporate random information as regards aspiration levels for the goals.	Integrative decision making in SC production distribution planning. Planning in Centralised SC	Planning in Decentralised SC. Multi-objective decision making problems	Production–distribution planning		✓		✓		
Zha et al. (2008)	Multi-criteria utility analysis method is proposed to allow evaluating a set of alternatives, given a set of criteria. An hybrid decision support model within a multi-agent framework integrates the compromise decision support	Making collaborative design decisions	-	Product design	✓			✓	✓	

Author	Proposal	Create decisions Collaboratively	Created decisions separately and align them	Application	Decision Level			Solution Type		
					S	T	O	M	G	T
	problem technique (cDSP) and the fuzzy synthetic decision model (FSD) to consider multiple criteria									
Alemany et al. (2011)	An application to support the integrated modelling of the collaborative planning decision-making considering different decisional centres that make decisions according to mathematical programming models		SC decentralised decision making, different decisional units are coordinated to achieve a certain level of SC performance	Collaborative Planning	✓	✓	✓	✓	✓	✓
Kristianto et al. (2012)	Decision Support System based on an optimisation model that combines decisions at strategic and tactical level. To validate the decisions a system dynamic based computer simulation model is used, in which performance indicators are compared (WIP adjustment, order rate, production rate, inventory adjustment, backorders)	An optimum supply chain network is configured by combining optimisation at the strategic and tactical level	-	Supply network configuration	✓	✓		✓		✓
Lin et al. (2012)	Global Decision Support System Model (GDSSM) proposed to allow an enterprise analysing a decision under consideration and identify how it favours other enterprises performance. The decisions are collected and analysed using the IMGP (Interactive Meta-Goal Programming) approach, allowing decision-makers to interact during the resolution process and obtain acceptable set of decisions to all the decision-makers. IMGP offers a multi-level structure that allows modelling different network enterprises	-	A set of decision are previously identified and with IMGP a solution, acceptable to all the decision-makers, is reached	Decision Making	✓	✓	✓	✓	✓	✓
Seok, Nof, and Filip (2012)	Decision Support System (DSS) is used to optimise solutions related with sustainability, applying Collaborative Control Theory (CCT) principles to extend DSS by a new Sustainability – Decision Support Protocol (S-DSP). Collaborative solutions are achieved to maximise the sustainability of supply networks. S-DSP consists of Disruption Analysis (DA), Negotiation Management (NM), and Knowledge Management (KM). Collaborative Control Theory (CCT) principles are applied.	One global objective is maximised: the sustainability of supply network	-	Sustainability in production planning Sustainability in scheduling		✓	✓	✓		
Shafiei, Sundaram, and Piramuthu (2012)	Multi-enterprise collaborative decision support system (MECDSS) framework and architecture assists decision makers within and across organisational boundaries to generate more accurate, effective and timely decisions. MECDSS communicates and operates integrating the diverse systems of the network partners, containing all the required data. MECDSS allows to each decision maker to explore what-if scenarios identifying the best set of decisions not only for its enterprise but also for its customers, suppliers considering the results	-	Each enterprise proposes its own decisions and dispose of all the data as regards the decision-making components of its partners. Enterprises identify how its decisions affect itself and its partners	Partners' Selection	✓			✓	✓	✓
Tan, Lee, and Goh (2012)	A multi-criteria decision making (MCDM) technique, Deviation Measure, is proposed to support decision making in B2B collaboration. MCDM uses the evaluation metrics proposed in the Quality of Solution	Collaboration criteria of different units of measure and specified preferred		Supplier Selection	✓			✓		

Author	Proposal	Create decisions Collaboratively	Created decisions separately and align them	Application	Decision Level			Solution Type		
					S	T	O	M	G	T
		values are used to reach a decision								
Verdecho, Alfaro, and Rodriguez (2012)	Analytic Network Process (ANP) models the prioritisations of collaborative partners' elements so that decision makers focus on the most important elements that influence their competitiveness identifying their contribution to achieve the strategy of the enterprises. An overall performance evaluation is done, to analyse if the key elements are contributing the increase of CN performance	-	Determines how the decisions defined by the CN enterprises influence on the strategies achievement of the network	Performance Management	✓		✓		✓	
Lu et al. (2013)	Fuzzy analytic hierarchy process (FAHP) for collaborative analysis. The weightings and rankings provide decision-makers a reference for the relative importance of the dimensions and processes to make decisions	Collaborative decision	-	Designing a Supply network	✓			✓	✓	
Macedo and Camarinha-Matos (2013)	Cognitive analysis approach based on fuzzy causal maps and qualitative assessment methods designed asses the values alignment. Qualitative causal reasoning to infer qualitative indicators about Core Value Systems alignment in a collaborative context is applied	-	Each collaborative partner holds its own values identifying through a qualitative approach those that are aligned	Partners' Values	✓			✓	✓	✓
Singh and Benyoucef (2013)	Fuzzy TOPSIS (Technique for order preference by similarity to ideal solution) and soft consensus based group decision-making methodology solve the multi-criteria decision making (MCDM) problems. Correlation coefficient and standard deviation (CCSD) based objective weight determination method is used for enumeration of the weights of the criterion for fuzzy TOPSIS	Partners make collective decisions to solve a number of problems, which are characterised by various quantitative and qualitative criteria.	-	Planning	✓			✓	✓	
Zhang et al. (2013)	Technique for order preference by similarity to ideal solution (TOPSIS) combined with a multi-criteria genetic optimisation feature. Modified multi-criteria genetic optimisation feature (MCOGA) is proposed based TOPSIS. Multi-criterion optimisation methodology merging GA and AHP	Central coordination system	-	Order distribution process			✓	✓		
Dao, Abhary, and Marian (2014)	Optimisation model to integrate the decision of partners' selection and collaborative transportation scheduling. A novel Genetic Algorithm (GA) is proposed to find an optimal solution to the integrated problem, in which a number of interlinked sub-problems are to be solved at the same time	Optimal solution proposed to an integrated problem		Partners' selection Transport scheduling	✓		✓	✓		
Guillaume et al. (2014)	A sequential decision problem under uncertainty is modelled. An approach based on subjective probabilities is proposed to evaluate (i) the probability that a decision of one partner is optimal for itself and (ii) the probability that a decision for the first partner is optimal for another network partner.	-	One enterprise takes into account how the decision made influences another network enterprise	Purchasing processes		✓		✓	✓	

3.4 Discussion of the reviewed works

One of the main troubles found when carrying out the research of strategies alignment is that this particular nomenclature itself is not found in the literature. Therefore, the author had to look for approaches addressing the same concept of strategies alignment hidden in other terms. To carry out the research other terms were used, having the same meaning as the strategies alignment concept here studied, such as collaborative decisions design, collective decisions, alignment of decisions. The term decision has been considered to represent the concept of strategy. Having considered this, this section goes further to discuss the findings obtained from the reviewed research.

First of all it, it must be highlighted that each of the reviewed works deal with different type of decisions, such as scheduling, inventory, purchasing, distribution processes, planning, performance management partners' value, partners' selection, product design and network design.

According to the state of the art carried out, it must be stated that the decisions related to partners' alignment has been broadly applied (Lau et al., 2003)(Shafiei et al., 2012)(Tan et al., 2012)(Dao et al., 2014). In order to deal with the partners' selection process some works lead the enterprises to look for those partners whose skills, capabilities, value proposals and decisions are aligned with the requirements that the main enterprise is looking for Piedade et al. (2010). Verdecho et al. (2012) determined that the problem of aligning strategies among network partners must be resolved from the beginning of the formation of the network when suppliers are selected, considering a primary aspect the selection of suppliers that are already aligned with the CN strategy.

The alignment of decisions, either by creating decisions collaboratively or initially creating the decisions separately and then choosing the aligned ones to carry them out, is resolved. In some papers, the action of align the decisions is made considering only two partners of the network (Dudek and Stadtler, 2005), or aligning decisions from a hierarchical point of view, in which the dominant partner of the network defines its own decisions and the other partners have to align their decisions according to the ones defined by the dominant partner (Seok et al., 2012).

A set of models, guidelines and tools are proposed in the literature with the main aim of aligning decisions among the enterprises of the network. Some of them can be highlighted: classified as models it can be found the multi-criteria methods such as FMCDS or MCDM, fuzzy approaches like FGP to deal with uncertain information. As regards the guidelines, collaborative strategies or negotiation-based schemes such as S-DSP are found. Considering the methods, MCDA, fuzzy logic, GA, ANP, ANN, FAHP, causal maps can be emphasised. Concerning tools MECDSS is found.

Despite of the importance of aligning strategies, in terms of avoiding partnership conflicts, to the best of our knowledge, there are some gaps in the literature as regards contributions providing a holistic approach that allows considering all the strategies formulated by all the partners in the CN context. The performed review has allowed identifying possible trends and gaps in the topic under study. According to this, a list of gaps (G) and trends (T) is proposed, and a set of actions (A) are determined to be addressed along the research work, all of them listed in Table 3.5.

Focusing on the strategies alignment process, an integrated approach consisting of a model, method, tool and guideline should be proposed from a decentralised perspective in order to equally consider the objectives and strategies of individual enterprises of the CN. An interesting approach is the one presented by (Guillaume et al., 2014) that considers the extent into which the decisions made by one enterprise positively influence in the same enterprise, and simultaneously considers how these decisions affect other network partners.

Table 3.5. Gaps and Trends: Clues of the work to be developed on strategies alignment

Gaps	Trends	Clues of the work to be developed
G1. A lack of a definition approach for the strategies alignment concept	*T1*. Collaborative and decentralised decision making T2. Strategies alignment process	*A1*. The introduction of the term "strategies alignment" to deal with the alignment of strategies that are defined in the enterprises of the same network. Propose a common conceptualisation of the strategies alignment process and spread the term and the definition of strategies alignment process
G2. Consideration of only two partners of the network. *G3*. Consideration of one dominant partner and the alignment of strategies of all the network partners according to those defined by the dominant node	*T3*. Collaborative NHN context *T4*. Complex problems modelling real networks *T5*. The possibility that one node can belong to one or more networks	*A2*. Address the strategies alignment process considering all the partners participating in the network Consideration of a decentralised perspective and non-hierarchical network contexts to deal with the strategies alignment process
G4. Alignment of pairs of strategies *G5*. Consideration of specific strategies	*T6*. CN context consisting of different independent and autonomous entities each one defining different strategies	*A3*. Considering all the strategies formulated by all the enterprises of the CN when dealing with the strategies alignment process. Identification of the aligned strategies from an holistic perspective regardless of their nature and type, taking into account the CN context
G6. Alignment of strategies of the same enterprise *G7*. Alignment between the global strategy of the network and them global strategy defined at the enterprise level	*T7*. Alignment between the global strategy formulated at network level and the set of strategies formulated by each individual enterprise of the network *T8*. Alignment among the strategies defined by all the network enterprises *T9*. Consideration of the influences derived from the activation of the strategies in the same enterprise and in the different enterprises of the network	*A4*. Modelling the strategies alignment process considering the (i) intra-enterprise strategies alignment (alignment of the strategies defined in the same enterprise), and (ii) inter-enterprise strategies alignment (alignment among the strategies defined by different enterprises of the network) The consideration of different types of alignment: (i) alignment between the a global strategy formulated at network level and the set of strategies formulated by each individual enterprise of the network, (ii) alignment among the strategies defined by all the network enterprises.
	T10. Measurement of KPIs to deal with the alignment process	*A5*. The measurement of KPIs is to be considered. In the light of this, the strategies influence, when activated, will be measured considering the increase and decrease of the KPIs defined in each enterprise. The estimation of the strategies influence will be performed at intra and inter-enterprise levels
	T11. Assessment of the alignment	*A6*. Assessing the strategies alignment process. Analysing the alignments and misalignments of all the strategies formulated by all the enterprises of the network. This analysis will reveal gaps in the process of strategies alignment and possible problems in the strategies activation. The assessment performed will allow minimising the impacts derived from the strategies misalignments. A key issue is to asses the level to which the alignment is achieved
G8. A lack of a global approach to deal with the strategies alignment in a CN context	*T12*. The consideration of models, methods, tools and guidelines in an integrated approach to deal with the alignment	*A7*. Proposal of a framework consisting of a model method, tools and guidelines to address the strategies alignment process from an holistic perspective by equally considering all the network partners

Legend: *Gx*: gap number *x*, *Tx*: trend number *x*, *Ax*: action number *x*

In order to address the found gaps in the contributions provided so far to deal with the strategies alignment, the main aim of our research is to propose an integrated approach to identify the aligned strategies from a holistic perspective, regardless of their nature and type, taking into account the CN context.

3.4.1 Research Questions

In the previous sections (3.3 and 3.4) an overview on how the strategies alignment process has been treated so far is proposed. Thus, a set of gaps, trends and actions are identified. The way in witch each research question, formulated in Chapter 1, deals with the actions (Ax) defined in Table 3.5 is described next in Table 3.6.

Table 3.6. Analogy between the research question formulated (RQx) and the proposed actions (Ax)

Proposed Actions	Research questions	Brief description	Thesis Chapter
A1	*GenQ* *RQ1* *RQ2*	Definition of the strategies alignment concept	Chapter 5
A2	*GenQ* *RQ1* *RQ2* *RQ3* *RQ4* *RQ5*	Consideration of all the partners of the network in the strategies alignment	Chapters 5, 6, 7, 8
A3	*GenQ* *RQ1* *RQ2* *RQ3* *RQ4* *RQ5*	Consideration of all type of strategies Holistic approach	Chapters 5, 6, 7, 8
A4	*RQ2* *RQ3*	Consideration of intra and inter-enterprise influences between the strategies and objectives	Chapters 5, 6
A5	*RQ2* *RQ3*	Consideration of the KPIs increase or decrease to measure the influences that the strategies activation has on the objectives of each network enterprise	Chapters 5, 6
A6	*RQ4* *RQ5*	Assessment of the strategies alignment Analysing if the impact is positive or negative and into which extent.	Chapter 7, 8
A7	GenQ	Holistic and integrated approach consisting of a model, guideline tools methods to address the strategies alignment process	Chapters 5, 6, 7, 8

Responding the formulated research questions will allow providing an original contribution to address and support collaborative enterprises on the strategies alignment process, from the CN perspective. The gaps found from the literature review performed will be filled and the trends identified will be considered.

In the light of this, this dissertation research proposes a mathematical model (Chapter 5), solved through System Dynamics method (SD) (Chapter 6), to support decision makers on identifying amongst all the formulated strategies those that have better levels of alignment, in CN environments. The tools used to deal with the problem will be proposed (Chapter 7). Finally, a guideline to support enterprises on how to implement the model, method and the tool will be presented (Chapter 8).

3.5 Conclusions

In Chapter 3 it has been presented a first conceptual definition of the strategies alignment concept; *Example 3.1* is proposed to clarify this concept. Afterwards, the contributions and approaches so far developed in the literature related to this concept have been discussed. The term strategies alignment is addressed in the literature in many ways, dealing with the problems of collaborative decisions design, collective decisions or alignment of decisions. A set of works have been identified treating this issue, and a table (Table 3.4) analysing the contributions is provided identifying some of the approaches used in the literature to deal with the decision-making process. These contributions have been analysed and some trends are identified as regards (i) treating the concept of strategies alignment process in the context of a CN (ii) dealing with the strategies alignment at both intra-enterprise and inter-enterprise levels, (iii) considering decentralised views of application instead of centralised ones in which certain enterprises dominate, and therefore less dominant enterprises are forced to align their strategies, acceding to the interests of the dominant ones, (iv) considering a whole perspective of the CN in terms of dealing with the strategies alignment from an holistic point of view and (v) proposing an integrated framework consisting of a model, method, tool and guidelines to support the strategies alignment process

Considering the reviewed works and to the best of our knowledge, most of the approaches provided in the literature, in terms of dealing with the strategies alignment process, are not completely adequate to deal with this process from the CN perspective. Despite of the importance of aligning strategies, in terms of avoiding partnership conflicts a gap has been found in the literature as regards contributions providing a holistic approach that allows considering all the strategies formulated by all the partners. A holistic and integrated approach will be presented further in this thesis, consisting of a model, method, tool and guidelines, to deal with the strategies alignment process. This integrated approach will allow modelling the influences that all the strategies formulated, by all the enterprises of a network, have on the objectives defined by these enterprises, all this considering the CN context.

The Part III of this document deals with the research questions, formulated in Chapter 1, and puts into practice the identified trends through proposing a model (Chapter 5), method (Chapter 6), tools (Chapter 7) and guidelines (Chapter 8) to deal with and support the strategies alignment process from a collaborative and decentralised perspective that characterises the CN.

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Chapter 4

A review of Approaches and Tools for Supply Networks Simulation

This chapter encompasses the approaches and tools associated with supply network simulation. Supply networks are characterised by being complex systems; thus, this chapter highlights the need of considering simulation approaches to support the resolution of supply networks models. Simulation approaches are seen as a supporting tool to analyse the formal model of a supply network. Three relevant simulation approaches are identified in the context of supply networks: Discrete Events Simulation (DES), System Dynamics (SD) and Agent Base Simulation (ABS). Along the chapter each simulation approach is briefly described. Moreover, the simulation paradigms are compared with each other according to a group of relevant features, with the main aim of aiding the modellers in the task of selecting the most appropriate simulation approach, to address the modelling process in the context of supply networks. A group of commercial and academic tools are listed for each simulation approach. Finally, some conclusions are given based on the information gathered.

4.1 Introduction

As described in (Beamon 1998), a supply network can be defined as an inclusive process, where a number of entities, such as suppliers, manufacturers, distributors and retailers, work together to (i) acquire raw materials, (ii) transform raw materials into finished products, and (iii) provide these end products to customers. Supply networks are characterised by being complex systems, derived from its management. In a supply network, one can encounter that the objectives defined and the strategies formulated could be raised in a contradictory way among the network partners (Andres and Poler 2015). These contradictions make difficult to develop a unified scenario that captures the different objectives and strategies of the network partners. The complexity increases when addressing collaboration within the supply network, that is, when dealing with CN. This complexity spreads in the modelling process of the supply network. Hence, the development of models to represent and solve these complex systems, which characterise the supply networks, is a very challenging task. It is at this point where the simulation approaches come into play.

This chapter aims to identify some simulation approaches that support the representation and resolution of the supply network models. In this dissertation, supply networks are characterised by implementing collaborative relationships, that is, CN. In the light of this, Section 4.1 goes on with the characterisation of supply networks as complex systems (subsection 4.1.2). Concluding that the complexity associated with supply networks makes the process of modelling an arduous task. Then, the subsection 4.1.3 highlights the importance of relying on simulation approaches and tools, as formal modelling analysis tools, to deal with the modelling and resolution of complex systems, such as the CN. Afterwards, three simulation approaches are described in Section 4.2, highlighting the importance on its application in supply networks. These approaches correspond to Discrete Event Simulation (DES), System Dynamics (SD) and Agent Based Simulation (ABS). The three approaches are compared in Section 4.3 and a set of tools is listed for each one in Section 4.4. Finally, the conclusions derived from the chapter development are given in Section 4.5.

4.1.1 Supply Networks as complex systems

The study of complex systems has its origin in the study of *Systems Theory*. The number of applications of systems theory to organizations is very wide, and a high variety of system models have been developed. The first models were proposed by (Barnard 1938), and were based on the notion of "balance". These models evolved towards the *Sociological Systems Theory*, defined by (Selznick 1948), which introduced the analogy between the organisms and organizations. Subsequently, the *General Systems Theory* was presented, whose roots were found in the biology study area (Bertalanffy 1950), which considered that the organisms are complex systems with rigorous operation of open systems. (Bertalanffy 1968) as a biologist defined the systems as a set of interactive elements, and considered as a complex systems (i.e. multicellular organisms, ant colonies, ecosystems, economies, societies, enterprises, supply networks...) those characterized by having a structure composed of several levels. Afterwards, the *Contingency Theory* (Kast and Rosenzweig 1981) and the *Theory of Socio-technical Systems* (Trist and Bamforth 1951) appeared. The *Contingency Theory* studies the organizations as sets of interdependent subsystems, each one carrying out its own functions to perform within the context of the organization. Due to the importance of the survival of any organization, each subsystem must be viable and effective and must be consistent with each other and with the environment in to which it is embedded.

Complex systems are characterised by (i) its decentralized nature, in which the system behaviour arises from the self-organization of its components without this being controlled or directed by any extrinsic entity to the system, (ii) the presence of loops of causality and nonlinear feedback, and (iii) the fact that it contains several self-contained units that can interact, evolve and adapt their behaviour to changes in the environment (Vicsek 2002).

Collaborative networks consist of a wide range of decentralised and heterogeneous entities each one carrying out different process and activities to provide goods or services to final customers. In CN, each organisation defines its own objectives and formulates its own strategies. This heterogeneity makes CN to be complex systems, involving that in most cases is very difficult to adequately model them to be mathematically solvable (Izquierdo et al. 2008). Consequently, CN (as complex systems) require the use of ad-hoc methodologies, models and techniques, applications and tools to tackle problems and succeed in identifying proper and optimal solutions (Castilla and Longo 2010) (Longo 2011).

4.1.2 Supply network model

The literature provides a broad number of definitions for the term "model". One of the first definitions was given by (Ackoff and Sasieni 1968) considering that "*a model is a representation of reality*". This is a commonly accepted definition due to its simplicity; nevertheless, the definition of "model" requires a broader view. In the definition it should be implicit that the model is done with a specific purpose, by not only considering its construction, but also considering its use. The latest is a crucial aspect because a model is always a simplification of the reality, and as such, the definition of the model must take into account the final use of it and its users; considering the complexity of the reality. According to this, the model definition is amended by (Pidd 1996) as follows:

> *"a model is an external and explicit representation of a part of the reality seen by people who want to use it in order to understand, change, manage and control that part of reality."*

Models can be classified according to the resolution process in normative or descriptive (Shapiro 2006). Normative models correspond to optimisation or heuristic mathematical models. While descriptive models encompass modelling techniques that do not define mathematical structures. Among descriptive models simulation models can be cited. The increase on the computing power of computers allows its use in the modelling processes. The use of simulation tools does not reduce the efforts required by the analytical tools; nevertheless, it solves problems that analytical tools are not able to address (Gross et al. 2008). The design of simulation models is comparable to the analytical experiments; therefore, when building simulation models modellers must deal with the same problems that must be faced in conventional experiments, such as the experimental design.

In the collaborative context, a supply network model allows representing the network enterprises and the relationships established among them, as well as the information, decision and materials flows. A global model of a supply network will serve to understand, represent, analyse, discus, design, simulate, integrate, evaluate, control, communicate and capture the knowledge referred to the enterprises belonging to the network. The main objective of developing a model, in the context of supply networks, is to generate different alternatives by changing the parameters, knowing their effects or consequences. Simulation experiments allow changing these parameters, defined in the model, giving ideas on how to improve the supply network system. Besides, a supply network model must be able to be flexible enough to represent the rapid changes (technological, economic or geopolitical) experienced by enterprises that belong to the network. The task of modelling plays an important role in supply networks due to many situations and problems require the use of models, such as planning, optimization, simulation, performance evaluations, or decision making (Poler, 1998).

4.1.3 Simulation as formal model analysis tool

Shanno (1998) describes simulation as the process of modelling a real system in order to carryout experiments with the main aim of understanding the system's behaviour, and explore different strategies for the operation of the system and test different hypothesis as regards its behaviour. The simulation of formal mathematical models allows identifying the best scenarios that lead to performance improvements.

Computers' emergence has facilitated the resolution and analysis of formal mathematical models of complex systems. Computational models can be expressed in mathematical language as a set of equations and are solved through simulation. Computer simulations are carried out from applying algorithmic rules that define the initial conditions of a parameterised model. Computer simulations are characterised by having inference engines performing algorithmic processes with speeds unattainable by the human mind. In short, a computational model is a formal model expressed in mathematical language as a set of equations, and computer simulation is a tool that allows studying beyond the current limits of mathematics (Izquierdo et al. 2008). Computer simulation approaches for studying supply networks have to be (Longo 2011):

- Flexible and parametric for creating and investigating different supply network scenarios;
- Efficient in terms of time required for simulation runs, even when modelling complex supply networks (i.e. high number of supply network stages, high numbers of items, etc.);
- Repetitive in its architecture for easily changing the supply network configuration.

Considering these characteristics, simulation-based models will allow modellers understanding the behaviour, causes and effects of the modelled systems. Besides, simulation-based models will allow introducing temporal aspects relative to the activation of processes, the evaluation of possible delays or the definition of durations of the simulated processes. The purpose of the simulation is to test the model and observe its behaviour when external or internal factors of the modelled system change and identify the consequences associated to these changes. The results and conclusions obtained from the simulation-based models will be extended to a real system.

Despite the advantages of using simulation tools, their use requires that the modeller has specialised skills in the simulation tool and the complete knowledge of the system to be modelled. Besides, gathering appropriate data consist of a laborious task that must be properly performed when using simulation tools if good results are to be obtained. Another drawback characterising simulation tools is that they do not yield optimal solutions, instead simulation tools can be used to analyse the modelled system under a predefined conditions (Shannon, 1998).

In the process of model-simulation twelve steps are defined (Shannon, 1998), which will be applied to the collaborative process modelled in this thesis:

1. Problem Definition. Define the goals of the system to study
2. Project Planning. Determine the specialised modellers, and identify the appropriate computer hardware and software
3. System Definition. Define the constraints that characterise the system to be modelled.
4. Conceptual Model Formulation. Develop a preliminary model using a pseudo-code to define the system elements and relations
5. Preliminary Experimental Design. Select the performance measures
6. Input Data. Identify and collect the model input data
7. Model Translation. Formulate the model in the simulation language
8. Verification and Validation. Confirm that the model operates the way the analyst intended
9. Final Experimental Design. Design an experiment to obtain desired results
10. Experimentation. Consider a real case of the modelled system
11. Analysis and Interpretation. Analyse the results obtained from the scenarios simulation is analysed
12. Implementation and Documentation. Report the obtained results

4.2. Supply Network Simulation Approaches

Concerning the *supply network* application area, simulation deals with (i) managing the complexity associated (as supply networks are considered complex systems), (ii) supporting the decision making process, and (iii) assessing the key factors (relevant performance measures) for the supply network, such as profits, customers' service or competitiveness. The construction of "WHAT-IF" scenarios, in supply network simulation approaches, will allow decision makers to obtain optimised solutions with less costs and time. Some examples can be found in terms of developing strategic plans based on market trends, company goals and competitors' strategies; creating adaptive operational management strategies that respond to internal and external dynamics such as demand fluctuations, change of suppliers, competitors' activities; or generating holistic plans considering strategic planning, marketing, and HR issues.

According to (Shannon, 1975) the construction of simulation-based models for supply networks are useful when:

- The supply network model to be simulated cannot be formulated in a mathematical notation.
- The supply network model can be mathematically formulated but there is no resolution method to solve the model.
- The supply network model can be expressed in a mathematical notation and there exist methods for its resolution, but these are costly, tedious and time consuming.
- The objective is to build experiments for comparing different scenarios of the supply network, and these experiments cannot be carried out in a real supply network.

Considering the literature reviewed, three are the main simulation approaches identified for its application in supply networks (Figure 4.1): Discrete Event Simulation (DES), System Dynamics (SD), and Agent Based Simulation (ABS). SD allows to model continuous process while DE and ABS are more used to model in discrete time. The level of abstraction is the other feature that differs from one simulation approach to another. Whereas SD allows representing models with higher levels of abstraction and causal dependencies, ABS and DES considers higher levels of detail in the representation of individual entities/agents (Tako and Robinson, 2012). Figure 4.1 provides a graphical comparison of the three simulation approaches, which are analysed in this chapter with the main aim of dealing with supply network simulation-based models.

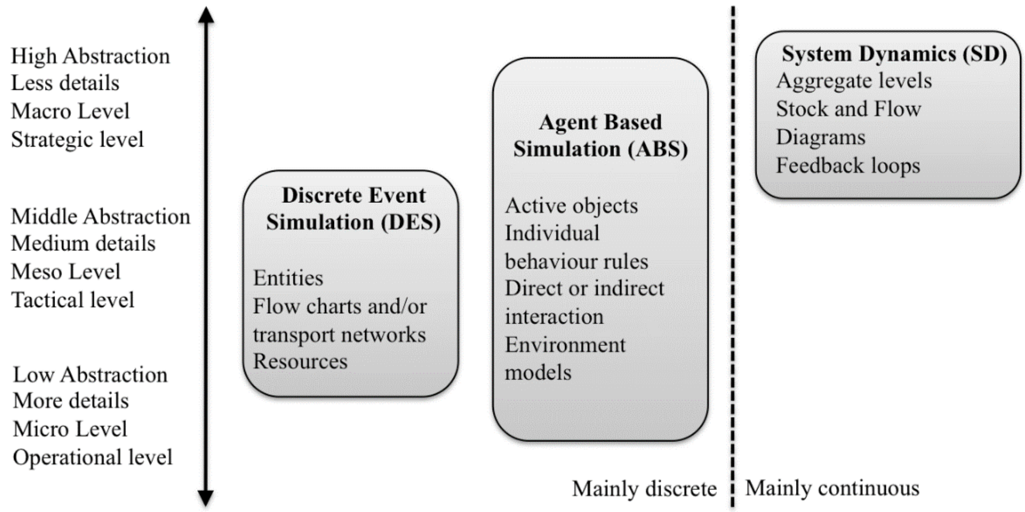

Figure 4.1. Simulation Approaches (adapted from Borshchev and Filippov (2004))

In the next subsections a brief definition is given for each simulation approach, previously identified.

4.2.1 Discrete Events Simulation

DES simulation approach has its origin in the evolution of the General Purpose Simulation System (GPSS) (originally *Gordon's Programmable Simulation System*) proposed by (Gordon, 1961). DES simulation approach considers individual entities each one with specific attributes, which determine their behaviour along the simulation process (Tako and Robinson, 2012). DES is based on the concept of entities (seen as passive objects representing people, machines, messages, tasks, etc.), resources and block flow charts, through which the entities pass and stay in queues, are delayed or are processed (Borshchev and Filippov, 2004). This means that, entities enter the system, visit some of the states and move between different states as time passes, after that the entities leave the system (Siebers et al., 2010). DES plays a significant role in modelling supply networks, especially at the tactical level. As DES does not represent systems from an aggregate perspective, it is not appropriate for strategic modelling. Works worth to mention in the context of supply networks are those developed by Lee et al. (2002) and Kleijnen and Wan (2007).

One characteristic of DES is that it includes stochastic elements through the use of statistical distributions, when randomness is generated, (Kleijnen, 2005). DES state changes occur at irregular discrete points of time, such as network of queues.

The drawbacks associated to DES simulation paradigm in the context of supply networks are the (i) lack of representation of continuous processes, and (ii) the higher complexity obtained due to DES represent high detailed models (Lee et al., 2002).

During the seventies DES was solely used in the research field; this changed in the nineties when software applications were developed for simulating the complex queuing theory and resource allocation problems. The acceptance of DES as a management tool was triggered by the development of well know software tools, such as Arena (Kelton, Sadowski, and Sturrock, 2003).

4.2.2 Systems Dynamics

Forrester is considered the precursor of System Dynamics (SD), which has its starting point in the Industrial Dynamics (Forrester, 1961). The Industrial Dynamics has its origins in a study carried out in a company of electronic components, *Sprague Electric*, as a new approach to address industrial problems. The main trouble found in this company was the appearance of oscillations in the order process. These oscillations were considered unusual due to the nature of the market in which *Sprague Electric* was embedded. That is, a market consisting of a few strong customers, from which it would expect that the orders' flow would be maintained regular. Unlike, in the mid 50's, it was observed that the orders generated were characterised by suffering oscillations.

In the light of this, Forrester, who was teaching at the newly formed *M.I.T. Sloan School of Management*, started to study this phenomenon. In the study, Forrester identified as key issue, in the operation of process, the feedback presented in the information structures. This finding involved an intelligent application of the theory of feedback systems; allowing representing the elements of the system, and their relations, by identifying the feedbacks to justify the appearance of oscillations. This representation enabled to identify and take the necessary measures to correct the existent oscillations in *Sprague Electric*. In the late fifties, and from the results of the performed work, Forrester formalized his ideas and methodology, resulting in the Industrial Dynamics methodology. Industrial Dynamics included structural aspects such as feedback control, and represented a new approach to address industrial problems, based on the analysis of the internal structure of the systems rather than the impact of exogenous factors affecting it.

Once the Industrial Dynamics method reached an acceptable level of maturity, the same concept was extended to social systems. Urban Dynamics was created in (Forrester, 1969) as a result from his collaboration with John Collins, the former mayor of Boston and visiting professor of Urban Affairs at Massachusetts Institute of Technology (M.I.T.).

In 1970, Forrester was invited by the *Club of Rome* to apply his methodology in the study of the world, considering it as a dynamic system. The result was the *Model of the World* (Forrester, 1971). The application of industrial dynamics at urban and worldwide context triggered to rename the Industrial Dynamics methodology into a broader term, currently known as System Dynamics (Forrester, 1968).

The SD is based on the feedback control theory, decision-making processes, experimental approaches and computational developments (Campuzano and Mula, 2011). Forrester developed the SD method as a set of tools and an approach to simulate complex systems, such as the supply network. Through SD it was possible to understand the structure of a system and identify how the intrinsic control policies operate. The supporting tools associated to SD enabled to improve the system assessment by simulating its behaviour.

Since its appearance, SD has been widely studied and disseminated in multiple research areas. Its application in case studies can be seen in areas such as defence (Cooper, 1980), social sciences (Richardson, 1991), medical science (Homer, 1987), ecology (Sterman, Richardson, and Davidsen, 1998), ecosystem (Wang and Eltahir, 2000), natural resources management, project management (Lyneis and Ford, 2007), social systems (Lane and Husemann, 2008), socioeconomic systems and transportation (Liu, Triantis, and Sarangi, 2010), civil construction (Lee and Peña-Mora, 2007), strategy management (Weil, 2007) (Gary, Kunc, and Morecroft, 2009), management (Roberts, 1978), knowledge sharing (Luna-Reyes et al., 2008), resource allocation (Lee, Ford, and Joglekar, 2007), disruptions (Williams, Ackermann, and Eden, 2003) or supply networks (Ashayeri, Keij, and Bröker, 1998) (Campuzano, Mula, and Peidro, 2010).

In the study context of this thesis, SD allows building (i) models based on previous situations faced by decision makers in the supply network, by considering their experience; (ii) dynamic models appearing on reality that are able to self-regulate their activities through feedback loops, applying the feedback systems theory; (iii) models using the computer as a supporting tool, allowing to compute models through simulating different scenarios in a short time and at low cost.

SD dissemination is done through the publication of papers in journals such as *System Dynamics Review* and other journals in management, operations research and social sciences. Besides, different groups worldwide, employing system dynamics, are also spreading the SD method, one referent group is the System Dynamics Group at MIT.

4.2.3 Agent Based Simulation

ABS approach was developed in the nineties as a novel tool to deal with problems that were not completely satisfactorily solved through using DES and SD. For example, in the operation research area, high complex management process and global and dynamic environments, in which enterprises are embedded, makes that traditional simulation approaches, such as DE, present limitations as a supporting tool to model and simulate complex systems (North and Macal, 2007). It is, therefore, recognised the high potential application linked to ABS for modelling and simulating complex systems (Siebers et al., 2010) performing a new step in the progress of simulation methods, and in the enhancement of simulation applications.

According to Siebers et al. (2010) ABS approach is used in the process of designing an agent-based model of a real system. ABS allows carrying out experiments with the agent-based model for the purpose of understanding the behaviour of the system and/or evaluating various strategies for the operation of the system being modelled. ABS allows representing complex systems though the use of a collection of agents that are programmed according to a set of behaviour rules and objectives, which enables them to have control over themselves and make their own decisions.

In agent-based models, the basic components of the real system are explicitly and individually represented in the model (Edmonds, 2002). ABS systems are characterized by comprising multiple autonomous, heterogeneous and independent agents, each one with their own objectives, and are generally capable to interact with each other and with their environment. Therefore, interactions established between the individual agents and the environment are also modelled. Each agent has the capacity to evolve over the time and adapt to new environmental conditions or objectives. One of the fundamental points of agent-based simulation is the concept of emergence. The agents' behaviour is modelled at the individual level, and the global behaviour emerges as a result of the interactions with many individuals, each one following its own behaviours and rules. Neither the expert nor the modeller imposes conditions on the overall behaviour of the system directly, due to it emerges as a result of the conditions imposed on the basic system components and their interactions. That is why ABS modelling is also called bottom-up modelling, corresponding to the macroscopic patterns that emerge from the decentralised interactions of simpler individual components (Holland, 1998). This bottom-up approach allows capturing the complexity and dynamicity of the modelled system. In ABS interactions between the basic components of the system are studied, therefore the system can be modelled even in the absence of the knowledge about the global interdependencies (Izquierdo et al., 2008).

ABS approach is a powerful technique for modelling complex systems, such as social systems (Gilbert, 2007), health (Brailsford et al., 1992) traffic and transportation, financial markets, energy usage (North and Macal, 2007) or supply networks (Hernández et al., 2009). Generally, ABS allows analysing the behaviours of real systems that consist of autonomous entities.

It is well known that depending on the type of modelled problem and its characteristics, the simulation approaches used to model and solve them will differ. In some situations, ABS will fit better the modelling requirements due to its flexibility and robustness; nevertheless for some other approaches DES and SD will be useful. In accordance to (Siebers et al., 2010) ABS are recommended when:

- The problem to be modelled has a natural representation as agents
- The goal is to model the behaviours of individuals in a diverse population
- Agents are related each other (social networks)
- Individual agents have associated movements in the space
- Agents to be modelled in the population have to learn or adapt
- Agents anticipate other agents' reactions when making decisions
- Represent collaborative behaviours
- The past is not used as a predictor of the future
- It is important to extend models in the future
- The emergence feature is a key issue in the problem modelled

4.3 Simulation approaches comparison

In order to select one or another simulation approach for modelling complex systems (supply networks), the literature brings some works making pairwise comparisons. The characteristics of DES approaches are mostly compared with the SD ones (Maidstone, 2012) (Tako and Robinson, 2012). Some authors focus on contrasting the usability and application between SD and ABS (Borshchev and Filippov, 2004), (Izquierdo et al., 2008), (Macal, 2010), (Maidstone, 2012). While others analyse DES paradigm versus ABS approaches (Borshchev and Filippov, 2004) (Siebers et al., 2010) (Maidstone, 2012). The work presented in Sumari et al. (2013) proposes a initial work comparing the three simulation approaches DES, SD and ABS but by only considering the disadvantages, the advantages and the tools (focusing in Promodel, Vensim, and AnyLogic) that can be used in each simulation method. In this research area a more comprehensive research is needed to jointly compare the three simulation approaches by considering more features such as the use appropriateness, the decision making level in which there can be applied, the degree of centralisation the level of abstraction, the complexity, components used, the entities behaviour, the modelling approach, the mathematical approximation, the evolution over the time, the data requirement, the validation requirements and the application into the SC context .

In the light of this, Table 4.1 is proposed giving an overall comparison of the same features for the three simulation approaches, DES, SD and ABS. Derived from the comparative work it can be concluded that the differences among the compared approaches are sometimes not so clear-cut. In this regard, Macal (2010) states that most of the models build in SD have an equivalent formulation in ABS approaches.

As a general recommendation, the choice of one or the other simulation approach depends on the perspective from which the modeller views the problem and the features that characterises the system, which, in fact, define the requirements of the modelled complex system. Besides, the modellers' familiarity with the software used must be considered in the selection of the simulation approach.

The research carried out to build the comparison work has allowed identifying how common is to combine different simulation approaches in order to model more accurately an only complex system. This definition corresponds to the term multi-method approach of simulation that according to Balaban and Hester (2013) consist of a combination of at least two different simulation approaches representing and modelling a unique system. The types of combinations are about:

- Combination of SD and ABS. Development of models in which a group of agents individually and explicitly represented interact in an environment in which certain variables evolve following a dynamic approach. The combination of both simulation approaches, SD and ABS will allow to enhance the ABS model, capturing more sophisticated dynamics (Borshchev and Filippov, 2004).
- Combination of SD and DES. In the context of representing the system of an integrated enterprise DES can be used to model local production planning or sequencing activities while SD can capture the long term effects caused by the disruptions or delays in production planning (Rabelo et al., 2005)
- Combination of DES and ABS. The process flow is modelled from a DES perspective and autonomous active entities in ABS approach (replacing passive entities modelled in DE), with the main aim of displaying proactive behaviours (Siebers et al., 2010).

Table 4.1. Simulation approaches comparison: DES vs. SD vs. ABS

	Discrete Event Simulation	System Dynamics	Agent Based Simulation
Use appropriateness	Convenient when the evolution of the entities state depends on the occurrence of asynchronous discrete events over the time. Its use is recommended in more detailed models. Mainly used to study the detailed operations of a supply network under uncertainty, and to evaluate the expected performance measures with a high level of accuracy. Useful in problems in which the processes can be well defined with queuing simulations. It focuses on the individual behaviour of entities	Convenient when the modeller has a previous knowledge of the complex system to be modelled and the objectives to achieve with the modelling process. Appropriate when taking a 'distant' perspective, where events and decisions are seen in the form of patterns of behaviour and system structures. It is recommended as a better choice in the high stages of decision making when less detailed models or results are required. It is mostly used for supply network analysis and policy formulation. It focuses more on flows around networks than on the individual behaviour of entities. Allows predicting the behaviour of the system just by looking at the structure	ABS simulation performs the abstractions directly on the basic components of the system. If the abstraction of the emergence process cannot be carried out in a scientifically valid way, given the modelling objectives, then it is more appropriate to explicitly model the emergence process by ABS simulation approach to study the model in detail. Allows modelling populations of diverse individuals (i.e human behaviour models) that have a variety of behaviours and interactions. It focuses more the individual behaviour of entities
Decision Making Level	Modelling problems at an operational level	Modelling problems at a strategic level to deal strategic issues and policy analysis	Modelling problems at operational and tactical level. Strategic levels of operation are less used
Degree of centralisation	Centralised. There is one thread of control. Entities are described as passive objects and the rules that drive the system are concentrated in the flowchart blocks	Centralised. Useful to model systems consisting of homogeneous entities, dominated by general laws, uniform in time and space (as the physical laws). SD is mostly used in entities that can be modelled correctly in a centralized way	Decentralised. Each agent has its own thread of control. The process is described from the entity's viewpoint, thus decentralize (some of) the rules. Therefore it is useful in more complex systems, characterised by high degrees of localization and heterogeneity of its individual components, and dominated by local information exchange processes with asymmetric and decentralized information (like most social systems)
Level of Abstraction	Low. Tends to look at the smaller detail of a system (microscopic)	High. The abstraction is done at the system level. System variables (usually aggregated) and causal relationships that link them are represented. Tends to take a more overall perspective and considers a holistic approach of systems, integrating many subsystems (macroscopic)	Low. The abstraction of the system basic components is individually done on each basic component, not the whole system (mesoscopic)
Complexity of the systems modelled	Low level of abstraction makes the process of modelling more detailed and therefore more complex	Higher degrees of abstraction lead to lower complexity models, facilitating its implementation, analysis and interpretation	The low level of abstraction makes the constructed model to be scientifically more rigorous but considerably more complex
Basic components and observable variables of the system	The model focuses on observable variables	Most of the models focus on observable variables of the aggregate system. Aggregate variables of the system are: flow, stock and auxiliary variables	The definition of the agents' behaviour is not necessarily determined by aggregate variables of the system, but can be based only on local information

	Discrete Event Simulation	System Dynamics	Agent Based Simulation
Entities behaviour to take decisions	Passive. The behaviour of the entities in the model is determined by the system. Passive entities implies that something is done to the entities while they move trough the system; intelligence (i.e., decision making) is modelled as part of the system	Passive. Individual entities are not specifically modelled, but instead, they are represented as a continuous quantity in stock. Feedback loops are used to represent the effects of policy decisions. A dynamic view of the cause and effect relationships is represented along the system elements	Active. Internal to the entities. Active entities, or agents, can take themselves the initiative to perform the decision-making. Specific attributes are assigned to each agent, which determine what happens to them throughout the simulation. Decisions emerge from the micro decisions of the individual agents. Autonomous (self-directed) agents follow a series of predefined rules to achieve their objectives whilst interacting with each other, as well as with the environment. Therefore, intelligence is represented in each individual agent (objects, enterprises, people)
Modelling approach	Process oriented. Top-down modelling approach focused on modelling the system in detail	Process oriented. Top-down modelling approach focused on modelling the system from a global perspective and high level of abstraction	Individual based. Bottom-up modelling approach focused on modelling the entities and interactions between them
Mathematical approximation	Generally stochastic in nature, where randomness is generated through the use of statistical distributions. Being stochastic in nature, it provides different results on different runs. Can use input distributions to model random behaviour	Generally deterministic and variables usually represent average values. Being deterministic in nature, it provides the same results run after run, so only needs to be run once	Generally stochastic feature. Can use input distributions to model random behaviour
Evolution over the time	The system is modelled as a network of queues and activities where state changes occur at discrete points of time. State changes occur at irregular discrete time steps	The system is represented as a set of stocks and flows where the state changes occur continuously over time. State changes are continuous, approximated by small discrete steps of equal length	The system is modelled considering that state changes occur at discrete points of time. State changes occur in a defined steps of discrete time
Data Requirements	Requires gathering more detailed data. Input distributions are often based on collecting/measuring (objective) data	Minimal data requirements to build a model. Input distributions are often based on theories or subjective data	Requires gathering more detailed data to model the agents' behaviour. Input distributions are often based on theories or subjective data
Validation	Established rules for validation	Established rules for validation	Validation rules cannot be directly transferred
Applications in SC context	Supply network structure Replenishment control policies Supply network optimisation Distribution and transportation planning SC integration Information sharing Inventory planning management Planning and forecasting demand Production planning and scheduling	Logistics Inventory planning Market evolution Bullwhip effect Disruptions SC integration Information sharing Inventory planning management Planning and forecasting demand Production planning and scheduling	Production planning and scheduling Information flow Risk management SC coordination Inventory, Production, Transportation Bullwhip effect SC configurations

4.4 Simulation Tools

This chapter gives a brief overview of the tools, and its characteristics, identified in each simulation approach (Table 4.2). In Table 4.3a list of tools – alphabetically ordered – is depicted for each simulation approach.

Most of the tools are characterised its specific use in a particular simulation approach. Nevertheless, AnyLogic (AnyLogic, 2015) commercial tool is characterised by offering a multi-method approach in which the three simulation paradigms can be represented in the same visual environment. It allows modelling different parts of an only model with different simulation approaches. The main disadvantage that modellers have to overcome using AnyLogic is related to their familiarity to work in Java environments.

Table 4.2. Comparison of tools characteristics of the studied simulation approaches

	Discrete Event Simulation	System Dynamics	Agent Based Simulation
Tools Availability and Software	High software maturity. The scientific community has experience on the software. Increasing computer power and evolving user interfaces led the DES software to progressively move towards 'drag and drop'. Languages, such as the Simul8, emerged to make the DES accessible and cost effective for all business sizes. Management tools are really applied	High software maturity. The process of designing a SD model is simpler, partly because formal models are usually less complex, and partly due to the availability of software tools at very high level. The ease of construction and analysis of system dynamics models using "drag and drop" tools has been one of the main reasons for its popularity in the scientific community	Low software maturity. The scientific community is less familiar with software. Tools use object-oriented programming languages (i.e. Java, C ++) allowing extensibility to model more agents and behaviours. Software is more focused to academic. Software is too technical for mass adoption and difficult to integrate into teaching

4.5 Conclusions

This chapter has discussed the use of different simulation approaches to support the modelling and resolution process of models representing complex systems, such as the supply network. Three simulation approaches are considered as relevant to the scope of our purpose: discrete event simulation (DES), system dynamics (SD) and agent based simulation (ABS); each one with its advantages and disadvantages. It has been considered that depending on the characteristics of problem/process to be modelled and the availability of the tools in which the simulation approach is supported, one approach or another will be selected.

Concluding, DES is recommended to be used for the study of supply network process characterised by being e under uncertainty conditions, or collaborative process that can be modelled with queuing simulations, in which the state of the model elements evolves according to discrete events behaviour. SD can be usefully applied in complex systems in which models are represented with less detail in order to predict the behaviour, given certain initial conditions. In SD the processes can be represented from a continuous perspective. Finally, ABS has its application in systems in which the elements that take part are sufficient autonomous to perform themselves the decision-making process. Amongst the tools identified to support the simulation approaches it must be highlighted AnyLogic simulation software due to the multimethod simulation approach offered.

The relationships, established between the companies that carry out the Strategies Alignment Process, are characterised by positive and negative flows. Therefore, it can be stated that, amongst the three simulation approaches analysed, the SD simulation approach is considered the more appropriate for its use to model the flows and causal relationships established between the objectives defined and the strategies formulated, characterising the Strategies Alignment Process. In chapter 6 a more extended justification as regards the selection of SD simulation approach and the appropriateness of SD to solve the strategies alignment model (formulated in Chapter 5), in the context of CN, is given. Moreover, the simulation software in which this process is going to be implemented and solved is picked out in Chapter 7.

Table 4.3. Simulation Approaches Tools

Discrete Event Simulation	**System Dynamics**	**Agent Based Simulation**			
adevs AnyLogic Arena CPN Tools DESMO-J Enterprise Dynamics ExtendSim Facsimile Flexim Galatea GoldSim Lanner L-SIM Server MASON MS4 Modeling Environemnt NetSim PlantSimulation PowerDEVS ProModel Ptolemy II Renque Sim Events SIM.JS Simcad Pro SimPy SIMUL8 SystemC Tortuga Vanguard Witness	Analytica **AnyLogic** ASCEND Consideo DYNAMO Dynaplan Smia Forio Simulations Insight Maker JDynSim MapleSim Mapsim Minsky NetLogo OptiSim Powersim Studio Pyndamics RecurDyn Simantics System Dynamics Simile Simulink Sphinx SD Tools Stella, iThink Sysdea SystemDynamics TRUE (Temporal Reasoning Universal Elaboration) Vensim VisSim	A3 / AAA (Agent Anytime Anywhere) ABLE (Agent Building and Learning Environment) Altreva Adaptive Modeler ADK (TryllianAgent Development Kit) AgentBuilder AgentSheets **AnyLogic** AOR Simulation AgentService Ascape Behaviour Composer (Rich Internet Application building on NetLogo) Brahms Breve Boris Construct Cormas(Common-pool Resources and Multi-Agent Systems) Cougaar CybelePro DALI DeX DigiHive D-OMAR(Distributed Operator Model Architecture) ECHO	ECJ FAMOJA(Framework for Agent-based MOdelling with JAva) Framsticks FLAME FLAME GPU FLUXY GAMA GPU Agents GROWlab iGen ICARO-T Insight Maker JABM JADE JAMEL (Java Agent-based MacroEconomic Laboratory) Janus JAS JASA (Java Auction Simulator API) Jason (Jason:Interpreter for extension of AgentSpeak) JCA-Sim jES (Java Enterprise Simulator) jEcho JESS LSD (Laboratory for Simulation Development)	MaDKit (Multi Agent Development Kit) MAGSY MAML (Multi-Agent Modeling Language) MASON MASS (Multi-Agent Simulation Suit) MAS-SOC (Multi-Agent Simulations for the SOCial Sciences) MIMOSE (Micro-und Multilevel Modelling Software) Moduleco MOOSE(Multimodeling Object-Oriented Simulation Environment) NetLogo OBEUS (Object Based Environment for Urban Simulation) Omonia(previouslyQuicksilver) oRIS PS-I (Political Science-Identity) Repast SDML (Strictly Declarative Modeling Language) SEAS (System Effectiveness Analysis Simulation)	SeSAm (Shell for Simulated Agent Systems) (fully integrated graphical simulation environment) Jade's sim++ JIAC SimPlusPlus SimAgent (alsosim agent) SimBioSys SimPack Spatial Modeling Environment(SME) Soar StarLogo MacStarLogo OpenStarLogo StarLogoT StarLogo TNG Sugarscape Swarm TerraME VisualBots VSEit Xholon ZEUS

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PART III. PROPOSAL

Chapter 5

Model to represent the Strategies Alignment Process in a CN

This chapter presents a model to deal with the strategies alignment process, and support the decision making of identifying which strategies to activate within the network in order to be aligned. This model allows analysing the strategies alignment in collaborative network (CN) environments. First of all, the elements that characterise a CN when addressing the strategies alignment process are identified. A formal definition of the strategies alignment concept is given. Afterwards, a mathematical model representing the strategies alignment is developed, consisting of decision variables, parameters, objective function and restrictions. This model aims to provide a global view as regards the strategies in order to identify those ones that have higher levels of alignment. The model is applied in a numerical example in order to illustrate its application.

5.1 Introduction

Taking into account the results derived from the analysis carried out in *Chapter 3*, it was concluded that, to the best of our knowledge, most of the approaches provided in the literature, in terms of dealing with the strategies alignment process, are not completely adequate to address it from the collaborative non-hierarchical network (NHN) perspective (Andres and Poler, 2015). Despite of the importance of aligning strategies, in terms of avoiding partnership conflicts, a gap has been found in the literature as regards contributions providing a holistic approach that allows considering all the strategies formulated by all the partners. In order to fill this gap, the aim of this research is to propose an approach to identify the aligned strategies from a holistic perspective, regardless of their nature and type, taking into account the CN context.

In the light of this, a mathematical model is developed, in this chapter, to identify amongst all the formulated strategies those that have higher levels of alignment, from the CN perspective. As described in Chapter 2 of this thesis (2.4 Collaborative Processes Matrix: Classification and Analysis), most networks formed by SMEs follow a non-hierarchical topology (NHN). Accordingly, the model presented below, to deal with the collaborative process of strategies alignment, has been proposed for its use in NHN. Thus, the model, considering the characteristics of a NHN features, takes into account all the strategies, objectives and KPIs of all the network nodes. So that, the resolution of the model provides the best combination of aligned strategies, to be activated, maximising the network (NHN) performance. In the light of this, henceforth no reference will be made to the application of the model, in a HN or NHN; considering that, by default, its implementation will be carried out in NHN. Although the model is proposed for NHN topology, it must be stated that the proposed is not limited for its application to HN topology, as this type of network could also use the model if the dominant node accepts to collaborate with the secondary ones (less dominant or with less power).

The proposed mathematical model allows modelling the CN considering the elements that define the strategies alignment process. These elements and the relations established among them are represented through mathematical formulation. The mathematical model is deterministic, thus, the enterprises' data is known and formulas are accurate enough to calculate the result.

For the model formulation the next considerations have been taken into account:

- Each networked enterprise defines its own objectives. The extent into which the objectives are achieved is measured through performance indicators (KPIs). The main aim of each enterprise is to achieve the maximum level of performance of its own KPIs defined. The objective at network level is to maximise the network performance.
- A set of strategies is formulated by each enterprise in order to achieve the defined objectives (KPIs). The strategies are devoted to improve the performance level of each KPI, and consequently to improve the network performance. The enterprises could formulate one or more strategies for attaining one objective.
- Not all the strategies formulated will be activated; the enterprises will only carry out some of the strategies formulated. In case that only one strategy is formulated to achieve a particular objective, the number of strategies activated might coincide with the ones formulated. Commonly, each enterprise will formulate several strategies to achieve each objective, so that the network enterprises should select the most suitable strategies. The enterprises would normally face the decision of identifying the set of strategies that allows them to achieve higher levels of alignment, amongst all the strategies formulated by the enterprises of the CN.
- The use of KPIs allows computing the increase/decrease of the enterprises and the network performance when specific set of strategies is activated.

- The decision of selection the strategies would be make according to the marginal cost of the strategies and the benefits/losses that the strategies provoke in the objectives, and will be computed through the performance levels generated when a specific set of strategies is activated.

The mathematical representation of the strategies alignment process, considering the collaborative perspective, will allows analysing, describing, explaining, simulating, assessing, monitoring and predicting misalignments among the strategies formulated within the CN. Moreover, the mathematical model will work as a supporting tool, for the decision maker, to identify which strategies to activate in order to obtain higher levels of alignment, and consequently of performance, not only in the same enterprise but also with the rest of enterprises of the network.

Hereafter the strategies alignment model is developed; to this end, in sections 2 and 3 the CN concept and the strategies alignment concept are respectively defined. Afterwards, the strategies alignment model is formulated in section 4, an example applying it is given in section 5. Finally, a brief discussion or the developed model, as well as some conclusions, are presented in section 6.

5.2 Formal definition of a Collaborative Network System

A formal definition of the CN is proposed, consisting of a 5-tuple of elements {*Networks, Enterprises, Objectives, Key Performance Indicators, Strategies*} that characterise the CN when addressing the strategies alignment process (Andres and Poler, 2014). The nomenclature to formally define a CN is given in Table 5.1.

Table 5.1. Nomenclature to formally define a CN

Index	
net	set of networks, $net = (1, ..., N)$
i	set of enterprises, $i = (1, ..., I)$
x	set of objectives, $x = (1, ..., X)$
k	set of key performance indicators, $k = (1, ..., K)$
s	set of strategies where $s = (1, ..., S)$
Objects to define the CN	
n	number of enterprises belonging to the network net
α_i	number of networks to which the enterprise i belongs to
γ_{inet}	*1*: the enterprise i belongs to the network net *0*: otherwise
o_{ix}	objective x defined at enterprise i
kpi_{ixk}	performance level of the key performance indicator k that measures the fulfilment of the objective o_{ix}
str_{is}	strategy s defined by the enterprise i
str_{is}^Z	status of strategy str_{is} z = 1: the strategy str_{is} is active z = 0: the strategy str_{is} is non-active

Network – the set of N networks. Each network net consists of n enterprises.

Enterprise – the set of n enterprises are related to each other through upstream or downstream links in the different processes and activities they perform. The main aim is to generate value by delivering products and services to end customers (Christopher, 2005). One enterprise i can belong to one or several networks (net).

$$\alpha_i = \sum_{net} \gamma_{inet} \begin{cases} \gamma_{inet} = 1 \leftrightarrow i \in net \\ \gamma_{inet} = 0 \leftrightarrow i \notin net \end{cases}$$

(5. 1)

Objective – to be defined and achieved by each enterprise. o_{ix} represents the objective x defined by the enterprise i.

Key Performance Indicator – provides the necessary information to monitor the accomplishment of the objectives (Rodriguez et al., 2008). kpi_{ixk} represents the KPI k defined by the enterprise i in order to measure the attainment of objective x. An objective (o_{ix}) can be measured by one or several kpi_{ixk}.

Strategies – set of actions formulated by each enterprise in order to define how to reach the defined objectives; str_{is} represents the strategy s formulated by the enterprise i. Considering the attribute of *active* and *non-active* that characterises a strategy. The *active* status (str_{is}^1) involves that a strategy previously formulated by an enterprise i is started and carried out; otherwise, the *non-active* status (str_{is}^0) involves that a strategy previously formulated is not finally launched by the enterprise.

5.3 Formal definition of Strategies Alignment

A CN is characterised by the enterprises heterogeneity (Camarinha-Matos and Afsarmanesh, 2005), each one defining its own objectives, heterogeneous too. Consequently, a high diversity of strategies is formulated, in order to reach the objectives defined. This diversity of strategies may result in conflict situations among enterprises of the same CN, since contradictions among the formulated strategies could emerge. The strategies misalignment may, ultimately, lead to the failure of the collaborative partnership if the conflicts that arise are not tackled. In order to deal with these conflicts, the strategies alignment process is required to be addressed, among enterprises of the same CN.

When an enterprise has to face the decision-making of the strategies to activate, in order to achieve its objectives, can opt for making the decision from an isolate perspective (non-collaborative scenario), or, on the contrary, from a common perspective (collaborative scenario). When considering the collaborative alternative, each enterprise decides which set of strategies activate, by not only taking into account the extent into which its own activated strategies influence its own objectives, but also considering how the activated strategies influence the objectives defined by other network enterprises. Generally, the strategies that, on the whole, positively influence the objectives defined by the majority the network enterprises will be characterised by being aligned.

The strategies alignment leads a situation in which the strategies formulated by the network partners are strictly combined and activated, being complementary one another. The collaborative strategies alignment enables to adequately coordinate the network objectives and appropriately identify those strategies that maximise positive impacts, minimising the negative ones, on the objectives defined by all the networked partners, so that the best solution coincides with the one that leads to maximise the network performance, even though some strategies have negative influences on some definite objective.

CNs consist of autonomous and heterogeneous enterprises each one defining its own objectives. The strategies are the set of actions raised to achieve the defined objectives; therefore, each enterprise of the CN formulates its own strategies with the main aim of achieving the defined objectives. There will be times in which all the strategies formulated are activated. Nevertheless, sometimes only a few of the formulated strategies will be activated, due to, for example, a restriction associated with the budged. Assuming that, the strategies alignment concept is defined next as:

"*the set of strategies, formulated by the enterprises belonging to the CN, whose activation positively influence, on the whole, the objectives achievement of the majority of the enterprises participating in the CN; obtaining the best performance at the network level,* although *some of the strategies negatively influence any of the defined objectives* "

The fully alignment of strategies is considered when all the strategies activated have positive influences in all the objectives defined by each enterprise of the CN. Nevertheless, the set of aligned strategies will not only be restricted to the strategies that exclusively have positive influences in all the objectives defined by each enterprise. If this was the case, it could happen that some of the objectives defined would not be achieved due to only few strategies (those that exert positive influences) would be activated. Thereby, the set of aligned strategies will include the strategies whose activation involves the attainment of all the defined objectives, maximising the positive influences and minimising the negative ones (in case some of the strategies negatively influence any of the defined objectives), so that the performance at network level is maximised. Accordingly, the best set of aligned strategies leads to maximise the network performance, even though some strategies have negative influences on some definite objective.

The ideal situation would be one in which the strategies defined by one enterprise of the CN promote both the achievement of the objectives defined in the same enterprise and the objectives defined in other networked partners. Nevertheless, it must be considered that (i) individual enterprises take part in several networks and, it is very likely that some of these networks have contradictory objectives and consequently contradictory strategies, and (ii) the enterprises belonging to one specific CN are heterogeneous, and contradictory objectives and strategies might arise. Therefore, for enterprises belonging to a CN, the defined objectives and the strategies formulated by one enterprise could favour, or not, the objectives defined by other enterprises. In order to achieve the ideal situation, enterprises belonging to a CN should be able to identify those aligned strategies, whose activation promotes the improvement of the majority the objectives defined by the networked enterprises.

Lets consider two enterprises: $enterprise\ i$ (e_i) and $enterprise\ j$ (e_j), each one defines one objective o_{ix} and o_{jx} and formulates one strategy str_{is} and str_{js}. Each objective has associated a KPI, kpi_{ixk} measures the achievement of o_{ix} and kpi_{jxk} measures the achievement of o_{jx}. The strategies str_{is} and str_{js} are considered to be fully aligned when the activation of both strategies, str_{is} and str_{js}, exerts a positive influence in both objectives defined, o_{ix} and o_{jx}. That is, when str_{is} is activated performance level of the KPIs, defined to measure the objectives, increases, $\Delta^{+}kpi_{ixk}$ and $\Delta^{+}kpi_{jxk}$. Simultaneously, the same has to occur when str_{js} is activated. Accordingly, the strategies are aligned when the total benefit obtained is higher than the sum of the benefits obtained by the activation of each strategy individually.

Assuming that the enterprises want to collaborate, the alignment of strategies is achieved when the activated strategies positively influence the majority of the KPIs defined by the networked enterprises. The strategies alignment will improve the performance of the objectives associated at enterprise level, and consequently the network performance.

5.3.1 Mathematical definition

The concept of strategies alignment is mathematically defined by Andres and Poler (2014). In the mathematical definition, the influence between the strategies and objectives is computed through the KPIs increase (Δkpi_{ixk}). This increase quantitatively models the improvement of an objective comparing the results when a strategy is active and not active. Two scenarios are considered when modelling the Δkpi_{ixk} when a strategy str_{is}/str_{js} is activated:

- Intra-enterprise influences: The active strategy str_{is}^{1} is formulated and carried out in the same enterprise i in which the objective o_{ix} is defined. The increase of the kpi_{ixk} (Δkpi_{ixk}) when str_{is} , of the same enterprise i, is activated, is defined by:

$$\Delta kpi_{ixk}^{is} = \frac{kpi_{ixk}|str_{is}^{1} - kpi_{ixk}|str_{is}^{0}}{kpi_{ixk}|str_{is}^{0}}$$

(5.2)

- Inter-enterprise influences: The active strategy str_{js}^{1} is formulated and carried out in a different enterprise j, of the CN. The Δkpi_{ixk} (that measures the attainment of o_{ix} of $enterprise\ i$) when a strategy str_{js} , of a different enterprise j, is activated, is defined by:

$$\Delta kpi_{ixk}^{js} = \frac{kpi_{ixk}|str_{js}^{1} - kpi_{ixk}|str_{js}^{0}}{kpi_{ixk}|str_{js}^{0}} \quad | \, i \neq j$$

(5.3)

When $kpi_{ixk}|str_{is}^{1} < kpi_{ixk}|str_{is}^{0}$ implies a *good increase* means that a reduction of the KPI has a positive connotation e.g. reduce the cost, stocks, etc.) the equations (5.2 and 5.3), defined to compute ∇kpi_{ixk}^{is} and Δkpi_{ixk}^{js}, remain as follows.

$$\Delta kpi_{ixk}^{is} = -\left(\frac{kpi_{ixk}|str_{is}^{1} - kpi_{ixk}|str_{is}^{0}}{kpi_{ixk}|str_{is}^{0}}\right)$$

(5.4)

$$\Delta kpi_{ixk}^{js} = -\left(\frac{kpi_{ixk}|str_{js}^{1} - kpi_{ixk}|str_{js}^{0}}{kpi_{ixk}|str_{js}^{0}}\right) \quad | \, i \neq j$$

(5.5)

5.3.2 Function of Alignment

The function of alignment is defined in order to identify those pairs of strategies that are fully aligned. The fully aligned strategies are those that, if activated, have positive influences in the objectives both in the same enterprise and in different enterprises resulting on an increase of the KPIs that measure the objectives achievement (Figure 5.1).

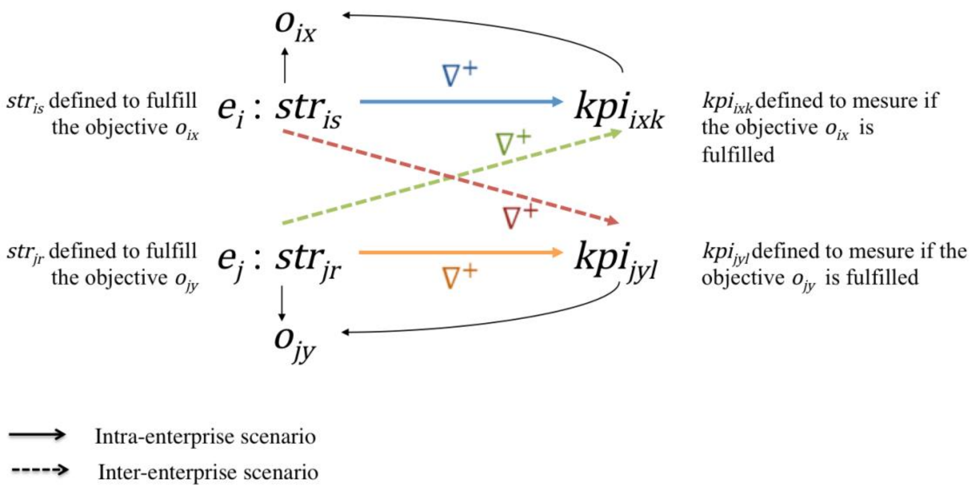


Figure 5.1. Scheme of Fully Aligned Strategies

<u>Intra-enterprise scenario:</u>

The enterprise e_i/e_j defines an objective o_{ix}/o_{jy}. The objective o_{ix}/o_{jy} has associated a key performance indicator kpi_{ixk}/kpi_{jyl} that allows to measure if the objective o_{ix}/o_{jy} is improved or is worsen. In order to achieve the objective o_{ix}/o_{jy} the strategy str_{is}^{1} / str_{jr}^{1} is activated. Therefore,

- the strategy str_{is}^{1} / str_{jr}^{1} has a positive impact on the objective o_{ix}/o_{jy} if the kpi_{ixk}/kpi_{jyl} associated has a positive increase ($\Delta^{+}kpi_{ixk}/\Delta^{+}kpi_{jyl}$).
- the strategy str_{is}^{1} / str_{jr}^{1} has a negative impact on the objective o_{ix}/o_{jy} if the kpi_{ixk}/kpi_{jyl} associated has a negative increase ($\Delta^{-}kpi_{ixk}/\Delta^{-}kpi_{jyl}$).
- the strategy str_{is}^{1} / str_{jr}^{1} has no influence on the objective o_{ix}/o_{jy} if the kpi_{ixk}/kpi_{jyl} associated does not experience neither positive nor negative effect.

Inter-enterprise scenario:

The enterprise e_i defines an objective o_{ix}, which has associated a performance indicator kpi_{ixk} that allows measuring the degree of achievement of the o_{ix}. To identify into which extent the strategy activated in another enterprise e_j (str^1_{jr}) positively or negatively influences the o_{ix}, the associated key performance indicator, kpi_{ixk}, is to be analysed. Two situations are possible:

- the kpi_{ixk} positively increases ($\Delta^+ \mathrm{kpi_{ixk}}$) when the str^1_{jr} is activated. Therefore, the strategy str^1_{jr} has a positive influence on the objective o_{ix}.
- the kpi_{ixk} negatively increases ($\Delta^- kpi_{ixk}$) when the str^1_{jr} is activated. Therefore, the strategy str^1_{jr} has a negative influence on the objective o_{ix}.
- the kpi_{ixk} is not influenced when the str^1_{jr} is activated. Therefore, the strategy str^1_{jr} has no influence on the objective o_{ix}.

The enterprise e_j defines an objective o_{jy}. The objective o_{jy} has associated a key performance indicator kpi_{jyl} that allows measuring the degree of achievement of o_{jy}. To identify into which extent the strategy activated in another enterprise e_i (str^1_{is}) affects positively or negatively to the o_{jy}, the associated key performance indicator (kpi_{jyl}) is to be analysed. Two situations are possible:

- the kpi_{jyl} positively increases ($\Delta^+ kpi_{jyl}$) when the str^1_{is} is activated. Therefore, the strategy str^1_{is} has a positive influence on the objective o_{jy}.
- the kpi_{jyl} negatively increases ($\Delta^- kpi_{jyl}$) when the str^1_{is} is activated. Therefore, the strategy str^1_{is} has a negative influence on the objective o_{jy}.
- the kpi_{jyl} is not influenced when the str^1_{is} is activated. Therefore, the strategy str^1_{is} has no influence on the objective o_{jy}.

Considering these two scenarios, a *function of alignment* $a(str_{is}, str_{jr})$ is proposed to quantitatively determine if two strategies are totally aligned. In the light of this, two strategies str_{is} and str_{jr} will be fully aligned if and only if, being both strategies active str^1_{is} and str^1_{jr}, the increase of the KPIs associated to both enterprises is positive $\Delta^+ kpi_{ixk}$, $\Delta^+ \mathrm{kpi_{jyl}}$.

$$a(str_{is}, str_{jr}) = \begin{cases} a(str_{is}, str_{jr}) = 1 \leftrightarrow \begin{cases} str^1_{is} \rightarrow \Delta^+ kpi_{ixk} \\ str^1_{is} \rightarrow \Delta^+ kpi_{jyl} \\ str^1_{js} \rightarrow \Delta^+ kpi_{ixk} \\ str^1_{js} \rightarrow \Delta^+ kpi_{jyl} \end{cases} \\ a(str_{is}, str_{jr}) = 0 \end{cases}$$

(5.6)

The function of alignment $a(str_{is}, str_{jr})$ allows defining pairs of strategies (str_{is} and str_{jr}) that are completely aligned when $a(str_{is}, str_{jr}) = 1$. On the other hand when $a(str_{is}, str_{jr}) = 0$ it is concluded that the strategies str_{is} and str_{jr} are not fully aligned. In each enterprise, the kpi_i improvement (kpi_i^{imp}) can be computed in order to determine into which extent the objectives enhance its performance levels when aligned strategies are activated.

$$kpi_i^{imp} = \sum_{x,k} \Delta kpi_{ixk}^{is} + \sum_{x,k} \Delta kpi_{ixk}^{ij} \qquad / \quad a(str_{is}, str_{jr}) = 1$$

(5.7)

Example 5.1 Considering a network with n enterprises, two of them are considered, e_1 and e_2 (Figure 5.2). Each enterprise defines a set of objectives; o_{11} is defined by the enterprise e_1 and o_{21} is defined by the enterprise e_2. In order to measure the objectives, two performance indicators are defined kpi_{111} (measures the o_{11}) and kpi_{211} (measures o_{21}). A set of strategies are proposed to meet these objectives: e_1: str_{11} and str_{21}; and e_2: str_{12} and str_{22}. It should be noted that the function of alignment could also be applied in order to determine if two strategies defined in a same company are fully aligned. Nevertheless, in order give a general insight, this example studies the alignment of strategies formulated in two different network companies. Two pairs of strategies are analysed in different scenarios.

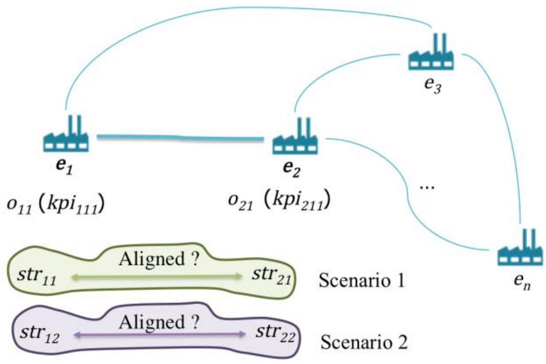


Figure 5.2. Network diagram for the numerical example

Depending on the strategies activated, the performance indicators kpi_{111}, kpi_{211} will increase or decrease in a higher or larger extent. Table 5.2 shows the data as regards the increase of the KPIs when certain strategies are activated and non-activated.

Table 5.2. Data: kpi_{ixk} values in scenarios 1 and 2

Scenario 1		
	kpi_{111}	kpi_{211}
str_{11}^1	10	9
str_{21}^1	7	10
str_{11}^0	5	11
str_{21}^0	9	5

Scenario 2		
	kpi_{111}	kpi_{211}
str_{12}^1	10	11
str_{22}^1	11	11
str_{12}^0	5	11
str_{22}^0	9	5

Applying the equations (5.2 – 5.5) the KPIs increase, when the strategies are active, is computed. The results are shown Figure 5.3 and Figure 5.4 for the scenarios 1 and 2 respectively.

<u>Concerning the *Scenario 1: Pair of strategies* str_{11} and str_{12}</u>

Intra-enterprise influences: How the activation of a strategy formulated in one enterprise influences in the objectives defined in the same enterprise.
• When str_{11}^1 is activated $kpi_{111} = 10$ • When str_{21}^1 is activated $kpi_{211} = 10$ • When str_{11}^0 is not activated $kpi_{111} = 5$ (the KPI increase is halved) • When str_{21}^0 is not activated $kpi_{211} = 5$ (the KPI increase is halved)
Inter-enterprise influences: How the activation of a strategy formulated in one enterprise influences in the objectives defined in another enterprise of the network
• When str_{11}^1 is activated $kpi_{211} = 9$ (the KPI is reduced in a unit with respect the initial value) • When str_{21}^1 is activated $kpi_{111} = 7$ (the KPI is reduced in three units with respect the initial value) • When str_{11}^0 is not activated $kpi_{211} = 11$ (the KPI is increased in a unit with respect the initial value) • When str_{21}^0 is not activated $kpi_{111} = 9$ (the KPI is reduced in a unit with respect the initial value)

Intra-enterprise influences

$$\Delta kpi_{ixk}^{is} = \frac{kpi_{ixk}|str_{is}^{1} - kpi_{ixk}|str_{is}^{0}}{kpi_{ixk}|str_{is}^{0}}$$

$$\Delta kpi_{111}^{11} = \frac{kpi_{111}|str_{11}^{1} - kpi_{111}|str_{11}^{0}}{kpi_{111}|str_{11}^{0}} = \frac{10-5}{5} = 1\ (\Delta^{+}kpi_{111}^{11})$$

$$\Delta kpi_{211}^{21} = \frac{kpi_{211}|str_{21}^{1} - kpi_{211}|str_{21}^{0}}{kpi_{211}|str_{21}^{0}} = \frac{10-5}{5} = 1\ (\Delta^{+}kpi_{211}^{21})$$

Inter-enterprise influences

$$\Delta kpi_{ixk}^{js} = \frac{kpi_{ixk}|str_{js}^{1} - kpi_{ixk}|str_{js}^{0}}{kpi_{ixk}|str_{js}^{0}} \quad |\ i \neq j$$

$$\Delta kpi_{211}^{11} = \frac{kpi_{211}|str_{11}^{1} - kpi_{211}|str_{11}^{0}}{\Delta kpi_{211}|str_{11}^{0}} = \frac{9-11}{11} = -\frac{2}{11}(\Delta^{-}kpi_{211}^{11})$$

$$\Delta kpi_{111}^{21} = \frac{kpi_{111}|str_{21}^{1} - kpi_{111}|str_{21}^{0}}{kpi_{111}|str_{21}^{0}} = \frac{7-9}{9} = -\frac{2}{9}\ (\Delta^{-}kpi_{111}^{21})$$

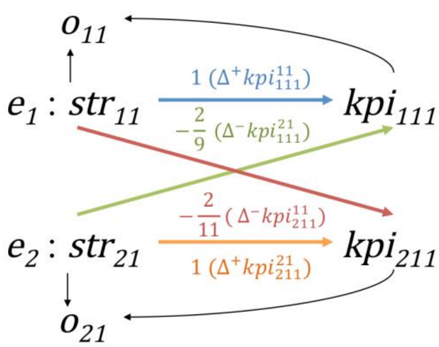


Figure 5.3. Scenario 1: Results from the numerical example

<u>Concerning the *Scenario 2: Pair of strategies* str_{12} *and* str_{22}</u>

Intra-enterprise influences: How the activation of a strategy formulated in one enterprise influences in the objectives defined in the same enterprise.
• When str_{12}^{1} is activated $\Delta kpi_{111} = 10$ • When str_{22}^{1} is activated $\Delta kpi_{211} = 11$ • When str_{12}^{0} is not activated $\Delta kpi_{111} = 5$ (the KPI increase is halved) • When str_{22}^{0} is not activated $\Delta kpi_{211} = 5$ (the KPI increase is halved)
Intra-enterprise influences: How the activation of a strategy formulated in one enterprise influences in the objectives defined in another enterprise of the network
• When str_{12}^{1} is activated $\Delta kpi_{211} = 11$ (the KPI is increased in a unit with respect the initial value) • When str_{22}^{1} is activated $\Delta kpi_{111} = 11$ (the KPI does not receives any influence) • When str_{12}^{0} is not activated $\Delta kpi_{211} = 11$ (the KPI is increased in a unit with respect the initial value) • When str_{22}^{0} is not activated $\Delta kpi_{111} = 9$ (the KPI is reduced in a unit with respect the initial value)

Intra-enterprise influences

$$\Delta kpi_{ixk}^{is} = \frac{kpi_{ixk}|str_{is}^{1} - kpi_{ixk}|str_{is}^{0}}{kpi_{ixk}|str_{is}^{0}}$$

$$\Delta kpi_{111}^{11} = \frac{kpi_{111}|str_{11}^{1} - kpi_{111}|str_{11}^{0}}{kpi_{111}|str_{11}^{0}} = \frac{10-5}{5} = 1\ (\Delta^{+}kpi_{111}^{11})$$

$$\Delta kpi_{211}^{21} = \frac{kpi_{211}|str_{21}^{1} - kpi_{211}|str_{21}^{0}}{kpi_{211}|str_{21}^{0}} = \frac{11-5}{5} = \frac{6}{5}\ (\Delta^{+}kpi_{211}^{21})$$

Inter-enterprise influences

$$\Delta kpi_{ixk}^{js} = \frac{kpi_{ixk}|str_{js}^{1} - kpi_{ixk}|str_{js}^{0}}{kpi_{ixk}|str_{js}^{0}} \quad | \ i \neq j$$

$$\Delta kpi_{211}^{11} = \frac{kpi_{211}|str_{11}^{1} - kpi_{211}|str_{11}^{0}}{kpi_{211}|str_{11}^{0}} = \frac{11-11}{11} = 0\ (\Delta^{+}kpi_{211}^{11})$$

$$\Delta kpi_{111}^{21} = \frac{kpi_{111}|str_{21}^{1} - kpi_{111}|str_{21}^{0}}{kpi_{111}|str_{21}^{0}} = \frac{11-9}{9} = \frac{2}{9}\ (\Delta^{+}kpi_{111}^{21})$$

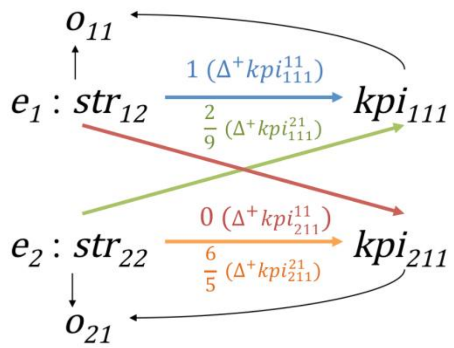


Figure 5.4. Scenario 2: Results from the numerical example

The obtained results show that str_{11} and str_{21} are not completely aligned being $a(str_{is}, str_{jr})=0$; whilst, str_{12} and str_{22} are fully aligned due to all the KPIs levels are positively increased resulting $a(str_{is}, str_{jr})=1$. Being e_1 and e_2 collaborative, the strategies to be activated will be str_{12}^1 and str_{22}^1 due to positively affect the accomplishment of all the objectives defined by each the enterprise (o_{11} and o_{21}).

The definition of the strategies alignment and the function of alignment are proposed considering pairs of strategies. The mathematical model, presented in next section, to address the strategies alignment process is extended to n enterprises and s strategies, considering the CN context. In order deal with the problem of aligning strategies in more than two strategies, the function of alignment proposed is extended and adapted considering that the aligned strategies will be those that positively influence the majority of the objectives defined by each of the network enterprises, but that in the absence of positive influences, the minimisation of the negative influences will be considered with the main aim of achieving all the objectives and maximising the performance at network level.

5.4 Strategies Alignment Model

Considering a CN, firstly, each enterprise defines the objectives to be reached. Secondly, each enterprise formulates a set of strategies to reach the objectives. Each strategy has an associated cost. Amongst all of these strategies, the enterprises can activate some of them in order to attain the defined objectives at the minimum cost. Taking into account this, the enterprises' interest lies in knowing what is the contribution of each activated strategy to achieve its objectives, taking into account the strategies costs. In order to measure this achievement the KPIs are used. Thus, the activation of a particular strategy influences the KPIs level. Therefore, when modelling the strategies alignment process, the KPIs increase/decrease is used to identify how the activated strategies influence the objectives achievement. The strategies of an enterprise *i* can also influence the KPIs of another enterprise *j* and vice versa; therefore, not only exists intra-enterprise influences but also inter-enterprise influences (Figure 5.5).

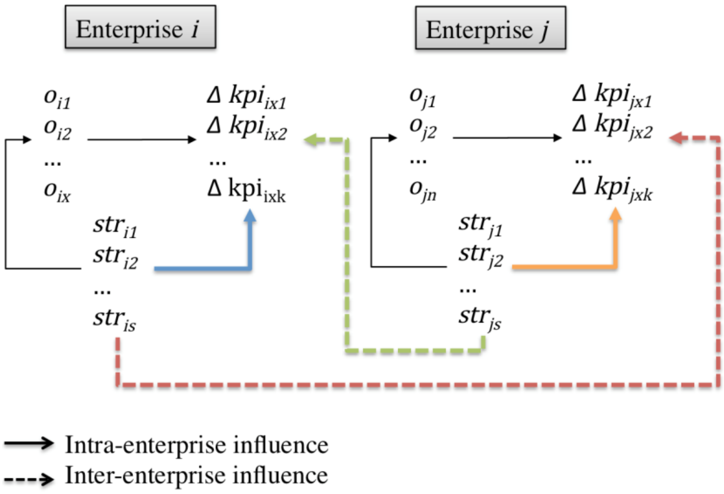


Figure 5.5. Relationship between the strategies and the KPIs

The mathematical language is used to model the strategies alignment process. Particularly, mathematical notation allows representing the elements that characterise the alignment in terms of strategies, objectives and performance indicators obtaining high degrees of accuracy and formality.

5.4.1 Parameters and decision variables

In order to represent the influences and relations between the KPIs and the strategies a mathematical notation model is proposed: the Strategies Alignment Model (SAM). First of all, the set of parameters and decision variables, used to model the SAM, are defined in Table 5.3.

Table 5.3. Nomenclature of SAM

Index	
net	set of networks, $net = (1, \ldots, N)$
i	set of enterprises, $i = (1, \ldots, I)$
x	set of objectives, $x = (1, \ldots, X)$
k	set of key performance indicators, $k= (1, \ldots, K)$
s	set of strategies where $s= (1, \ldots, S)$
Model Parameters	
n	number of enterprises belonging to the network
o_{ix}	objective x defined in enterprise i
b_i	budget owned by the enterprise i to invest in the activation of the strategies str_{is}, in monetary units *[m.u.]*
str_{is}	strategy s defined by enterprise i
kpi_{ixk}	key performance indicator (KPI) k used to measure the objective o_{ix}
Δkpi_{ixk}	increase observed in the kpi_{ixk} when the str_{is} is activated. It can be decomposed in: • Δkpi_{ixk}^{intra} increase of the kpi_{ixk} when the str_{is} of the same enterprise i (e_i) is activated • Δkpi_{ixk}^{inter} increase of the kpi_{jxk} when the str_{js} of a different enterprise j (e_j) is activated
Δkpi_{ixk}^{max}	maximum increase of kpi_{ixk} estimated by the *enterprise* i (used to homogenise all the KPIs)
$Threshold\_kpi_{ixk}$	value from which the associated kpi_{ixk} is affected by the activation of a strategy str_{is}. Below $Threshold\_kpi_{ixk}$ the influence of str_{is} is not observed, from $Threshold\_kpi_{ixk}$, the influence exerted by str_{is} is considered
Δkpi_{ixk}_T	increase experienced by the kpi_{ixk} once the $Threshold\_kpi_{ixk}$ is computed

Model Parameters	
Δkpi_{ixk}_min	minimum increase that the enterprise estimates for the kpi_{ixk} , once the $Threshold\_kpi_{ixk}$ is computed
$fulfillment\_kpi_{ixk}$	binary parameter that indicates that increase experienced by the kpi_{ixk} is higher than the minimum increase that the enterprise estimates for the kpi_{ixk} , once the $Threshold\_kpi_{ixk}$ is computed
w_{ixk}	weight of kpi_{ixk}, determines the relevance that the kpi_{ixk} has for enterprise i
Δkpi_i	increase experienced by the KPI defined at enterprise i level
Δkpi_{net}	increase experienced KPI defined at network net level
$f\_inf\_str_{is}\_kpi_{ixk}(t)$	function that models the behaviour of the kpi_{ixk} when str_{is} is activated
$f\_kpi_{ixk}(t)$	function that models the overall behaviour of the kpi_{ixk} considering all the activated strategies
$f\_kpi_{ixk}\_T(t)$	function that models the behaviour of the kpi_{ixk} when the $Threshold\_kpi_{ixk}$ value is computed
c_str_{is}	cost of activating one unit of strategy str_{is} [m.u.]
str_{is}_mu	monetary units invested in the activation of str_{is} [m.u.]
$val\_str_{is}\_kpi_{ixk}$	numerical value estimated by the enterprise e_i, that registers the increase or decrease of the kpi_{ixk} when one unit of str_{is} is activated (u_str_{is})
$inf\_str_{is}\_kpi_{ixk}$	maximum level of influence on the kpi_{ixk} when certain number of units of strategy (u_str_{is}) are activated
$slope\_str_{is}\_kpi_{ixk}$	slope of the ramp in represented in $f\_inf\_str_{is}\_kpi_{ixk}(t)$
H	horizon, time units [t.u.], period of time in which the set of strategies are to be activated. Normalised to the unit, $H = 1$.
$d_1\_str_{is}$	delay, time period between the initial time of activation of str_{is} (ti_str_{is}) and the time when the kpi_{ixk} is started to be influenced by the activated str_{is} [t.u.]
$d_2\_str_{is}$	time period between the str_{is} starts to influence the kpi_{ixk} until the maximum level of influence in is achieved ($inf\_str_{is}\_kpi_{ixk}$), [t.u.]
$d_3\_str_{is}$	time period in which str_{is} is exerting the highest influence ($inf\_str_{is}\_kpi_{ixk}$) on the kpi_{ixk} [t.u.]
$d_4\_str_{is}$	total duration of str_{is} [t.u.]
tf_str_{is}	time unit when str_{is} is finished [t.u.]
Decision Variables	
u_str_{is}	units of strategy [u.s] str_{is} to be activated
ti_str_{is}	initial time of activation of str_{is} [t.u.]

5.4.2. Objective Function and Restrictions

The SAM is hereafter developed, consisting of an objective function and the associated restrictions, representing the relations amongst all the defined variables and parameters. The main aim is to identify, amongst all the strategies defined, those strategies that have higher level of alignment. The activation of the aligned strategies positively influences the majority of the objectives defined by the networked partners, maximising the performance at network level. The SAM computes the KPIs improvement or worsening when a strategy is activated. Thus, the developed model supports enterprises on the decision making as regards the number of units of strategy (u_str_{is}) to be activated and the time in which the strategies have to be activated (ti_str_{is}) with the objective of maximising the network performance, given by kpi'_{net} as the homogenised version of the kpi_{net}. Therefore, the objective function of the SAM is mathematically represented by equation (5.8):

$$max. \quad \Delta kpi'_{net} \tag{5.8}$$

The $\Delta kpi'_{net}$ is obtained considering a procedure of four steps described next (Figure 5.6).

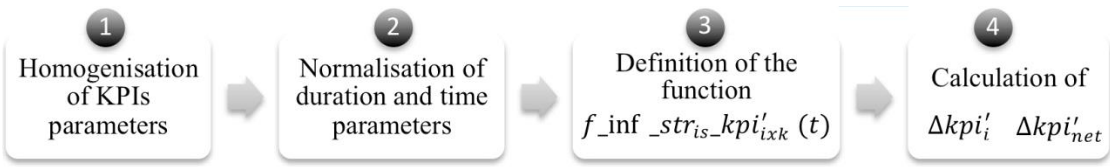


Figure 5.6. Procedure to follow for computing $\Delta kpi'_{net}$

STEP 1. Homogenisation of parameters related to KPIs ($\Delta kpi'_{ixk}$)

First of all, it has to be considered that the SAM is designed based on homogenised versions of the parameters related to KPIs. Because of that, the objective function is lead to maximise the Δkpi_{net} in its homogenised version, $\Delta kpi'_{net}$. Starting with Δkpi_{ixk}, its homogenised version is represented by $\Delta kpi'_{ixk}$ and is defined as the dimensionless parameter of Δkpi_{ixk}. The estimation of Δkpi^{max}_{ixk}, by the enterprise *i*, allows homogenising the kpi_{ixk} defined and comparing all the parameters Δkpi_{ixk}one with another, both within the same enterprise and between other network enterprises. The equation (5.9) is applied,

$$\Delta kpi'_{ixk} = \frac{\Delta kpi_{ixk}}{\Delta kpi^{max}_{ixk}}$$

(5.9)

Example 5.2. Let us suppose an apparel-manufacturing network (*net*) comprising *n* enterprises. Focusing on one of these enterprises, the *enterprise 1* defines a set of *x* objectives (o_{1x}) and a set of *k* KPIs (kpi_{1xk}) to measure these objectives. o_{11}: *Increase Market share by 10%* is defined by the *enterprise 1*. kpi_{111} and kpi_{112} are defined in order to measure the performance level of o_{11}; and both have the same relevance for the *enterprise 1* ($w_{11k} = 0.5$):

- Δkpi_{111}: $\Delta marketShare_{[\%]} = marketShare_t - marketShare_{(t-1)}$, where Δkpi^{max}_{111} = *30%*
- Δkpi_{112}: $\Delta numOrders_{[units]} = numOrders_t - numOrders_{(t-1)}$, where Δkpi^{max}_{112} = *80 units*

In order to achieve o_{11}, *enterprise 1* formulates two strategies, s_{11}: *Internationalisation, opening new markets abroad* and s_{12}: *Open new sales channels through Internet*. Assuming that *enterprise 1* carries out the two strategies formulated, the KPIs results are: $\Delta kpi_{111} = 25\%$ and $\Delta kpi_{112} = 10$ *units*. These KPIs cannot be compared because there are measured in different units. To make them comparable the estimated parameter Δkpi^{max}_{ixk} is used. Consequently:

$$\Delta kpi'_{111} = \frac{25\%}{30\%} = 0{,}833$$

$$\Delta kpi'_{112} = \frac{10\ units}{80\ units} = 0{,}125$$

The homogenised values of $\Delta kpi'_{111}$ and $\Delta kpi'_{112}$ can now be compared and computed together. Thus, $\Delta kpi'_1 = (0{,}833 \cdot 0{,}5) + (0{,}125 \cdot 0.5) = 0{,}479$.

STEP 2. Normalisation of the parameters related to durations and time.

The parameters of duration in the SAM, given by $d_{1}\_str_{is}$, $d_{2}\_str_{is}$, $d_{3}\_str_{is}$ and $d_{4}\_str_{is}$, and the points in time represented by ti_str_{is} and tf_str_{is}, are used based on the horizon (*H*) of time in which the strategies alignment process is modelled. Besides this, the proposed SAM uses a normalised horizon of time, what means that the total time to be modelled is the unit, *H'=1*. For instance, if the problem to be modelled has a horizon of five years, *H=5*, in the SAM, this horizon has to be normalised to the unit. Consequently, duration parameters ($d_{1}\_str_{is}$, $d_{2}\_str_{is}$, $d_{3}\_str_{is}$ and $d_{4}\_str_{is}$) and the decision variable (ti_str_{is}) will be also referred to the unit. To normalise all the data to the unit, the equations (5.10), (5.11), (5.12), (5.13), (5.14), (5.15), (5.16) are to be applied:

$$H' = \frac{H}{H} = 1$$

(5.10)

$$d'_1\_str_{is} = \frac{d_1\_str_{is}}{H}$$

(5.11)

$$d'_2\_str_{is} = \frac{d_2\_str}{H}$$

(5.12)

$$d'_4\_str_{is} = \frac{d_4\_str}{H}$$

(5.13)

$$d'_3\_str_{is} = d'_4\_str_{is} - 2 \cdot d'_{2str_{is}} - d'_1\_str_{is}$$

(5.14)

$$t'_i\_str_{is} = \frac{t_i\ \_str_{is}}{H}$$

(5.15)

$$t'_f\_str_{is} = \frac{t_f\ \_str_{is}}{H}$$

(5.16)

The time constraint refers to the time instant in which the activated strategies end up:

$$t'_f\_str_{is} \geq H'$$

(5.17)

Example 5.3. An illustrative example is proposed to normalise duration parameters, applying the equations (5.10 – 5.16). Lets suppose that the horizon to be modelled is $H = 5\ years$ therefore, $H' = \frac{5}{5}$; where the inverted comma indicates that the parameter has been normalised to the unit of time. As regards the duration parameters:

- $d_1\_str_{is} = 3\ months\ (0{,}25\ years)$, $d'_1\_str_{is} = \frac{0{,}25}{5} \rightarrow d'_1\_str_{is} = 0'05\ t.u.$
- $d_2\_str_{is} = 16\ days\ (\frac{16\ days}{12\ moths \cdot 4\ weeks \cdot 7\ days} = 0{,}048\ years)$, $d'_2\_str_{is} = \frac{0{,}048}{5} \rightarrow d'_2\_str_{is} = 0'009$ $t.u.$
- $d_4\_str_{is} = 3\ years\ and\ 9\ months\ (\frac{9\ months}{12\ moths} = 0{,}75\ years)$, $d'_4\_str_{is} = \frac{3{,}75}{5} \rightarrow d'_4\_str_{is} = 0'75\ t.u$
- $d'_3\_str_{is} = 0{,}75 - (2 \cdot 0{,}009) - 0{,}05 = 0{,}628\ t.u.$

STEP 3. Definition of the function $f\_inf\_str_{is}\_kpi'_{ixk}$

Two *decision variables*, u_str_{is} and t_str_{is}, are defined in order to maximise the parameter $\Delta kpi'_{net}$. The decision variable u_str_{is} decomposes the strategy (str_{is}) in units of strategy, allowing representing the "intensity" in which each strategy str_{is} is activated.

Depending on the strategies being modelled, the decision variable u_str_{is} will behave differently and will hold different values. Three main types of strategies are considered:

- u_str_{is} binary {0, 1}: the strategy can only achieve two states: activated or non-activated. Therefore, the decision variable u_str_{is} only holds binary values. The activation cost is the same as the cost of totally activating the strategy.

- u_str_{is} discrete: the strategy, when active, can achieve different values of intensity holding integer values. The activation cost depends on the units of strategies activated.
- u_str_{is} continuous: the strategy can achieve different values of intensity, holding real values. The activation cost depends on the units of strategies activated.

The SAM considers that what is being modelled in the strategies alignment process is one unit of strategy, coinciding with the decision variable, u_str_{is}. In the light of this, the strategies must be formulated according to the unit of strategy (u_str_{is}). In order to give a clear comprehension, an example of strategy formulation is proposed for each of the three types of values that one unit of strategy can hold.

Example 5.4.a The strategy can only acquire binary values. u_str_{is}: "Open a new market". This strategy can only achieve two states, active (str_{is}^{1}) being u_str_{is} =1 to open a new market, or non-active (str_{11}^{0}) u_str_{is}=0 not to open a new market. Therefore, the decision variable u_str_{is} only holds binary values [0, 1] ("all or nothing").

Example 5.4.b The strategy acquires discrete values. str_{is}: "Buy machines (at maximum 3)" → Translating this strategy to one unit of strategy, u_str_{is}: "Buy 1 machine". The activation of one unit of strategy (u_str_{is}) has associated the cost of buying one machine (i.e. 10000 m.u.). The resource machines cannot be divided; therefore, the decision that enterprises have to make will be related with how many machines to buy [0, 1, 2, 3]. The machine/s will be bought only once. Therefore, regardless the horizon to model, one investment will be done along the simulation horizon.

Example 5.4.c The strategy acquires continuous values. str_{is}: "Invest on Marketing activities (at maximum 500 m.u.)" → Translating this strategy to one unit of strategy, u_str_{is}: "Invest 100 m.u. in Marketing activities". Unlike occurring with machines/workers, the monetary units invested can be divided; therefore, the decision will be related with how many monetary units invest, from 0 to the maximum amount that the enterprise is willing to invest (i.e. 500 m.u.). Different degrees of spending may occur; depending on the number of units of strategy activated (u_str_{is}). Marketing activities will be carried out along the strategy duration.

As introduced in the *Example 5.4*, one unit of strategy has an associated a cost (c_str_{is}). Therefore, depending on the parameter c_str_{is}, the enterprise' budget (b_i) will be reduced in a lesser or larger extent. The higher budget, the more units of strategies (u_str_{is}) can be activated; hence, the more u_str_{is}, the less quantity of monetary units will remain in the budget. The total amount of monetary units spent when the strategy str_{is} is activated, considering a linear relationship, is computed as follows:

$$str_{is}\_mu = u\_str_{is} \cdot c\_str_{is}$$

(5.18)

The budget, b_i, owned by each company defines the monetary capacity constraint.

$$b_i \geq \sum_s str_{is}\_mu \quad \forall s$$

(5.19)

A strategy str_{is} is activated when $u\_str_{is} > 0$. The activation of a strategy has an influence that can be positive, negative or null, in the objectives achievement. In order to identify the influence that one unit of strategy ($u\_str_{is} = 1$) has over the $\Delta kpi'_{ixk}$, parameter $val\_str_{is}\_kpi'_{ixk}$ is used. Depending whether $val\_str_{is}\_kpi'_{ixk}$ is positive or negative, the kpi'_{ixk} will be increased or decreased when the strategy str_{is} is activated. Considering the values of u_str_{is} and $val\_str_{is}\_kpi'_{ixk}$, the parameter $inf\_str_{is}\_kpi'_{ixk}$ is computed as:

$$inf\_str_{is}\_kpi'_{ixk} = u\_str_{is} \cdot val\_str_{is}\_kpi'_{ixk}$$

(5.20)

The influence that one strategy str_{is} has on a particular $\Delta kpi'_{ixk}$ is modelled through the function $f\_inf\_str_{is}\_kpi'_{ixk}$. This function, $f\_inf\_str_{is}\_kpi'_{ixk}$, is a piecewise function that depends on the time [$f_1(t)$], that is, the duration parameters ($d_1\_str_{is}$, $d_2\_str_{is}$, $d_3\_str_{is}$ and $d_4\_str_{is}$) and the decision variable ti_str_{is} (Figure 5.7). The decision variable ti_str_{is} identifies the starting point of activation of the str_{is} and allows modelling that not all the strategies are activated at the same time, i.e. at the initial time (t_0). Unlike, the strategies are activated in different times (ti_str_{is}) of the horizon identified (H).

Once identified the ti_str_{is} it must be considered that str_{is} does not immediately influence the level of kpi'_{ixk}, but it experiments a delay given by $d_1\_str_{is}$. Besides, $f\_inf\_str_{is}\_kpi'_{ixk}$ is modelled according to a ramp shape ($slope\_str_{is}\_kpi'_{ixk}$). The representation of the ramp allows modelling that, after the delay time ($d_1\_str_{is}$), the str_{is} progressively influences the kpi'_{ixk}. This ramp depends on the duration defined by $d_2\_str_{is}$. Once passed $d_2\_str_{is}$, the maximum level of influence, $inf\_str_{is}\_kpi'_{ixk}$, is achieved. The parameter $d_4\_str_{is}$ is given by the enteprise as the total duration in which the strategy str_{is} is active.

$$slope\_str_{is}\_kpi'_{ixk} = \frac{inf\_str_{is}\_kpi'_{ixk}}{d'_2\_str_{is}}$$

(5.21)

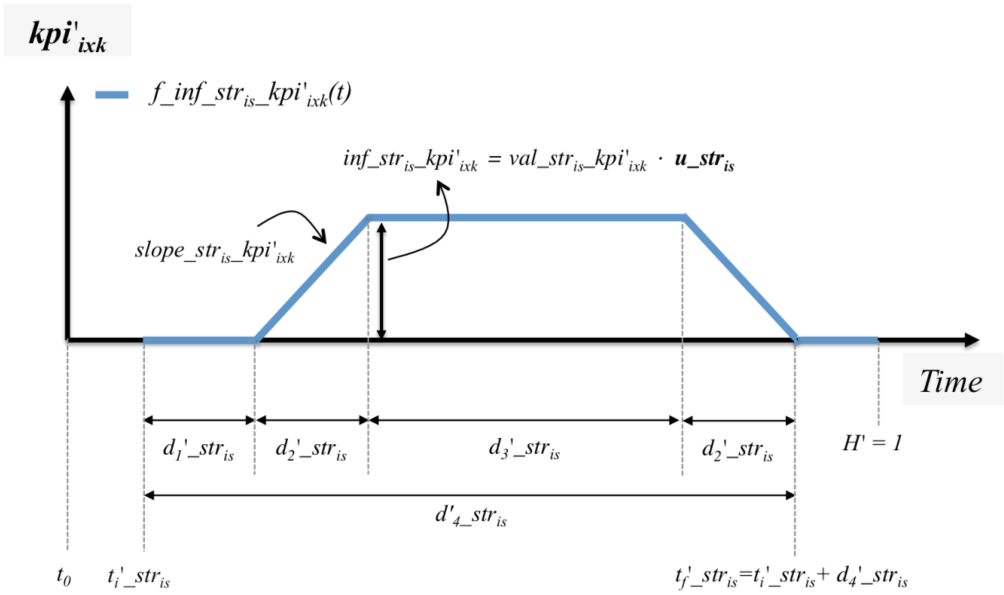


Figure 5.7. Curve that models the influence of str_{is}on the kpi'_{ixk}: $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$

Taking into account the aforementioned, the function of influence$f_inf_str_{is}_kpi'_{ixk}\ (t)$ is mathematically represented as a piecewise function:

$$f\_inf\_str_{is}\_kpi'_{ixk}\ (t) = \begin{cases} 0 \longrightarrow t \leq t'_i\_str_{is} + d'_1\_str_{is} \ \wedge \ t \geq t'_i\_str_{is} + d'_4\_str_{is} \\ slope\_str_{is}\_kpi'_{ixk} \longrightarrow t'_i\_str_{is} + d'_1\_str_{is} < t < t'_i\_str_{is} + d'_1\_str_{is} + d'_2\_str_{is} \\ inf\_str_{is}\_kpi'_{ixk} \longrightarrow t'_i\_str_{is} + d'_1\_str_{is} + d'_2\_str_{is} \leq t \leq t'_i\_str_{is} + d'_1\_str_{is} + d'_2\_str_{is} + d'_3\_str_{is} \\ -slope\_str_{is}\_kpi'_{ixk} \longrightarrow t'_i\_str_{is} + d'_1\_str_{is} + d'_2\_str_{is} + d'_3\_str_{is} < t < t'_f\_str_{is} \end{cases}$$

(5.22)

STEP 4. Computing the increase of the KPIs at both enterprise and network level: $\Delta kpi'_i$ and $\Delta kpi'_{net}$

The influence received by the KPIs defined in one enterprise i not only depends on the strategies activated in the same enterprise, but also depends on the strategies activated in the other enterprises j of the network. Accordingly, the $\Delta kpi'_{ixk}$ is caused by both intra-enterprise influence, $\Delta^{intra} kpi'_{ixk}$, (Figure 5.7) and inter-enterprise influences, $\Delta^{inter} kpi'_{ixk}$, (Figure 5.8), mathematically modelled as:

$$\Delta^{intra} kpi'_{ixk} = \int_{t'_i\_str_{is}+d'_1\_str_{is}}^{H'} f\_inf\_str_{is}\_kpi'_{ixk}(t) \cdot dt$$

(5.23)

$$\Delta^{inter} kpi'_{ixk} = \int_{t'_i\_str_{js}+d'_1\_str_{js}}^{H'} f\_inf\_str_{js}\_kpi'_{ixk}(t) \cdot dt$$

(5.24)

Thus,

$$\Delta kpi'_{ixk} = \Delta^{intra} kpi'_{ixk} + \Delta^{inter} kpi'_{ixk}$$

(5.25)

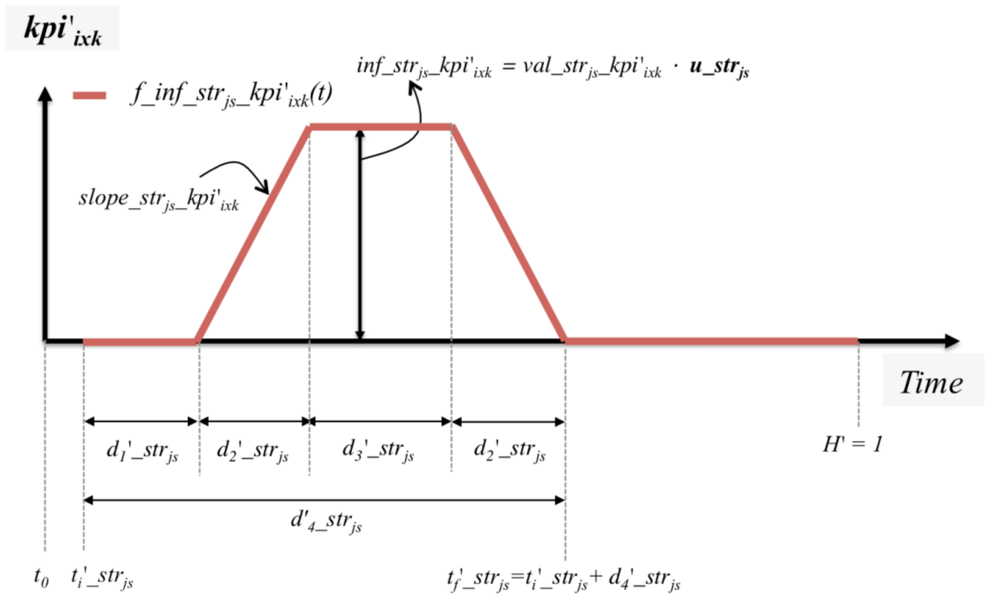


Figure 5.8. Inter-enterprise influence curve. Modelling the influence of str_{js}on the kpi'_{ixk}: $f\_\text{inf}\_str_{js}\_kpi'_{ixk}\ (t)$

Accordingly, the function representing the curve of the total increase of the kpi'_{ixk} is also a piecewise function that depends on time (*f2(t)*)given by:

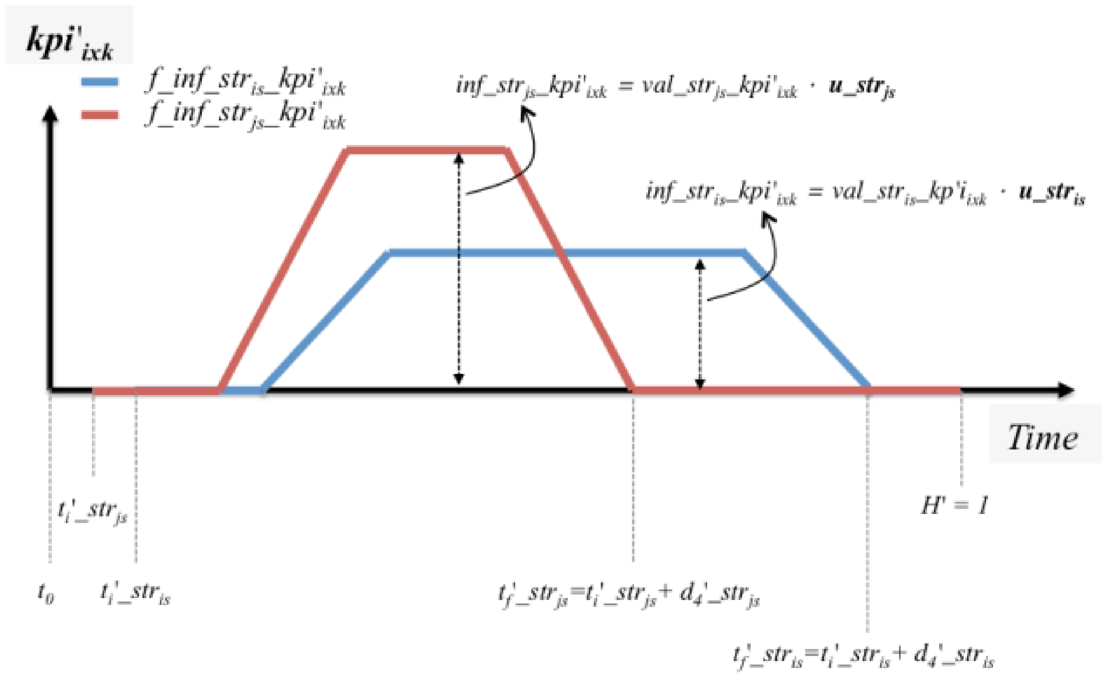
$$f\_kpi'_{ixk} = f\_inf\_str_{is}\_kpi'_{ixk}\ (t) + f\_inf\_str_{js}\_kpi'_{ixk}\ (t)$$

(5.26)

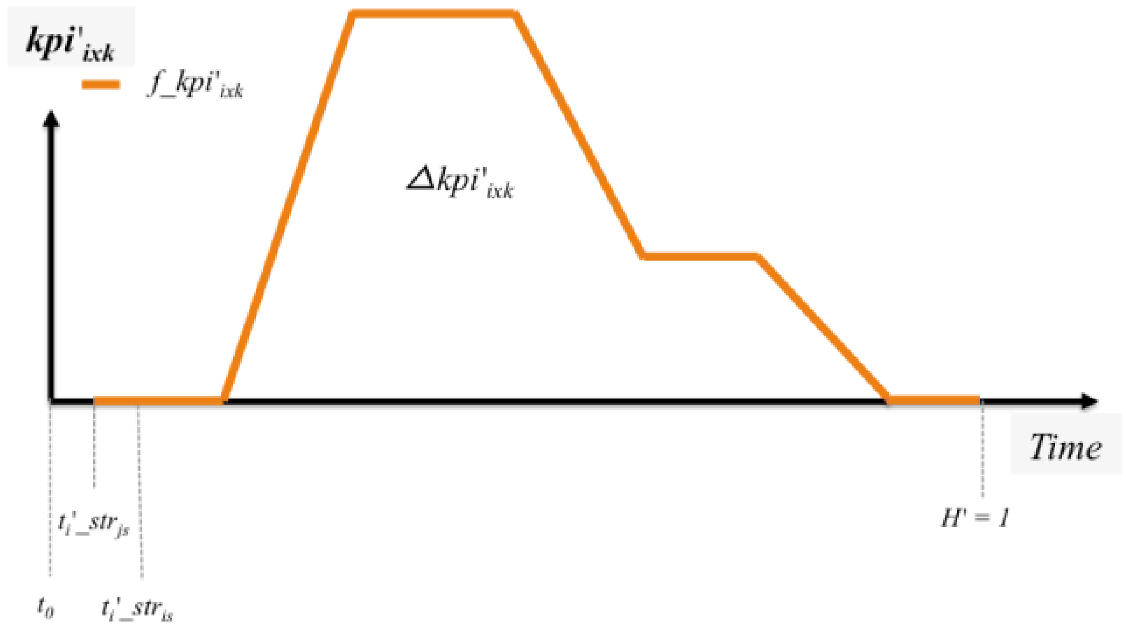
$$\Delta kpi'_{ixk} = \int_0^{H'} f\_kpi'_{ixk}(t) \cdot dt$$

(5.27)

And represented as follows in Figure 5.9.



a)



b)

Figure 5.9. a) $f\_inf\_str_{is}\_kpi'_{ixk}$ (t) and $f\_inf\_str_{js}\_kpi'_{ixk}$ (t). b) $f\_kpi'_{ixk}$

After being depicted the function $f\_kpi'_{ixk}$ and computed the $\Delta kpi'_{ixk}$, the value estimated by the threshold ($Threshold\_kpi'_{ixk}$) must be considered (Figure 5.10).

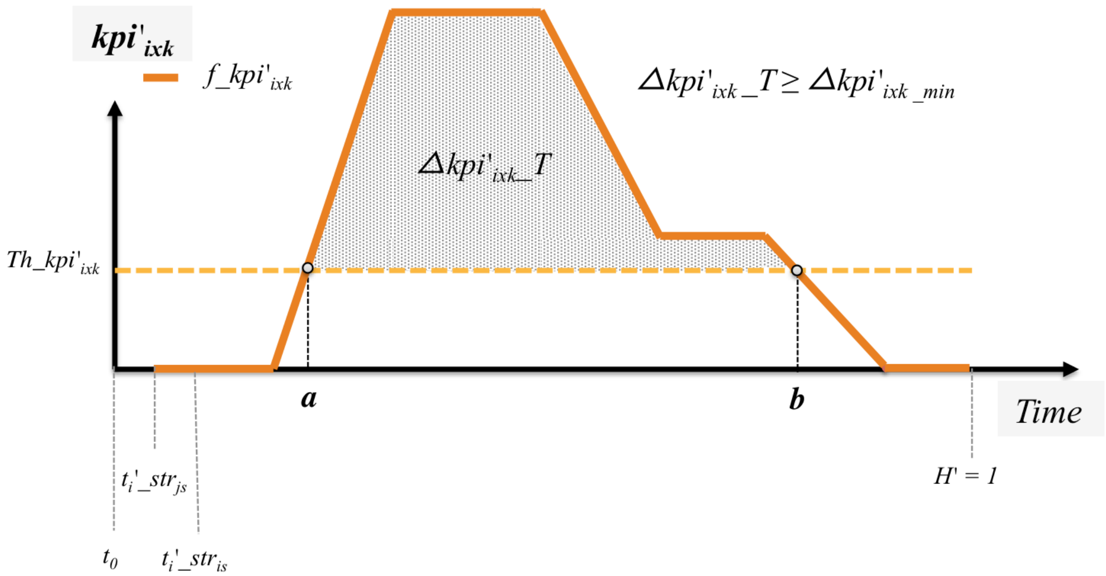


Figure 5.10.Threshold value consideration ($Threshold\_kpi'_{ixk}$)

Being,

$$f\_kpi'_{ixk}\_T(t) = f\_kpi'_{ixk}(t) - Th\_kpi'_{ixk}$$

(5.28)

The real increase of the kpi_{ixk} noticed by the enterprise when a certain set of strategies str_{is} are activated, is calculated considering that:

$$\Delta kpi'_{ixk}\_T = \int_a^b f\_kpi'_{ixk}(t) \cdot dt - \int_0^{H'} Th\_kpi'_{ixk} \cdot dt$$

(5.29)

Where,

$f\_kpi'_{ixk}(a) = Threshold\_kpi_{ixk}$

$f\_kpi'_{ixk}(b) = Threshold\_kpi_{ixk}$ / $b > a$ $(b = tf\_str_{is})$

There is a restriction associated with the parameter $\Delta kpi'_{ixk}\_T$ that consist of considering the minimum increase that the enterprise estimates for each kpi'_{ixk}. After computing the value $Threshold\_kpi'_{ixk}$ to the function $f\_kpi'_{ixk}(t)$, the $\Delta kpi'_{ixk}\_T$ has to be higher than the minimum increase defined by the enterprise $\Delta kpi'_{ixk}\_min$.

$$fulfillment\_kpi'_{ixk} = \begin{cases} 1 \rightarrow \Delta kpi'_{ixk}\_T \geq \Delta kpi'_{ixk}\_min \\ 0 \rightarrow \Delta kpi'_{ixk}\_T < \Delta kpi'_{ixk}\_min \end{cases}$$

(5.30)

The $\Delta kpi'_{ixk}\_min$ is the homogenised version of the Δkpi_{ixk}_min and is computed as follows

$$\Delta kpi'_{ixk}\_\min = \frac{\Delta kpi_{ixk}\_min}{\Delta kpi^{max}_{ixk}}$$

(5.31)

To finally characterise the SAM, two KPIs are defined, at enterprise and network levels:

- At enterprise level the parameter $\Delta kpi'_i$ is defined as the sum of the results perceived by each $\Delta kpi'_{ixk}\_T$ belonging to the same enterprise *i*.

  Each enterprise *i* defines each own objectives to be achieved o_{ix}, which are measured through KPIs (kpi_{ixk}). Each kpi_{ixk} has associated a weight (w_{ixk}):

$$\sum_{x,k} w_{ixk} = 1 \qquad \forall\, x, k$$

(5.32)

, where $w_{ixk} = [0, \ldots, 1]$

The parameter $\Delta kpi'_i$ takes into account the weights defined (w_{ixk}) for each kpi'_{ixk}. $\Delta kpi'_i$ gives an insight on how the performance is behaving at enterprise level.

$$\Delta kpi'_i = \frac{\sum_{x,k} \Delta kpi'_{ixk}\_T \cdot w_{ixk}}{\sum_{x,k} w_{ixk}}$$

(5.33)

- At network level the $\Delta kpi'_{net}$ parameter is defined as the sum of the all the $\Delta kpi'_i$ obtained in each the network enterprise. $\Delta kpi'_{net}$ gives a whole perspective on how the performance is behaving at network level.

$$\Delta kpi'_{net} = \frac{\sum_i \Delta kpi'_i}{n}$$

(5.34)

The proposed mathematical optimisation model (SAM) has its main aim on maximising the network performance level ($\Delta kpi'_{net}$). Through identifying the number of units of strategies to activate (u_str_{is}) and the initial time when activate them (ti_str_{is}), so that make positive impacts on the objectives defined by the nodes of the network.

5.5 Example 5.5. Illustrative Example

An example is presented with the main aim of illustrating how the previously developed SAM can be used to:

- formally represent the relationships between the formulated strategies and the objectives defined,
- model the negative and positive influences between the strategies and the objectives, and
- having modelled the strategies alignment process, applying the SAM, a reasoned solution is described to identify the strategies that have better levels of alignment.

The example is proposed considering two enterprises (Figure 5.11), each one defining two objectives. The achievement of the objectives is measured through the KPIs (kpi_{ixk}) each one with its corresponding weights (w_{ixk}):

- enterprise 1 (e_1)
  - o_{11}: Increase the product sales by a 10%
    $$\Delta kpi_{111} = \Delta sales = \frac{sales_{\,t} - sales_{t-1}}{sales_{\,t}} \times 100$$
  - o_{12}: Reduce the costs of the product by a 5%
    $$-\Delta kpi_{121} = -\Delta costs = -\left(\frac{costs_{\,t} - costs_{t-1}}{costs_{\,t-1}} \times 100\right)$$

- enterprise 2 (e_2)
  - o_{21}: *Increase the enterprise profit by a 15%*

    $$\Delta kpi_{211} = \Delta netProfit = \frac{netProfit_t - netProfit_{t-1}}{netProfit_t} \times 100$$
  - o_{22}: *Reduce the quantity of product that cannot be sold by 100 %*

    $$\Delta kpi_{121} = \Delta prodNOdistributed = -\left(\frac{prodNOdistributed_t - prodNOdistributed_{t-1}}{prodNOdistributed_{t-1}} \times 100\right)$$

In order to achieve the objectives each enterprise formulates two strategies (e_1: str_{11} and str_{12}, e_2: str_{21} and str_{22}).

- enterprise 1 (e_1)
  - str_{11}: Increase the marketing activities on the product
  - str_{12}: Conduct negotiations with the manufacturing partner to reduce purchasing costs
- enterprise 2 (e_2)
  - str_{21}: Use different distribution channels to open the product in other markets.
  - str_{22}: Promotions combining the disturbed product with others (i.e. hamburger with hamburger bun).

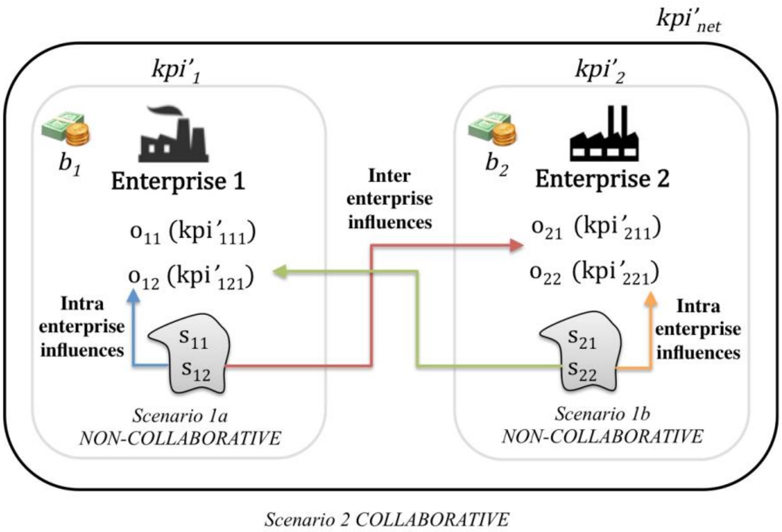


Figure 5.11. Scenarios description

All the data gathered directly from the enterprises is stored inTable 5.4, in which it can be seen the data related with the strategies durations and costs as well as the values of influence $val\_str_{is}\_kpi'_{ixk}$ estimated by each enterprise and the budget. Afterwards, Table 5.5 is presented, in which the data regarding the KPIs parameters is already homogenised according to equation 5.9 and the duration parameters are normalised to the unit considering the equations 5.10 – 5.16.

Table 5.4. Numerical Example: Enterprises Data

H = 5 years																
Enterprise 1 ***b_1* = 3**																
													kpi_{111}		kpi_{121}	
													kpi_{111}^{max}	10%	kpi_{121}^{max}	5%
													w_{111}	0,5	w_{121}	0,5
													$Threshold\_kpi_{111}$	2%	$Threshold\_kpi_{121}$	0,5%
str_{11}	u_str_{11}	?	ti_str_{11}	?	c_str_{11}	2	$d_1\_str_{11}$	3 months	$d_2\_str_{11}$	16,8 days	$d_4\_str_{21}$	3 years	$val\_str_{11}\_kpi_{111}$	8%	$val\_str_{11}\_kpi_{121}$	-0,05%
str_{12}	u_str_{12}	?	ti_str_{12}	?	c_str_{12}	3	$d_1\_str_{12}$	12 months	$d_2\_str_{12}$	1,8 months	$d_4\_str_{21}$	2,5 years	$val\_str_{12}\_kpi_{111}$	3%	$val\_str_{12}\_kpi_{121}$	3,5%
													$val\_str_{21}\_kpi_{111}$	-1%	$val\_str_{21}\_kpi_{121}$	-1,5%
													$val\_str_{22}\_kpi_{111}$	3%	$val\_str_{22}\_kpi_{121}$	1%
Enterprise 2 ***b2* = 6**																
													kpi_{211}		kpi_{221}	
													kpi_{211}^{max}	15%	kpi_{221}^{max}	100%
													w_{211}	0,5	w_{221}	0,5
													$Threshold\_kpi_{211}$	4,5%	$Threshold\_kpi_{221}$	15%
str_{21}	u_str_{21}	?	ti_str_{21}	?	c_str_{21}	6	$d_1\_str_{21}$	6 months	$d_2\_str_{21}$	1,2 months	$d_4\_str_{21}$	3,75 years	$val\_str_{21}\_kpi_{211}$	10,5%	$val\_str_{21}\_kpi_{221}$	0%
str_{22}	u_str_{22}	?	ti_str_{22}	?	c_str_{22}	5	$d_1\_str_{21}$	3 months	$d_2\_str_{21}$	16,8 days	$d_4\_str_{21}$	2,5 years	$val\_str_{22}\_kpi_{211}$	3%	$val\_str_{22}\_kpi_{221}$	80%
													$val\_str_{11}\_kpi_{211}$	4,5%	$val\_str_{11}\_kpi_{221}$	4%
													$val\_str_{12}\_kpi_{211}$	3%	$val\_str_{12}\_kpi_{221}$	-3%

Table 5.5. Homogenised and normalised data

Enterprise 1 $b_1 = 3$

													kpi'_{111}		kpi'_{121}	
													w_{111}	0,5	w_{121}	0,5
													$Threshold\_kpi'_{111}$	0,2	$Threshold\_kpi'_{121}$	0,1
str_{11}	u_str_{11}	?	ti_str_{11}	?	c_str_{11}	2	$d'_1\_str_{11}$	0,05	$d'_2\_str_{11}$	0,01	$d'_4\_str_{21}$	0,6	$val\_str_{11}\_kpi'_{111}$	0,8	$val\_str_{11}\_kpi'_{121}$	-0,01
str_{12}	u_str_{12}	?	ti_str_{12}	?	c_str_{12}	3	$d'_1\_str_{12}$	0,2	$d'_2\_str_{12}$	0,03	$d'_4\_str_{21}$	0,5	$val\_str_{12}\_kpi'_{111}$	0,3	$val\_str_{12}\_kpi'_{121}$	0,7
													$val\_str_{21}\_kpi'_{111}$	-0,1	$val\_str_{21}\_kpi'_{121}$	-0,3
													$val\_str_{22}\_kpi'_{111}$	0,3	$val\_str_{22}\_kpi'_{121}$	0,2

Enterprise 2 $b2 = 6$

													kpi'_{211}		kpi'_{221}	
													w_{211}	0,5	w_{221}	0,5
													$Threshold\_kpi'_{211}$	0,3	$Threshold\_kpi'_{221}$	0,15
str_{21}	u_str_{21}	?	ti_str_{21}	?	c_str_{21}	6	$d'_1\_str_{21}$	0,1	$d'_2\_str_{21}$	0,02	$d'_4\_str_{21}$	0,75	$val\_str_{21}\_kpi'_{211}$	0,7	$val\_str_{21}\_kpi'_{221}$	0
str_{22}	u_str_{22}	?	ti_str_{22}	?	c_str_{22}	5	$d'_1\_str_{21}$	0,05	$d'_2\_str_{21}$	0,01	$d'_4\_str_{21}$	0,5	$val\_str_{22}\_kpi'_{211}$	0,2	$val\_str_{22}\_kpi'_{221}$	0,8
													$val\_str_{11}\_kpi'_{211}$	0,3	$val\_str_{11}\_kpi'_{221}$	0,4
													$val\_str_{12}\_kpi'_{211}$	-0,2	$val\_str_{12}\_kpi'_{221}$	-0,3

Focusing on kpi'_{111} (Table 5.5) it can be stated that the strategies defined in the same enterprise 1 influence the achievement of o_{11} in a way in which:

- The strategy str_{11} strongly influences in a positive way (increasing the level of kpi'_{111}) the achievement of kpi'_{111} ($val\_str_{11}\_kpi'_{111}$ = *0,8*).
- The strategy str_{12} slightly influences in a positive way (increasing the level of kpi'_{111}) the achievement of kpi'_{111} ($val\_str_{12}\_kpi'_{111}$ = *0,3*).

Besides, *kpi'₁₁₁* is also influenced by the strategies defined in another network enterprise (e_2):

- The strategy str_{21} slightly influences in a negative way (decreasing the level of kpi'_{111}) the achievement of kpi'_{111} ($val\_str_{21}\_kpi'_{111}$ = *-0,1*)
- The strategy str_{22} slightly influences in a positive way (increasing the level of kpi'_{111}) the achievement of kpi'_{111} ($val\_str_{22}\_kpi'_{111}$ = *0,3*)

This influences experienced by kpi'_{111} are graphically depicted in Figure 5.12a through four curves of influence:

- $f\_\inf\_str_{11}\_kpi'_{111}(t)$, influence that the strategy str_{11} exerts over the normalised kpi'_{111}
- $f\_inf\_str_{12}\_kpi'_{111}(t)$, influence that the strategy str_{12} exerts over the normalised kpi'_{111}
- $f\_inf\_str_{21}\_kpi'_{111}(t)$, influence that the strategy str_{21} exerts over the normalised kpi'_{111}
- $f\_inf\_str_{22}\_kpi'_{111}(t)$, influence that the strategy str_{22} exerts over the normalised kpi'_{111}

After that, the function $f\_kpi'_{111}(t)$ is depicted in Figure 5.12b as:

$$f\_kpi'_{111}(t) = \sum_{i,s} f\_inf\_str_{is}kpi'_{111}(t) \quad \forall\, i, s$$

(5.35)

Finally, taking into account that the $Threshold\_kpi_{111} = 0.2$ the real increase of the kpi'_{111} is computed as follows:

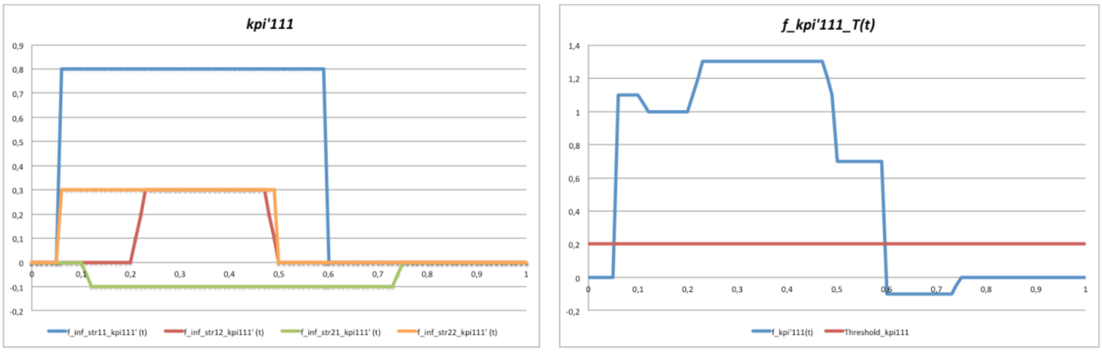
$$\nabla kpi'_{111}\_T = \int_a^b f\_kpi'_{111}(t) \cdot dt - \int_0^{H'} Th\_kpi'_{111} \cdot dt$$

(5.36)

Where,

$f_{kpi'_{ixk}}(a) = 0.2$

$f_{kpi'_{ixk}}(b) = 0.2$ / $b > a$



a) b)

Figure 5.12. Graphical Example for kpi'_{111}

The rest of functions regarding the kpi'_{121}, kpi'_{211} and kpi'_{221} are respectively draw from Figure 5.13, Figure 5.14 and Figure 5.15

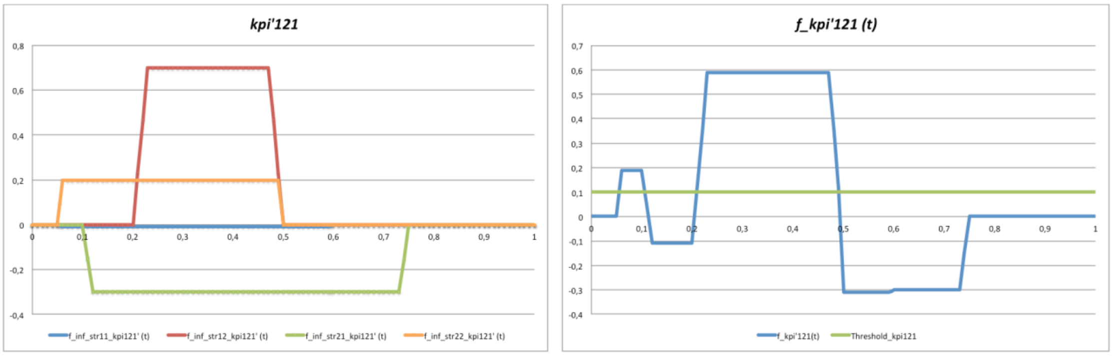


Figure 5.13. Graphical Example for kpi'_{121}

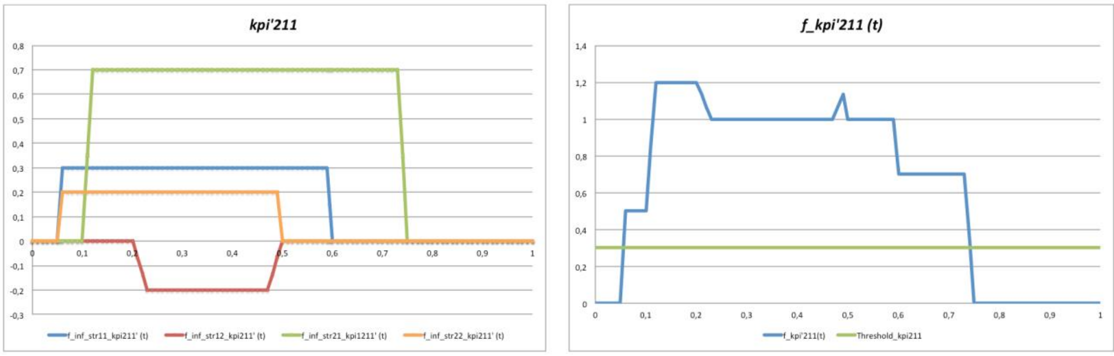


Figure 5.14. Graphical Example for kpi'_{211}

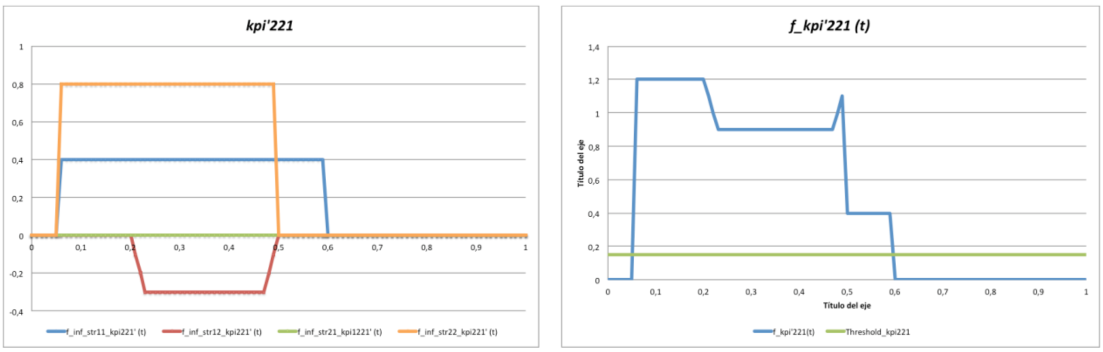


Figure 5.15. Graphical Example for kpi'_{221}

Considering a logical reasoning the solution of the raised illustrative example can be deduced by taking into account the values estimated by the enterprises as regards the value $val\_str_{is}\_kpi_{ixk}$. For this logical reasoning, a supposition is made, considering that the units of strategies are considered as $u\_stris = 1$.

Within the non-collaborative context the enterprises only take into account the values regarding their own strategies and their own objectives (KPIs). the values ($val\_str_{is}\_kpi_{ixk}$) considered are those of the cells shaded in dark grey (see Table 5.5).

In *enterprise 1* (Scenario 1a) the values ($val\_str_{is}\_kpi_{ixk}$) considered are only those related with the influences that its own strategies (str_{1s}) have in its own objectives (o_{1x}, kpi_{1xk}). Thus, it can be stated that the strategy str_{12} has higher positive influences than the str_{11}. This is due to the str_{12} has positive connotations in both KPIs kpi_{111} and kpi_{121}. Although str_{11} increases the kpi_{111} in 0,8, the kpi_{121} reduces its performance level in $0{,}01$ points. On the whole, the str_{12} offers better performance levels ($0{,}7 + 0{,}3$) than the str_{11} ($0{,}8 - 0{,}01$).

In *enterprise 2* (Scenario 1b): the values ($val\_str_{js}\_kpi_{ixk}$) considered are only those related with the influences that its own strategies (str_{2s}) have in its own objectives (o_{2x}, kpi_{2xk}). It can be stated that the strategy str_{22} has higher positive influences than the str_{21}. This is due to the str_{22} has positive values $val\_str_{22}\_kpi_{ixk}$, which are higher than 0, for both kpi_{111} and kpi_{121}; Although str_{21} increases the kpi_{211} in 0,7, the kpi_{221} reduces its performance level until 0 points. Overall, the str_{22} offers better performance levels ($0{,}8 + 0{,}2$) than the str_{21} ($0{,}7 + 0$).

In the collaborative context (Scenario 2) the data from both enterprises is considered and the decisions are made collaboratively considering which strategies could disfavour and which ones benefit the achievement of the performance indicators defined in the two enterprises participating in this illustrative network example. In this scenario, all the data depicted in the Table 5.5 must be taken into account. The two enterprises considered in the numerical example know the values of influence ($val\_str_{is}\_kpi_{ixk}$) for all KPIs of all enterprises belonging to the CN. These values show that the strategies activated by an enterprise not only affect the attainment of objectives in the same enterprise, in which the strategies are formulated, but also influence the achievement (in a positive or a negative way) of the objectives of other companies in the CN. According to the data given in the numerical example it can be observed that:

In enterprise 1, on the one hand, the activation of the str_{11} has positive connotations in the kpi_{111} but has slightly negative connotations in the performance level measured by the kpi_{121} (defined in the same company). However, the same strategy str_{11} has positive connotations in the KPIs defined by the enterprise 2 (that is, kpi_{211} and kpi_{221}). Therefore, the decision making of activating the str_{11} is a good one due to is considered a good global solution because positively affects all the KPIs in the network, except the kpi_{121} ($val\_st11_{2}\_kpi_{121}$). This reduction kpi_{121} is considered very slight. On the other hand, the decision making of activating the str_{12} has positive connotations in both KPIs defined in the enterprise 1, but has negative connotations in the KPIs of the enterprise 2, so that considering the performance level of the network as whole, the best solution is given by the choice of str_{11} since in general the negative effects experienced by performance level of the network are significantly lower than when the str_{12} is activated.

In enterprise 2, on the one hand, the activation of the str_{21} has positive connotations in the kpi_{211}, and does not influence the kpi_{221}. Besides, the str_{21} has negative connotations in the KPIs defined by the enterprise 1. On the other hand the activation of the str_{22} has associated positive influences in the KPIs defined in the enterprise 2. Moreover, the activation of the str_{22} has positive impacts for the KPIs defined in the enterprise 1, therefore, the activation of str_{22} results on better performance levels than the activation of the strategy str_{21}.

Summarising, according to the reasoning above described, for the non-collaborative scenario the best solution for each isolated enterprise is to activate str_{12} in enterprise 1 and str_{22} in enterprise 2. On the contrary, considering the collaborative scenario, the best solution is to activate str_{11} in enterprise 1 and str_{22} in enterprise 2. In this reasoned solution the costs, duration parameters and restrictions are not considered. Nevertheless, the approximated solution above presented allows showing how different are the solutions between the non-collaborative and collaborative scenarios. Aligning the strategies is related with the decision of which strategies to activate, considering all the influences that each strategy exerts on all the KPIS defined in the network, with the main aim of obtaining higher levels of performance both at network level.

This illustrative example considering two enterprises has been constructed in order to explain the SAM and its function. The homogenisation and normalisation of the SAM parameters is also shown. The approximate solution above proposed does not correspond to the optimal solution, considering the u_str_{is} decision variable. In the optimal solution, the decision variable regarding the ti_str_{is} will be also computed In order to obtain the optimum solution a formal method is to be identified and applied for the SAM resolution.
Concluding, the application of the proposed model (SAM) is the first step for dealing with the strategies alignment process, trough:

- Identifying the strategies that are aligned, that is, the set of strategies that positively influence the achievement of objectives not only in the own enterprise but also in other network enterprises. Maximising the global performance of the network ($\Delta kpi'_{net}$) and obtaining good performances at the enterprises level ($\Delta kpi'_i$), in order to improve the collaborative relationships during a determined horizon of operation.
- Identifying the units of strategies (u_str_{is}) that are to be activated in order to achieve the best performance, without overloading the budget. The strategies will be characterised by having better levels of alignment, positively influencing the enterprises' objectives achievement and the network performance.
- Identifying the initial time of activation of the strategies (ti_str_{is}) in order to achieve the best performance, without overloading the Horizon time, positively influencing the enterprises' objectives achievement and the network performance.
- Comparing the performance at network level and at enterprises level between the non-collaborative and the collaborative scenarios.
- Demonstrate that the establishment of a collaborative decision making, when identifying the set of strategies to be activated; leading to higher levels of alignment and providing better results than making the decision of which strategies activate from an isolated way (non-collaborative scenario). The solutions obtained in the collaborative scenario, as regards the strategies to activate, will provide higher levels of performance at network level than the solutions given by the non-collaborative scenario.

5.6 Chapter discussion and conclusions

This chapter presented the Strategies Alignment Model (SAM), allowing identifying the set of strategies to be activated in order to obtain maximum levels of network performance. The strategies with higher degrees of alignment will be characterised by promoting higher levels of performance with the related KPIs. The SAM is proposed considering the CN environment. SAM contributes to solve the main problem addressed by this dissertation, and more specifically to answer research questions 1 and 2 as regards (i) how to model the impact of the strategies at the inter-enterprise level and (ii) the proposal of an adequate model to support the process of identification of aligned strategies, through modelling the strategies impact on the objectives defined by each enterprise, in CN context.

A formal definition of CN is presented, in order to introduce the notion of objectives definition and strategies formulation and how both are related with the KPIs. Furthermore, a formal definition of strategies alignment is also given in order to promote a global understanding. A mathematical definition is developed in order to give a more precise definition.

Once the formal definitions are presented, a mathematical representation of the strategies alignment process is proposed to assess the alignment process. The SAM consists of the definition of a set of parameters, and decision variables (u_str_{is} and ti_str_{is}) used in a objective function ($max\,\Delta kpi'_{net}$) that looks out the values of the decision variables, maximising the network performance according to a certain set of restrictions associated to the SAM. The definition of the parameters and decision variables, as well as the restrictions associated to the SAM will be the basis for the development of a method to analyse the strategies alignment process and assess the alignment amongst all the strategies activated.

The modelling examples (*Examples 5.1 - 5.5*) outlined in this chapter show the potential application of the proposed model for strategies alignment in collaborative and non-collaborative scenarios (SAM). Moreover, some of the computations as regards the parameters decision variables and functions that feature the model are shown. The main contributions of each of the examples proposed are described in Table 5.6.

Table 5.6. Contribution of the provided numerical examples

Purpose	Ex. 5.1	Ex. 5.2	Ex. 5.3	Ex. 5.4	Ex. 5.5
To differentiate between strategies compatibility and strategies alignment	✓				
To define the strategies alignment concept, mathematical representation	✓				
To show Intra-enterprise influences between strategies and objectives of the same enterprise	✓				✓
To show Inter-enterprise influences between strategies and objectives of different enterprises	✓				✓
To show how to calculate the function of alignment	✓				
To compare of scenarios in pairs of aligned strategies	✓				
To show how to homogenise of parameters related to KPIs		✓			✓
To show how to normalise the duration parameters			✓		✓
To define the decision variable number of units of strategy u_str_{is}(binary, discrete and continuous values)				✓	
To show how to apply SAM to deal with the strategies alignment process					✓
To show the graphical representations of $f\_inf\_str_{is}\_kpi'_{ixk}$					
To show how to compute the increase of the KPIs at both enterprise and network level: $\Delta kpi'_i$ and $\Delta kpi'_{net}$					✓
To show how the objectives, KPIs and strategies raised in the enterprise are used to deal with the SAM					✓
To show the data required to feed the SAM					✓
To compare collaborative and non-collaborative scenarios when establishing the strategies alignment process					✓
To show how higher levels of strategies alignment, provides better results					✓

Despite the advantages of the application of the SAM, there is a main drawback that must be taken into account in future sections (especially in the Chapter 8. Guideline to deal with the Strategies Alignment Process in a CN). This limitation is related with the information gathering as regards the value $val\_str_{is}\_kpi'_{ixk}$, especially if the strategy str_{is} has never been activated before this parameter it is very difficult to estimate. In the light of this, network enterprises can opt for (i) estimating the parameter $val\_str_{is}\_kpi'_{ixk}$ or (ii) waiting until the strategy (str_{is}^1) is activated and measure the real value of $val\_str_{is}\_kpi'_{ixk}$. If the enterprise has stored the increase of the KPIs when a strategy specific strategy was activated in the past ($\Delta kpi'_{ixk}$ | $\nabla \mathrm{kpi}_{\mathrm{ixk}} | \mathrm{str}^1_{\mathrm{is}}$), the enterprise can objectively compute $val\_str_{js}\_kpi'_{ixk}$, for strategies activated in the same enterprise; and $val\_str_{js}\_kpi'_{ixk}$ for strategies active in different network enterprises.

5.7 References

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Chapter 6

Method to solve the Strategies Alignment Process in a CN

This chapter proposes System Dynamics (SD) method to deal with the strategies alignment process in a collaborative network (CN) context. First of all, the chapter discusses the appropriateness of the selected method to solve the strategies alignment model (SAM). Secondly, the model previously proposed in a mathematical notation are expressed in System Dynamics, and the causal and flow diagrams are presented. The parameters and decision variables defined in the mathematical model (SAM) are analogously categorised according to the variables' classification given by SD: level, flow and auxiliary variables.

6.1 Introduction

In Chapter 5 it has been pointed out that the misalignments among the strategies formulated by the collaborative enterprises might lead to a partnership failure. It was highlighted that an approach to promote alignment in the activation of strategies of each enterprise belonging to the CN was needed. In the light of this, a mathematical model (SAM) was proposed representing the enterprises, its objectives and strategies, and the relations established between them. The model was proposed based on computing the increase, or decrease, of the objectives performance level depending on the activated strategies. Nevertheless, a resolution method of the SAM is missing, so far. The main aim of this chapter is to respond to the need of identifying a suitable method that enables to understand, analyse, operate, graphically represent and solve the proposed SAM.

The term *method* stems from the Greek "*method"*, meaning goal, and "*odos"* meant as a way or path. Thus, a *method* provides the path, or the process, that enables to select and use techniques, which in turn enable to select and use tools. According to the (Oxford English Dictionary, 2015), the scientific method is "*a method or procedure that consists of a systematic observation, measurement, experimentation, development, analysis and modification of hypotheses*". A method will be identified, as a mechanism used to obtain the optimal solution of the SAM.

This chapter starts with a brief overview of the method selected, System Dynamics (SD), discussing why SD is an appropriate method to deal with the strategies alignment (Section 6.2). Afterwards, in Section 6.3 the mathematical model previously formulated in Chapter 5 (SAM) is constructed considering the principles of SD. The SD is the method used for the resolution of the SAM. In Section 6.4 an illustrative example is presented in order to show how the equations of the SAM are expressed in the SD context. Finally, some conclusions are given in Section 6.5.

6.2 System Dynamics application in the Strategies Alignment

Many developments in different disciplines can contribute to the foundation of CN, i.e. complexity theories, game theory, industrial dynamics methodology, multi-agent systems, graph theory, formal engineering methods, federated systems, self-organising systems, swarm intelligence, and social networks (Camarinha-Matos and Afsarmanesh, 2008).

System Dynamics is the method selected to solve the SAM, from a CN context. SD allows solving abstract models, such as the mathematical ones, using computer techniques to model and solve complex systems. SD is intuitive enough to represent the CN complex system, which consist of different autonomous entities and the decisions of one node may affect the other network nodes operation. Therefore, SD will enable to understand the structure and dynamics of CN, as a complex system. SD revolves around the concept of feedback and causality between observable variables. According to (Campuzano and Mula, 2011) SD examines the interaction between various functions within a system. In SD the representation of the causal relationships among the system components facilitate the understanding of their occurrence allowing improving the interaction between them.

The Strategies Alignment Process is characterised by the positive and negative flows generated among the components of the modelled system, and the causal relationships established between the defined objectives and the strategies formulated by each enterprise of the network. SD simulation approach allows simulating the features modelled in the SAM as regards the flows, feedback loops and causal relations. Therefore, it can be stated that the SAM proposed in Chapter 5 can be solved conveniently in SD. Other methods for solving the proposed model, such as mathematical programming (analytical methods of resolution), do not conveniently support some features of the SAM, such as (i) aspects of temporality or (ii) the modelling parameters such as $Threshold\_kpi_{ixk}$.

This chapter focuses on simulating the CN as a complex system, looking for possible conflicts between the formulated strategies and the defined objectives. SD will allow characterising the causal relationships established between the strategies and the objectives, and modelling the influences that the objectives experience when certain set of strategies are activated. The use of partial derivatives in SD enables to model how the increase in one variable (strategy) positively or negatively affects another variable (objective performance level). Besides, in SD the variables used allow to study aggregate magnitudes of the overall system enabling to model the system as a whole; that is the CN as a whole considering all the strategies and objectives of the enterprises belonging to the network. According to the aforementioned, SD allows understanding the structural reasons that lead the network to obtain optimal performance levels (Martin, 2006) through activating the most suitable strategies in each collaborative partner. The optimisation methods included in SD allow identifying which are the strategies that if activated brings about a maximum performance at network level.

6.3 Model construction in System Dynamics

The model constructed in Chapter 5 (SAM) is characterised by representing the strategies alignment process, using mathematical formalisms and accuracy. Taking into account the work presented so far in this dissertation, there has not been proposed yet a resolution method to solve the SAM to support the decision making of identifying the strategies that are aligned, considering the CN context. In order to solve the model raised to deal with the strategies alignment process, the *System Dynamics* (SD) method is adopted. In this section, the SAM is built considering the System Dynamics method. SD provides a graphical representation of the mathematical notation; hence, both representations are included in the SD resolution method: the graphical and mathematical.

The SAM is constructed in SD taking as a reference the guidelines listed by (Campuzano and Mula 2011). A system dynamics-based simulation model is built in order to solve the SAM and identify the optimum values of the decision variables (u_str_{is} and t_str_{is}) that maximise the performance level of the global network using the causal loop diagram and the flow diagram (Forrester 1961) to model the CN. Both diagrams are depicted and described in next sub-sections

6.3.1 Casual Loop Diagram Creation

The causal loop diagram is the graphical description that represents the system in SD. It includes all the system elements and represents the relationships among them. The relationships are represented by arrows, each of them have enclosed a positive "+" or negative "–" symbol. The "+" symbol means that a change on the original element of the arrow produces a change in the same direction in the destination variable; what means that, an increase/decrease in the initial element produces an increase/decrease in the destination element. On the contrary, the "–" symbol means that a change in the original element of the arrow brings about change in an opposite direction in the destination variable; so that an increase on the original element produces a decrease in the destination element, and vice versa. Next steps are considered to create the causal loop diagram (Figure 6.1).

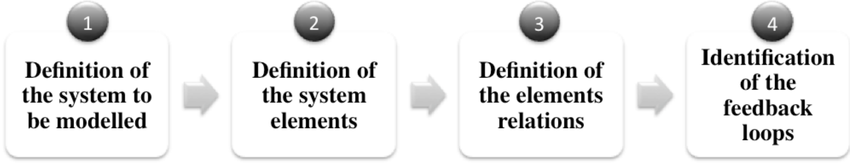

Figure 6.1. Building steps: Causal Loop Diagram

STEP 1. Definition of the system to be modelled

The modelled system corresponds to a CN that consists of a group of enterprises. The general casual diagram represented is focused on two enterprises (i and j) (see Figure 6.2); although, it can be extended to represent any amount (n) enterprises of the network (net). Each enterprise is independent and defines a set of objectives, whose achievement is measured by the increase of the associated KPIs ($\Delta kpi'_{ixk}$); and formulates strategies in order to achieve these objectives, represented by the decision variable u_str_{is} and characterised by ti'_str_{is}. The relationship between the strategies and the objectives is represented in order to identify the positive and negative influences that the activation of certain strategies exerts on the objectives attainment. The strategies' positive or negative influences affect the enterprises performance, and by extension the network performance.

STEP 2. Definition of the elements that belong to the system

The elements belonging to the system are represented by the parameters and decision variables previously defined in the SAM (Chapter 5). These elements are characterised by representing aggregate magnitudes of the overall system, modelling the system as a whole. The parameters, identified to define the SAM, are transcribed in order to be applied in SD domains (see Table 6.1).

Table 6.1.Elements of the Causal Loop Diagram

Mathematical Model (SAM)	Elements in SD model
c_str_{is}	c_Sis
$d'_1\_str_{is}$	d1_Sis
$d'_2\_str_{is}$	d2_Sis
$d'_3\_str_{is}$	d3_Sis
$d'_4\_str_{is}$	d4_Sis
kpi'_{ixk}_min	KPIixk_min
$Threshold\_kpi'_{ixk}$	Threshold_KPIixk
$t'_i\_str_{is}$	ti_Sis
u_str_{is}	u_Sis
$val\_str_{is}\_kpi'_{ixk}$	val_Sis_KPIixk
w_{ixk}	Wikx
$f\_inf\_str_{is}\_kpi'_{ixk}$	Inf_Sis_KPIixk
$\Delta kpi'_i$	KPI_i
$\Delta kpi'_{net}$	KPI_GLOBAL
Δkpi_{ixk}	KPIixk
Δkpi_{ixk}_T	KPIixk_T
str_{is}_mu	Sis_mu
b_i	bi
$f\_kpi'_{ixk}(t)$	curve_KPIixk
$f\_kpi'_{ixk}\_T(t)$	curve_KPIixk_T
$fulfillment\_kpi_{ixk}$	fulfill_KPIixk_min
$slope\_str_{is}\_kpi_{ixk}$	slope_Sis_KPIikx
tf_str_{is}	tf_Sis

STEP 3. Definition of the relations through arrows and attach positive or a negative signs to each relation.

The way in which the elements, of the system, influence one another is hereafter explained. These causal relations among the elements of the system are represented in the causal diagram (Figure 6.2)

Firstly, the intra-enterprise relations and influences are considered; that is, between the strategies, str_{is}, defined in enterprise i and the objectives, kpi_{ixk}, formulated by the same enterprise i. Starting with the element representing the budget, bi, an increase on bi implies that the enterprise owns more monetary units to invest in the activation of a strategy (Sis_mu); being this relation positive "+". Conversely, an increase on the monetary units spent in activating a strategy (Sis_mu) produces a decrease in the budget (bi). Therefore the arrow that represents this relation has attached a "–" symbol.

As regards the element that represents the decision variable u_Sis, an increase on the number of units of strategies activated by an enterprise i produces an increase on the monetary units invested (Sis_mu) having associated a "+" symbol in the arrow representing the relation. Besides, a higher cost of one unit of strategy, c_Sis, results on an increase on the element Sis_mu.

Considering the graphical representation of the function that models the behaviour of the kpi_{ixk} when str_{is} is activated ($f\_inf\_str_{is}\_kpi_{ixk}(t)$), (see Figure 5.8) it can be stated that higher values of the elements d4_Sis and ti_Sis result on higher values of tf_Sis being this relations positive "+".

Concerning the elements representing the durations, there is an increase on d3_Sis when d4_Sis increases, being the first relation positive "+". On the contrary, d3_Sis decreases when d1_Sis and d2_Sis increase being this relation negative "–".

Continuing with the graphical representation of $f\_inf\_str_{is}\_kpi_{ixk}(t)$, the increase of the number of units of strategies (u_Sis) and the increase of the numerical value estimated by the enterprise i val_Sis_KPIixk that registers the increase or decrease of the kpi_{ixk} when one unit of str_{is} is activated ($u\_str_{is}=1$), produces an increase on the element slope_Sis_KPIixk, being the causal relation positive "+", nevertheless this element decreases when d2_Sis increases "–".

The function of influence $f\_inf\_str_{is}\_kpi'_{ixk}$, equivalent to the element Inf_Sis_KPIixk in SD notation, is influenced by the elements slope_Sis_KPIixk, ti_Sis, d2_Sis, d3_Sis and d1_Sis. The element Inf_Sis_KPIixk changes in the same direction as the elements represented by the slope_Sis_KPIixk and d3_Sis "+". A change in the elements ti_Sis, d2_Sis and d1_Sis brings about change in an opposite direction in the destination element, Inf_Sis_KPIixk, being the relation negative "–".

An increase in Inf_Sis_KPIixk brings about a change in the same direction in curve_KPIixk. When the element curve_KPIixk increases the KPIixk also increases.

The curve_KPIixk_T is influenced by the elements KPIixk and Threshold_KPIixk. The increase of KPIixk and curve_KPIixk_T is done in the same direction "+". The elements Threshold_KPIixk and curve_KPIixk_T are oppositely related "–".

An increase in the curve_KPIixk_T and Wixk produces an increase in the same direction in KPIixk_T, "+".

The element fulfill_KPIixk_min changes in the same direction as KPIixk_T, having associated a positive sing, "+". Nevertheless, the higher KPIixk_min implies that the element fulfil_KPIixk_min is decreased due to it is harder to achieve this minimum level of the KPI to be achieved defined by KPIixk_min, being the relation negative "–".

An increase in the element KPIixk_T involves an increase in KPIi, therefore the arrow that represents this relation has associated a "+" sing. Finally, both elements KPIi and KPI_GLOBAL change in the same direction, having the arrows associated a "+" sing.

Secondly, the inter-enterprise relations and influences are considered, that is, between strategies defined in one enterprise i and the objectives formulated by the other j enterprises of the network. These causal relations are represented in the flow diagram (Figure 6.2) by the arrows in bold and the variables in dark grey.

Accordingly, when two or more enterprises of the same network are related, the following relations between variables appear. Taking as an example the element `Inf_Sis_KPIjxk`: an increase in the element `val_Sis_KPIjxk` causes an increase in *slope*`_Sis_KPIjxk`, “+”. An increase in *slope*`_Sis_KPIjxk` produces an increase in `Inf_Sis_KPIjxk`, “+”. Besides, the element `Inf_Sis_KPIjxk` changes in the same direction as `d3_Sis`. On the contrary, `Inf_Sis_KPIjxk` changes in a opposite direction when the elements `ti_Sis`, `d1_Sis` and `d2_Sis` change, being the relation negative “–”.

<u>STEP 4. Identification of the feedback loops and their signs. Positive loops cause an alteration over the system and negative loops leads the system towards the stability.</u>

The negative relationship between the elements that represent the budget, `bi`, and the `Sis_mu` generates a negative closed loop, acting as a stabiliser. The feedback loops represented in the model are classified as negative reinforcement, or “balancing” B. The stabiliser loop allows to model that growth cannot continue forever, because as more monetary units are invested on activate strategies (`Sis_mu`), there remain fewer monetary units in the element represented by the budget, `bi`. This negative loop enables modelling the objective pursued by the SAM: maximise of the network performance level, max. kpi'_{net}, the element `GLOBAL_KPI` according to the notation in SD.

Considering these four steps, the causal loop diagram is represented for the strategies alignment process in Figure 6.2. In the causal diagram, the relations between the elements modelling the strategies alignment within the enterprises of a CN are depicted.

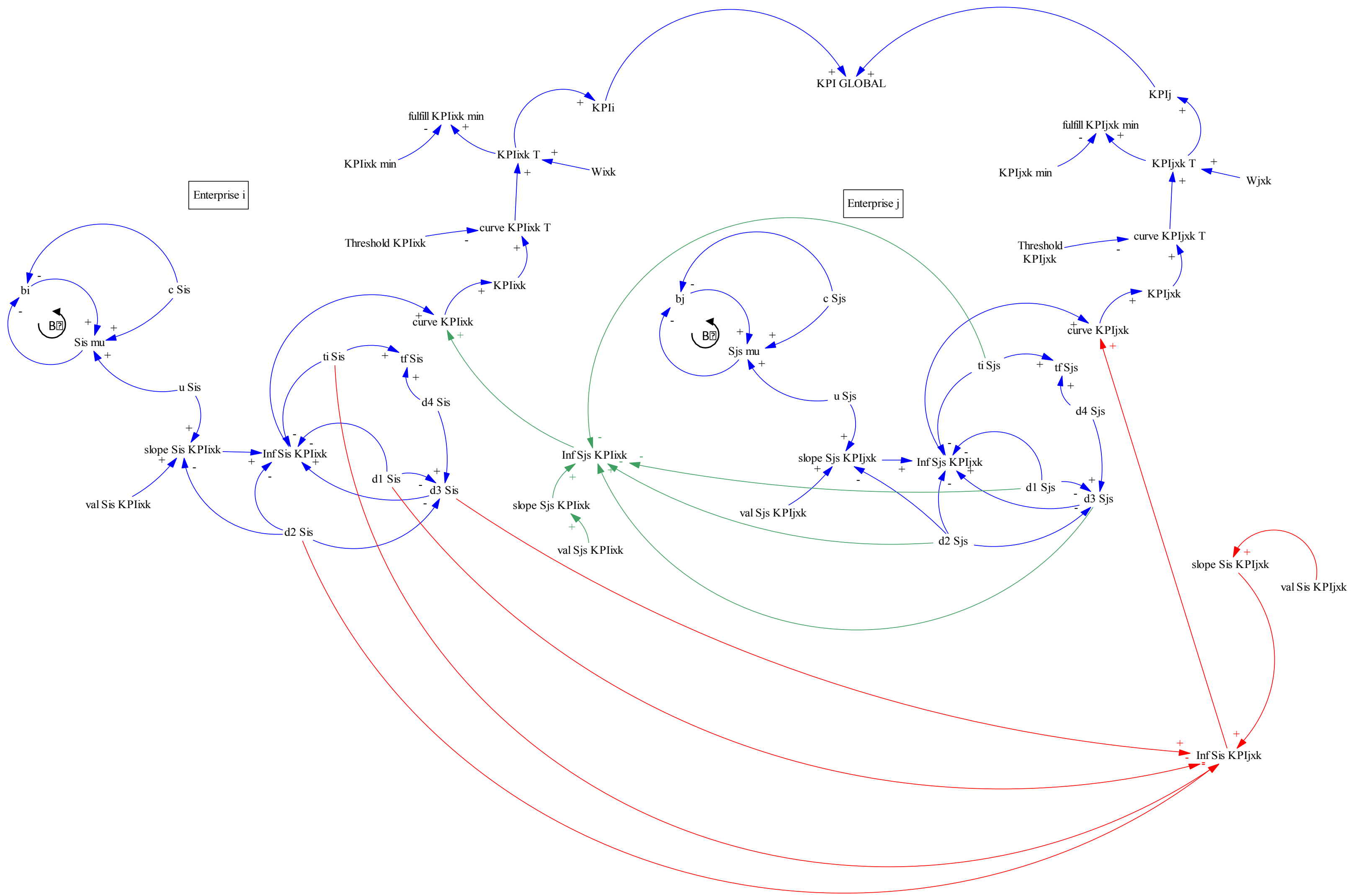

Figure 6.2. Causal Loop Diagram: Strategies Alignment Process

6.3.2 Flow Diagram Creation

The causal diagram has allowed to qualitatively represent the behaviour of the modelled system. In order to carry out a quantitative analysis the flow diagram is constructed. The flow diagram interprets the causal loop diagram (the information and the casual relationships depicted) into a terminology that allows transcribing the equations within a simulation software.

The steps followed to create the flow diagram are given in (Figure 6.3). Considering these steps the flow diagram is build for the SAM, in which the relations between the elements modelling the strategies alignment, within the enterprises of a CN, are represented.

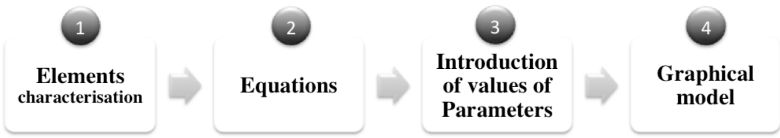

Figure 6.3. Building steps: Flow Diagram

STEP 1. Characterisation of the elements through the identification of the stock, flow, parameter and auxiliary variables.

SD uses three types of variables (Forrester, 1961) when building the flow diagram:

- Stock variables, elements defining the state of the SAM, represented in all the times. The level of the stock variables varies when inputs and outputs are established from the flows variables.
- Flow variables, elements influencing on the variation of levels in the stock variables.
- Auxiliary variables, the rest of elements that determine the performance of flow variables.

According to this classification, the parameters and decision variables defined to model the strategies alignment process are categorised from the SD perspective (Table 6.2).

Table 6.2. Stock, Flow and Auxiliary Variables in the Strategies Alignment Process

Type of Variable in SD	Graphic representation in SD	Elements in SD model
Parameter	Parameter	c_Sis
		d1_Sis
		d2_Sis
		d4_Sis
		KPIixk_min
		Threshold_KPIixk
		ti_Sis
		u_Sis
		val_Sis_KPIixk
		Wikx
Auxiliary Variable	Auxiliary Variable	d3_Sis
		Sis_mu
		fulfill_KPIixk_min
		slope_Sis_KPIikx
		tf_Sis
		KPI_i
		KPI_GLOBAL
Stock	Stock Variable	KPIixk
		KPIixk_T
		bi
Flow	Flow Variable	curve_KPIixk
		curve_KPIixk_T
		Inf_Sis_KPIixk

STEP 2. Write down the equations that define the behaviour of the system and the relationships of the variables.

This step considers the formulation of the equations used to model the strategies alignment process from SD method perspective. The equations are depicted considering a general notation in Table 6.3.

Table 6.3. Equations for the SAM in SD

Dimensions
`dimension_KPIixk`, representing the indexes of the KPIs defined in the model `index_KPIixk`
`dimension_Sis`, representing the indexes of the strategies defined in the model `index_Sis`

Budget `bi - ΣSis_mu`
Monetary units invested in the activation of str_{is} `Sis_mu = u_Sis · c_Sis.get(index_Sis)`
Unit of time when str_{is} is finished `tf_Sis = ti_Sis + d4_Sis.get(index_Sis)`
Time period in which str_{is} is exerting the highest influence ($inf\_str_{is}\_kpi_{ixk}$) on the kpi_{ixk} `d3_Sis = d4_Sis.get(index_Sis) - d1_Sis.get(index_Sis) - (2·d2_Sis.get(index_Sis))`
Slope of the ramp in represented in $f\_inf\_str_{is}\_kpi_{ixk}(t)$ `slope_Sis_KPIixk = (u_Sis · val_Sis_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_Sis)`
Function that models the behaviour of the kpi_{ixk} when str_{is} is activated[1] `Inf_Sis_KPIixk = delay (ramp (slope_Sis_KPIixk[dimension_KPIixk], ti_Sis, ti_Sis + d2_Sis.get(index_Sis)) - ramp (slope_Sis_KPIixk[dimension_KPIixk], ti_Sis + d2_Sis.get(index_Sis) + d3_Sis, ti_Sis + 2 · d2_Sis.get(index_Sis) + d3_Sis) , d1_Sis.get(index_Sis))`
Function that models the overall behaviour of the kpi_{ixk} considering all the activated strategies `curve_KPIixk = ΣInf_S11_KPIixk[dimension_KPIixk]`
Increase observed in the kpi_{ixk} `KPIixk = ∫ curve_KPIixk[dimension_KPIixk]`
Function that models the curve of the behaviour of the kpi_{ixk} when the $Threshold\_kpi_{ixk}$ value is rested `Curve_KPIixk_T = IF ((curve_KPIixk[dimension_KPIixk] >= Threshold_KPIixk[dimension_KPIixk]) THEN (curve_KPIixk[dimension_KPIixk] - Threshold_KPIixk[dimension_KPIixk]) ELSE (IF (curve_KPIixk[dimension_KPIixk]<0) THEN curve_KPIixk[dimension_KPIixk] ELSE 0))`
Increase experienced by the kpi_{ixk} once the $Threshold\_kpi_{ixk}$ is computed `KPIixk_T = ∫ curve_KPIixk_T[ dimension_KPIixk ]`
Acomplishment of the minimum increase that the enterprise determines for the kpi_{ixk}, once the $Threshold\_kpi_{ixk}$ is computed `fulfill_KPIixk_min = IF ((KPIixk_T[ dimension_KPIixk ] >= KPIixk_min[ dimension_KPIixk ]) THEN 1 ELSE 0)`
Increase experienced by the KPI defined at enterprise i level `KPI_i = Σ KPIixk_T.get(index_KPixk) · Wixk[dimension_KPIixk]`
Increase experienced KPI defined at network net level `KPI_GLOBAL = Σ KPI_i / n`

STEP 3. Introduce the values associated to each parameter.

The values of the parameters are given by each enterprise participating in the strategies alignment process within the CN. In Chapter 8 the guidelines followed by the enterprises to gather the information required to feed the SAM, is developed.

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[1] *delay (function, length of delay)*

ramp (slope of the Ramp, time in which the ramp is initiated, time in which the ramp finishes)

STEP 4. Create the graphical model.

This step covers the creation of the SAM flow diagram (Figure 6.4). In the SAM, the stock variables are the elements related with the Budget, bi, of each enterprise participating in the SAM, and the increase of the kpi_{ixk} before computing the $Threshold\_kpi_{ixk}$ (KPIixk) and after (KPIixk_T). The stock variables represent the situation of the SAM in all times. The elements associated to the stock variables show an accumulation as a result of the input and output flows of the system. In the represented model, some of the stock variables associated to the flow variables are represented by clouds indicating that the content is unlimited.

The flow variables, represented by the elments Inf_Sis_KPIixk, curve_KPIixk and curve_KPIixk_T, defining the variation of stock variables. In this particular case, the flow variables represent the behaviour of the kpi_{ixk} when certain set of strategies str_{is} are activated (Inf_Sis_KPIixk). Flow variables are defined by piecewise functions that depend on time; the stock variables control them according to the defined rules and conditions that regulate the system.

Auxiliary variables and parameters are given by (i) the data that define the strategies, such as costs (c_Sis, Sis_mu) and duration (d1_Sis, d2_Sis, d3_Sis and d4_Sis), (ii) the data that affect the increase/decrease of the KPIs, such as the values of influence (val_Sis_KPIixk) and the slope (slope_Sis_KPIixk), (iii) the decision variables, represented by the elements u_Sis and ti_Sis, and (iv) the equations related to the KPIs both at Enterprise level, KPI_i, and at Network level, KPI_GLOBAL.

The schema represented in Figure 6.4 will be extended according to the number of enterprises, the number of KPIs defined and the strategies formulated, all of them belonging to the elements modelled to support the strategies alignment process.

Two dimensions are defined dimension_KPIixk and dimension_Sis that represent the index of the kpi_{ixk} and the str_{is} (index_KPIixk, index_Sis), respectively. There will be many index_KPIixk as defined KPIs, and many index_Sis as strategies defined in the CN.

For example if enterprise 1 defines two KPIs kpi_{111} and kpi_{121}, the dimension_KPIixk will consist of two index: index_KPI111 and index_KPI121. If the same enterprise 1 formulates two strategies str_{11} and str_{12}, the dimension_Sis will consist of another two different indexes index_S11 and index_S12.

Parameters c_Sis, d1_Sis, d2_Sis, d4_Sis, Threshold_KPIixk, Wixk, KPIixk_min are defined once in the SAM. Each associated parameter contains the values for each kpi_{ixk} in case of Threshold_KPIixk, Wixk, KPIixk_min and for each str_{is} in case of c_Sis, d1_Sis, d2_Sis, d4_Sis.

The stock variable bi is defined by each enterprise therefore there will be many bi elements as enterprises participating in the SAM.

Each auxiliary variable Sis_mu, tf_Sis, d3_Sis, slope_Sis_KPIixk will be represented according to the number of strategies str_{is} modelled in the system. The same occurs with parameters u_Sis, ti_Sis, val_Sis_KPIixk. Besides, the flow variable Inf_Sis_KPIixk is replicated depending on the number of strategies formulated in the system representing the CN.

Flow variables representing the elements curve_KPIixk and curve_KPIixk_T and the associated stock variables KPIixk and KPIixk_T are represented once in the system and have associated the values corresponding to the kpi_{ixk} (dimension_ixk). The same occurs with the auxiliary variable fulfil_KPIixk_min.

The auxiliary variable `KPI_i` is associated to each enterprise therefore it will be replicated as many times as enterprises participating in the CN. Finally, the `GLOBAL_KPI` is represented once and it is associated at the network level.

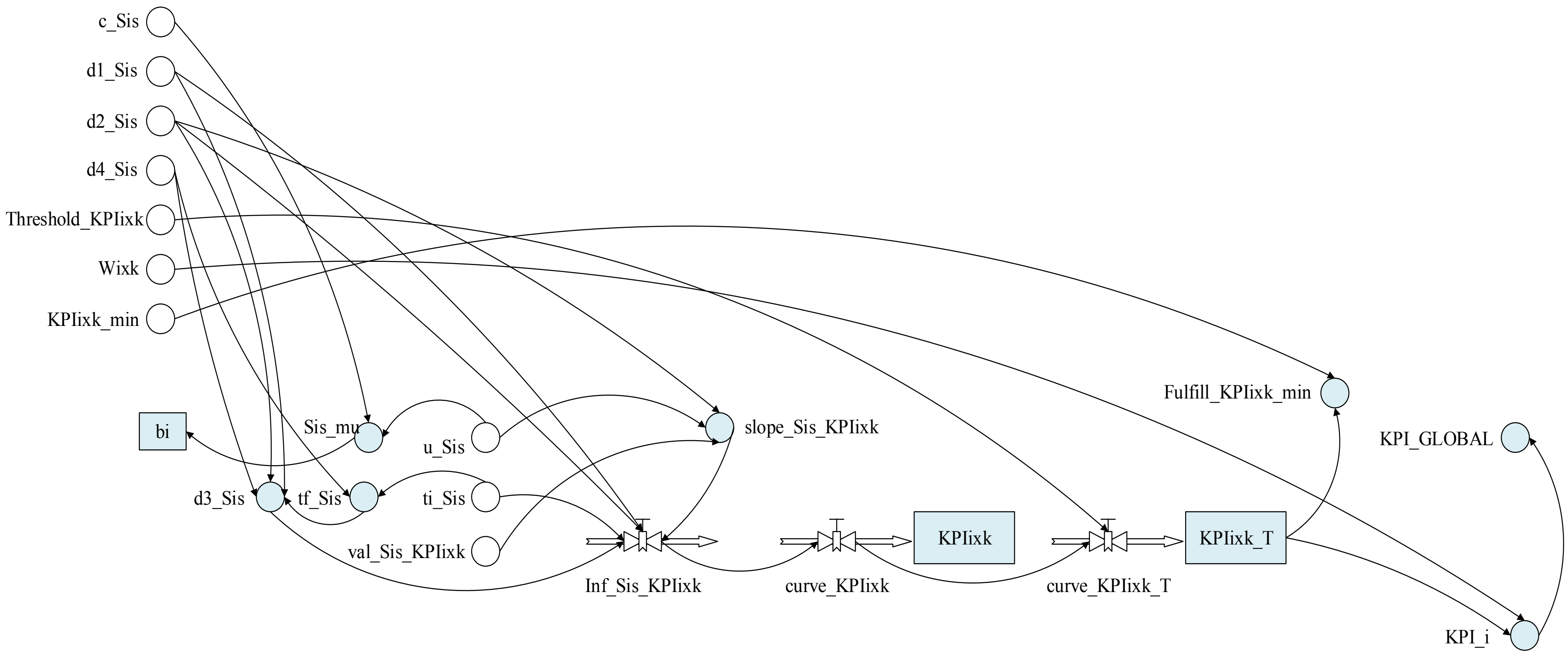

Figure 6.4. Flow diagram: SAM

6.4. *Example 6.1*: Formulating the equations of the SAM in SD

The illustrative ***Example 5.5*** in Chapter 5 described a network of two enterprises. This example was proposed in order to give a better comprehension of the proposed SAM. In this section the same example is considered and the equations required to solve the SAM in SD method are proposed. Two scenarios are considered: the non-collaborative scenario and the collaborative one.

6.4.1 Scenario 1: Non-Collaborative

In the non-collaborative scenario the enterprises are separately modelled. The decision variables, u_str_{is} and ti_str_{is} and the equations are raised by only considering the influence of the strategies activated in the same enterprise (or enterprise 1 or enterprise 2). Therefore, the enterprises are now separately modelled in order to simulate the non-collaborative scenario. The equations raised, considering the formal notation of Systems Dynamic, for the Enterprise 1, in an isolate way, are given in Table 6.4. Whilst the equations for the Enterprise 2 are given in Table 6.5.

Table 6.4. Equations for Enterprise 1 to model the strategies alignment process in SD

Dimensions	
dimension_ixk index_KPI111 index_KPI121	dimension_is index_S11 index_S12
Budget b_1	
b1 - S11_mu - S12_mu	
Strategy str_{11}	
S11_mu = u_S11 · c_Sis.get(index_S11)	
tf_S11 = ti_S11 + d4_Sis.get(index_S11)	
d3_S11 = d4_Sis.get(index_S11) - d1_Sis.get(index_S11) - (2·d2_Sis.get(index_S11))	
slope_S11_KPIixk = (u_S11 · val_S11_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S11)	
Inf_S11_KPIixk = delay (ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11, ti_S11 + d2_Sis.get(index_S11)) - ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11 + d2_Sis.get(index_S11) + d3_S11, ti_S11 + 2·d2_Sis.get(index_S11) + d3_S11) , d1_Sis.get(index_S11))	
Strategy str_{12}	
S12_mu = u_S12 · c_Sis.get(index_S12)	
tf_S12 = ti_S12 + d4_Sis.get(index_S12)	
d3_S12 = d4_Sis.get(index_S12) - d1_Sis.get(index_S12) - (2 · (d2_Sis.get(index_S12)))	
slope_S12_KPIixk = (u_S12 · val_S12_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S12)	
Inf_S12_KPIixk = delay (ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12, ti_S12 + d2_Sis.get(index_S12)) - ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12 + d2_Sis.get(index_S12) + d3_S12, ti_S12 + 2·d2_Sis.get(index_S12) + d3_S12) , d1_Sis.get(index_S12))	
KPIs: *kpi_{1xk}*	
curve_KPIixk = Inf_S11_KPIixk[dimension_KPIixk] + Inf_S12_KPIixk[dimension_KPIixk]	
KPIixk = ∫ curve_KPIixk[dimension_KPIixk]	
Curve_KPIixk_T = IF ((curve_KPIixk[dimension_KPIixk] >= Threshold_KPIixk[dimension_KPIixk]) THEN (curve_KPIixk[dimension_KPIixk] - Threshold_KPIixk[dimension_KPIixk]) ELSE (IF (curve_KPIixk[dimension_KPIixk] < 0) THEN curve_KPIixk[dimension_KPIixk] ELSE 0))	
KPIixk_T = ∫ curve_KPIixk_T[dimension_KPIixk]	
fulfill_KPIixk_min = IF ((KPIixk_T[dimension_KPIixk] >= KPIixk_min[dimension_KPIixk]) THEN 1 ELSE 0)	
KPIs: *kpi_1*	
KPI_1 = KPIixk_T.get(index_KPI111) · Wixk.get(index_KPI111) + KPIixk_T.get(index_KPI121) · Wixk.get(index_KPI121)	

Table 6.5. Equations for Enterprise 2 to model the strategies alignment process in SD

Dimensions	
dimension_ixk index_KPI211 index_KPI221	dimension_is index_S21 index_S22
Budget b_2	
b2 – S21_mu – S22_mu	
Strategy str_{21}	
S21_mu = u_S21 · c_Sis.get(index_S21)	
tf_S21 = ti_S21 + d4_Sis.get(index_S21)	
d3_S21 = d4_Sis.get(index_S21) - d1_Sis.get(index_S21) - (2·d2_Sis.get(index_S21))	
slope_S21_KPIixk = (u_S21 · val_S21_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S21)	
Inf_S21_KPIixk = delay (ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21, ti_S21 + d2_Sis.get(index_S21)) - ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21 + d2_Sis.get(index_S21) + d3_S21, ti_S21 + 2·d2_Sis.get(index_S21) + d3_S21) , d1_Sis.get(index_S21))	
Strategy str_{22}	
S22_mu = u_S22 · c_Sis.get(index_S22)	
tf_S22 = ti_S22 + d4_Sis.get(index_S22)	
d3_S22 = d4_Sis.get(index_S22)- d1_Sis.get(index_S22) - (2·(d2_Sis.get(index_S22)))	
slope_S22_KPIixk = (u_S22 · val_S22_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S22)	
Inf_S22_KPIixk = delay (ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22, ti_S22 + d2_Sis.get(index_S22)) - ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22 + d2_Sis.get(index_S22) + d3_S22, ti_S22 + 2·d2_Sis.get(index_S22) + d3_S22) , d1_Sis.get(index_S22))	
KPIs: kpi_{2xk}	
curve_KPIixk = Inf_S21_KPIixk[dimension_KPIixk] + Inf_S22_KPIixk[dimension_KPIixk]	
KPIixk = ∫ curve_KPIixk[dimension_KPIixk]	
Curve_KPIixk_T = IF ((curve_KPIixk[dimension_KPIixk] >= Threshold_KPIixk[dimension_KPIixk]) THEN (curve_KPIixk[dimension_KPIixk] - Threshold_KPIixk[dimension_KPIixk]) ELSE (IF (curve_KPIixk[dimension_KPIixk] < 0) THEN curve_KPIixk[dimension_KPIixk] ELSE 0))	
KPIixk_T = ∫ curve_KPIixk_T[dimension_KPIixk]	
fulfill_KPIixk_min = IF ((KPIixk_T[dimension_KPIixk] >= KPIixk_min[dimension_KPIixk]) THEN 1 ELSE 0)	
KPIs: kpi_2	
KPI_2 = KPIixk_T.get(index_KPI211) · Wixk.get(index_KPI211) + KPIixk_T.get(index_KPI221) · Wixk.get(index_KPI221)	

6.4.2 Scenario 2: Collaborative

In the collaborative scenario both enterprises, Enterprise 1 and Enterprise 2, collaboratively participate in the decision making of identifying the strategies to activate. The information as regards the influence that the strategies, formulated by both enterprises, exert on the objectives (KPIs) is known by the two enterprises belonging to the CN. That is, in order to make the decision of which strategies activate: the enterprise 1 not only considers how its strategies influence in the objectives defined in the same enterprise 1 but also takes into account how the strategies of enterprise 2 influence the objectives formulated in the enterprise 1. The same occurs with the enterprise 2. According to the aforementioned, the equations for the collaborative scenario in both enterprises are given inTable 6.6.

Table 6.6. Equations for Enterprise 1 and Enterprise 2 to model the strategies alignment process in SD from a collaborative context

Dimensions	
dimension_ixk index_KPI111 index_KPI121 index_KPI211 index_KPI221	dimension_is index_S11 index_S12 index_S21 index_S22
Budget b1	
b1 - S11_mu - S12_mu	
Budget b2	
b2 - S21_mu - S22_mu	
Strategy str11	
S11_mu = u_S11 · c_Sis.get(index_S11)	
tf_S11 = ti_S11 + d4_Sis.get(index_S11)	
d3_S11 = d4_Sis.get(index_S11) - d1_Sis.get(index_S11) - (2·d2_Sis.get(index_S11))	
slope_S11_KPIixk = (u_S11 · val_S11_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S11)	
Inf_S11_KPIixk = delay (ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11, ti_S11 + d2_Sis.get(index_S11)) - ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11 + d2_Sis.get(index_S11) + d3_S11, ti_S11 + 2·d2_Sis.get(index_S11) + d3_S11) , d1_Sis.get(index_S11))	
Strategy str12	
S12_mu = u_S12 · c_Sis.get(index_S12)	
tf_S12 = ti_S12 + d4_Sis.get(index_S12)	
d3_S12 = d4_Sis.get(index_S12)- d1_Sis.get(index_S12) - (2·(d2_Sis.get(index_S12)))	
slope_S12_KPIixk = (u_S12 · val_S12_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S12)	
Inf_S12_KPIixk = delay (ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12, ti_S12 + d2_Sis.get(index_S12)) - ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12 + d2_Sis.get(index_S12) + d3_S12, ti_S12 + 2·d2_Sis.get(index_S12) + d3_S12) , d1_Sis.get(index_S12))	
Strategy str21	
S21_mu = u_S21 · c_Sis.get(index_S21)	
tf_S21 = ti_S21 + d4_Sis.get(index_S21)	
d3_S21 = d4_Sis.get(index_S21) - d1_Sis.get(index_S21) - (2·d2_Sis.get(index_S21))	
slope_S21_KPIixk = (u_S21 · val_S21_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S21)	
Inf_S21_KPIixk = delay (ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21, ti_S21 + d2_Sis.get(index_S21)) - ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21 + d2_Sis.get(index_S21) + d3_S21, ti_S21 + 2·d2_Sis.get(index_S21) + d3_S21) , d1_Sis.get(index_S21))	
Strategy str22	
S22_mu = u_S22 · c_Sis.get(index_S22)	
tf_S22 = ti_S22 + d4_Sis.get(index_S22)	
d3_S22 = d4_Sis.get(index_S22)- d1_Sis.get(index_S22) - (2·(d2_Sis.get(index_S22)))	
slope_S22_KPIixk = (u_S22 · val_S22_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S22)	
Inf_S22_KPIixk = delay (ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22, ti_S22 + d2_Sis.get(index_S22)) - ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22 + d2_Sis.get(index_S22) + d3_S22, ti_S22 + 2·d2_Sis.get(index_S22) + d3_S22) , d1_Sis.get(index_S22))	
KPIs: kpi_{ixk}	
curve_KPIixk = Inf_S11_KPIixk[dimension_KPIixk] + Inf_S12_KPIixk[dimension_KPIixk] + Inf_S21_KPIixk[dimension_KPIixk] + Inf_S22_KPIixk[dimension_KPIixk]	
KPIixk = ∫ curve_KPIixk[dimension_KPIixk]	
Curve_KPIixk_T = IF ((curve_KPIixk[dimension_KPIixk] >= Threshold_KPIixk[dimension_KPIixk]) THEN (curve_KPIixk[dimension_KPIixk] - Threshold_KPIixk[dimension_KPIixk]) ELSE(IF (curve_KPIixk[dimension_KPIixk] < 0) THEN curve_KPIixk[dimension_KPIixk] ELSE 0))	

`KPIixk_T = ∫  curve_KPIixk_T[ dimension_KPIixk ]`
`fulfill_KPIixk_min = IF ((KPIixk_T[dimension_KPIixk] >= KPIixk_min[dimension_KPIixk]) THEN 1 ELSE 0)`
KPIs: kpi_i
`KPI_1 = KPIixk_T.get(index_KPI111) · Wixk.get(index_KPI111) + KPIixk_T.get(index_KPI121) · Wixk.get(index_KPI121)`
`KPI_2 = KPIixk_T.get(index_KPI211) · Wixk.get(index_KPI211) + KPIixk_T.get(index_KPI221) · Wixk.get(index_KPI221)`
KPIs: kpi_n
`KPI_GLOBAL = (KPI_1 + KPI_2) /2`

6.5 Conclusions

In this chapter the System Dynamics method is presented to solve the SAM, mathematically defined in Chapter 5. The representation of the SAM with SD allows complementing the abstract mathematical model defined, Acin order to represent and assess the strategies alignment process. The use of SD method is discussed considering its appropriateness to deal with the strategies alignment process. In this particular case the CN is characterised by being a complex system. Hence, traditional analysis approaches make very complex the representation of the non-lineal causal relations established among the system variables, which simultaneously generate feedback loops within the system. Therefore, the use of SD is justified in order to deal with this complexity. In addition, the use of System Dynamics allows using algebraic equations to model the system. Accordingly, the equations that define the objective function and the restrictions in the SAM can be transcribed for their introduction in a SD model.

Causal and feedback relations among the observable variables of the system are represented as a whole and aggregate magnitudes of the CN system are studied (strategies and KPIs). The equations previously proposed in the mathematical model (SAM, Chapter 5) are raised according to the features of SD. The variables used in SD context are classified and their relations are determined and drawn in the casual loop diagram. Afterwards, the flow diagram is represented.

The proposed SAM and its resolution in SD method allows modelling the strategies influences at the intra and inter-enterprise levels. After that a simulation software will be used in order to solve though SD method the specific problem modelled. The main aim will be identifying the set of aligned strategies that together have positive influences in the attainment of all the objectives (measured through KPIs), defined by all the networked nodes.

The numerical Example 5.5 (described in Chapter 5) is extended in the Example 6.1 formulating the SAM equations in SD terminology. The main contributions of Example 6.1 are listed next:

- To show how the parameters and decision variables are classified according to the SD terminology. That is, stock variables, dynamic flows, and auxiliary variables and parameters.
- Formulate the algebraic equations to be introduced in SD simulation software
- To show how the indexes are created for each dimension (`dimension_KPIixk` and `dimension_Sis`)
- To show how to create the flow diagram that models the strategies alignment process
- To show how each element of the SAM is replicated in the flow diagram
- Compare the resolution equations in both collaborative and non-collaborative scenarios

Summarising, this chapter has contributed to propose the method in which the SAM is going to be solved. The problem of assessing and dealing with the strategies alignment process in collaborative context is now modelled and implemented through using the SD formal method.

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Chapter 7

Tools to support the Strategies Alignment Process in a CN

This chapter presents the set of tools used to support the resolution of the strategies alignment process, in the CN context. The model (SAM) and the method (SD), proposed in chapters 5 and 6, are implemented in a SD simulation software named AnyLogic. In order to automatically generate the strategies alignment model (SAM) in the simulation software an application named SAGEN (Strategies Alignment GENerator) is designed and implemented. The automatic generation of the SAM is supported by a database management system (DMS), which gathers all the data related to the parameters required to feed the SAM and automatically build the simulation model. In this chapter, a description of the three tools developed for supporting the resolution of the strategies alignment process in CN (simulation software in SD, Database Management System *and SAGEN) is given.*

7.1 Introduction

Considering the model developed in Chapter 5 (SAM) and the SD resolution method described in Chapter 6, in this chapter the three tools used to address the strategies alignment process, from a CN context are described and implemented. The resolution of the strategies alignment process is based on the use of three tools (Figure 7.1):

- a simulation software supporting system dynamics (SD) method, in which the SAM is solved. *AnyLogic®* simulation software is used, allowing representing the SAM in SD,
- a Database Management System (DMS) that stores all the information required in the SAM. The parameters required to feed the SAM are gathered in a *Microsoft Access Database* specifically designed, and
- the *Strategies Alignment GENerator* (SAGEN), an application that automatically generates the SAM in SD simulation software.

The DMS built in *Microsoft Access Database* contains the necessary information to automatically build the SAM in SAGEN application. SAGEN automatically generates an XML file containing all the data as regards the parameters and the structure required in SD to build the SAM in AnyLogic simulation software.

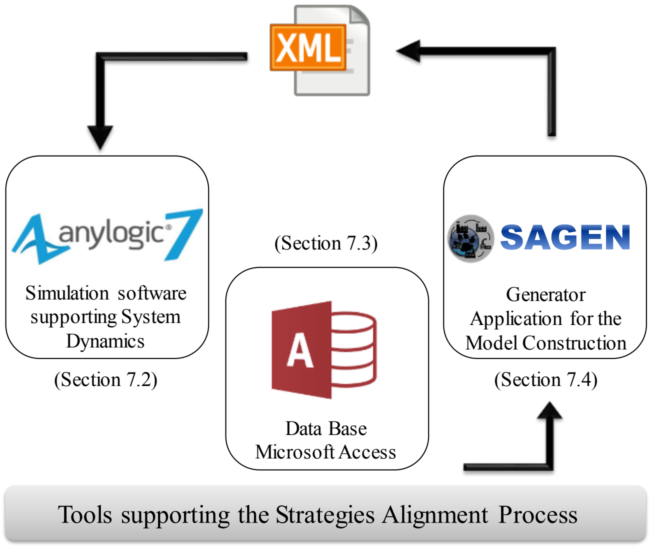


Figure 7.1. Tools to support the Strategies Alignment Process in CN

7.2 System Dynamics Simulation Software

7.2.1 Simulation Tools used in System Dynamics

According to Chapter 6 the SD method is used to support the resolution of the SAM. To this extent, different software packages can be used to model and simulate systems in SD. The most known are (in order of appearance): DYNAMO (Forrester, 1969), STELLA/iTHINK (Isee System, 2015), POWERSIM (Powersim, 2015), VENSIM (Vensim, 2015) and ANYLOGIC (*AnyLogic*, 2015). A summary of relevant information for each of this SD simulation tools is given in Table 7.1.

Considering the characteristics of each simulation tool, *AnyLogic®* simulation software is selected, for the development of this dissertation, to solve and represent the SAM, according to SD rigorous method. AnyLogic is a tool that uses a comprehensible code using Java as implementation language. Moreover, the models constructed in AnyLogic have the particularity of being read in XML files. This allows building the SAM in XML and opening it in AnyLogic. Besides the optimisation heuristics used in AnyLogic, provide good solutions for the optimisation experiments in SD (Kleijnen and Wan, 2007).

Table 7.1. Summary of Simulation Tools used in SD

Simulation Tools	Last updated	Features	XML Reading	Implementation Language	Applications	Supporting Platforms	Optimisation
DYNAMO	1986	Dynamic Thinking Systems Analysis Dynamic optimisation system	×	AED, Pascal	Lyneis, Kimberly, and Todd (1994) Barlas (1996)		Dynamic optimisation system
STELLA iTHINK	2012	Mapping, modelling, simulation, and communication of dynamic processes. Model builder based around an intuitive icon-based graphical interface. Not much involves programming and use of equations.	×	-	Feng, Chen, and Zhang (2013)	Windows™ XP/Vista/7 or higher, QuickTime Mac OS 10.5 or higher	-
POWERSIM	2013	Design and simulation of business processes based on SD	×	C++	Vlachos, Georgiadis, and Iakovou (2007)	Microsoft Windows 8, Windows 7, Vista, or XP with ServicePack 2	Stochastic Optimisation in Policy Space (SOPS)
VENSIM	2014	Combines SD concepts and simulation with discrete events to represent SC events and uncertainty, and analyse their performance and the existing causal relationships among their components. Model builder icon-based is used to represent the flow diagram. Not much involve programming and use an equations.	×		Sterman (2000) Sharif (2005) Mendoza, Mula, and Campuzano (2014)	Windows 98 / NT / 2000 / XP / Vista / 7 / 8 / 8.1. Vensim is a 32 bit program but will run fine on 64 bit versions of Windows. The Macintosh version requires OSX version 10.4 or higher on an Intel processor	Markov chain Monte Carlo (MCMC) explores a calibration likelihood surface. Perfrom a random walk over the payoff surface, with moves chosen according to point likelihoods; stationary distribution of the Markov process reflects likelihood surface. Simulated Annealing: optimise in presence of many local optimums. Powell hill-climbing algorithm searches through the parameter space looking for the largest cumulative payoff. There are no limits on the numbers of payoff variables or policy parameters to search over. Advanced sensitivity analysis is available from optimization simulations.
ANYLOGIC	2015	Combines Heuristics, Discrete events, optimisation, agents, and SD. Graphic is used in order to show the interaction that occurs among entities. Build with 3D display	✓	JAVA	Heath, Ciarallo, and Hill (2012) Park et al. (2014) Andres and Poler (2014)	Microsoft Windows Vista/7/8, x86-32 and x64 Apple Mac OS X 10.7.3 (Lion), Universal SuSE Linux Enterprise Server 10 SP2, 11.x, x86-32 Ubuntu Linux 10.04 or above	AnyLogic uses the built-in OptQuest optimizer to search for the best solution, given the objective function, constraints, requirements, and parameters (decision variables). Supports objective values that are based on experimentation through the General Replication Algorithm. Optimization under uncertainty is supported by using replications: a stochastic model is run multiple times with the same parameters values (those runs are called replications) and the decision on the next iteration in the parameter space is then based on their aggregated output. Monte Carlo simulations are also included

7.2.2 Simulation Software: *AnyLogic*

AnyLogic simulation software brings together the most common modelling methods: System Dynamics (SD), Discrete Events (DE), and Agent Based (AB). SD was developed in the 1950s assuming high levels of abstraction, employing a top-down view, essentially used at the strategic decision making level. DE was developed in 1960s employing also a system-level view of things being principally used at the tactical and operational decision making level. Finally, the recent approach of AB method, employs a bottom-up view focusing on the individual elements, their behaviours and relationships, it is used at all levels when individual data is available. Considering the differences between these approaches, SD is used when there is information about global *dependences* and DE is considered when describing specific process. *AnyLogic* supports in a same environment and language the three simulation approaches. This dissertation research only uses so far in SD. Nevertheless, further research could be extended to the other simulation approaches; using *AnyLogic* the modeller has higher flexibility learning the functionality of the three methods in one language.

7.2.2.1 System Dynamics

AnyLogic allows representing, in SD, complex and heterogeneous systems (i.e. in business, economical, ecological, social systems) to identify the interdependent causal relations inside and around the modelled system and allows building formal computer simulations in order to understand the structure and dynamics of complex systems at high level of aggregation of the objects modelled. In our particular case the complex system consist of the CN and the enterprises participating, as well as their objectives, KPIs, and strategies. Simulations combining space and time can be constructed in order to experiment long-term effects and assess the decisions made in terms of identifying the best set of strategies, for its activation, to obtain maximum levels of performance at enterprises and network levels and avoid misalignments in regard to the strategies activated.

SD in *AnyLogic* permits to:

- Define stock and flow variables
- Use table functions (look up tables) with step, linear, or spline interpolation
- Define array variables with an arbitrary number of dimensions. Some problems require multi-dimensional data. Array is a storage of numbers that may have any number of *dimensions*. Each dimension has finite number of indexes. Arrays are used when it is necessary to store a large set of coefficients and access them or when there are multiple model layers. The latter case is useful when defining a model for some subsystem and there are other subsystems, which have the same structure, as the first one, but other numerical parameters. Implementing multi-dimensional models can be done thorough making copies of the default diagram and changing the parameters.
- Define dimensions. *Dimensions* are used for defining dimensions of *array* variables. There are three types of dimensions in *AnyLogic*:
    - Enumerations - list of named items that refer to the array elements. When defining an array using enumerations, the elements of the array can be referred using self-descriptive names of enumeration elements.
    - Ranges - interval definitions that can be used to specify dimensions for array variables. When defining arrays using numerical ranges, array elements are accessed by index numbers.
    - Sub-dimensions - allow defining sub-ranges of dimensions. It is very useful when a particular sub-dimension refers to multiple places of the model, for example in sub-arrays definitions. Rather than dealing with sub-dimension definitions, the modeller creates a sub-dimension once and then refers to it by its name when needed. Sub-dimension can be defined by both for enumerations and ranges.
- Use both SD-specific and standard Java mathematical functions

AnyLogic tool easily allows combining SD model components with components developed using agent based or discrete event methods. For example, including SD diagrams inside agents representing the enterprises of a CN.

7.2.2.2 Discrete Event Simulation

Discrete Event (DE) package in *AnyLogic* allows simplifying the analysis of continuous real-world processes through dividing them in discrete parts. DE method is used to represent sequence of activities or operations i.e. a customer arriving at a shop, the movement of vehicles, the conveyor stops, the launching of a new product, the management of inventory levels when reach a certain threshold, etc.

In DE modelling, *AnyLogic* provides the Process Modelling Library toolkit, as a collection of objects for defining process workflows and their associated resources, for customising all objects. Complex systems with complex components can be modelled in a detailed way considering different objects or sub-processes. Afterwards the components can be instated at the top level connecting all the objects and sub-processes together.

7.2.2.3 Agent Based Simulation

AnyLogic agent based package consist of the representation of active entities, agents and their individual properties and behaviour, and connections (normally establishing complex relationships), all of this considering a certain environment. The output gives the modeller an easy, precise, and up to date way to forecast, compare scenarios, and optimise.

7.2.2.4 Integrating Optimisation and Simulation

AnyLogic integrates both simulation and optimisation experiments. Through optimisation techniques *AnyLogic* software searches for the values of the model parameters (decision variables) that lead to obtain greater performance levels of the model, given an objective function and the set constraints and requirements. Optimisation is used in a bundle with simulation to perform efficient search. AnyLogic uses *OptQuest*[2] engine to carry out the optimisation of the represented simulation model. In OptQuest, if a candidate solution does not fit the requirements defined in the model, then that solution is eliminated and candidates that are more likely to be better are explored (Kleijnen and Wan, 2007).

The homepage of OptQuest provider[3] refers the use of metaheuristic, mathematical optimization, and neural network components to guide the search for best solutions of decision. Nevertheless, the exact heuristic of optimisation is unknown for commercial reasons. Some papers found on the literature (Glover, Laguna, and Martí, 2000) (Liu, 2007) (Bianchi et al., 2008) give a hint on the optimisation heuristics used in AnyLogic and determine that Tabu Search, Neural Networks, and Scatter Search are combined into a single search heuristic to carry out the optimisation procedure. The main differences between the different metaheuristics raise on how the delimitation and the selection of the solutions is carried out. Therefore, it can be concluded that a combination of mathematical optimisation and meta-heuristics is used. These meta-heuristics work as a set of systematic rules of an iterative method, designed to find generate or select a heuristic (partial search algorithm) that may provide a sufficiently good solution in problems of very large scale and with incomplete or imperfect/uncertain information (Othman and Mustaffa, 2012). Meta-heuristic algorithms use to implement random search and can find several solutions (it cannot ensure the optimum) using a search strategy which needs a stop rule (it can be time).

[2] The *OptQuest* Engine obtains a sample of the objective function at the end of each simulation. The engine analyses a sample, modifies optimization parameters according to its optimization algorithm, and starts a new simulation.

Optimization is an iterative process where:

- The *OptQuest* Engine calculates possible solutions for the parameters
- The objective function and constraints are evaluated using the suggested solutions
- The results are analysed by the *OptQuest* Engine, and a new set of possible solutions is calculated

[3] http://www.opttek.com/OptQuest

According to Kleijnen and Wan (2007) OptQuest treats the simulation model as a black box thorough observing only the Input/Output of the simulation model. The general procedure followed in any optimisation process consist of two parts: generate candidate solutions and evaluate this solutions (Othman and Mustaffa, 2012). In AnyLogic, the optimiser runs as a master application that controls the simulation model. The optimiser works considering an objective (to minimise or maximise), and a set of restrictions; then it searches the values for a set of parameters that minimise or maximise the objective. The optimiser runs the model multiple times and search in the parameter space and returns what it considers a good solution (sub-optimal solution). The solutions found are sub-optimal because the parameter space can be huge, and unless the model is very simple, it is not possible to guarantee that the optimiser will be able to find an optimal solution in a finite time. The optimiser software is programmed to work with local minimums and maximums with very complicated parameter spaces. Besides, optimisation under uncertainty is supported by using replications and the decision on the next move in the parameter space (next iteration) is then based on their aggregated output. *AnyLogic* provides a graphical interface to set up and control the optimisation. In the SAM the input consists of the parameters defining the strategies and the KPIs; the output consists of the decision variables: number of units of strategies (u_str_{is}) and time of activation of strategies (ti_str_{is}). The values of the decision variables, resulting from the optimisation experiment, will lead to maximise the network performance ($\Delta kpi'_{net}$).

The *OptQuest* Engine varies controllable parameters (variables that are to be optimised) from simulation to simulation to find the optimal values that solve the problem. During the optimisation process, the parameters' value is changed in accordance to its type within an interval, specified by *lower* and *upper bounds*. Besides *suggested* values are also determined as the starting point (input combination) to start the optimisation; this choice affects the efficiency and effectiveness of the search. Two types of optimisation parameters can be considered OptQuest optimisation package:

- *Discrete parameter*, represented by a finite set of decisions with essential direction: the parameter influences the objective like a numeric parameter, but can take values from the specified set only. It begins at a lower bound and increments by a step size up to an upper bound. If the step for the parameter is specified, only the discrete points will be involved in the optimisation. Discrete parameters will be used in the model when the strategy (u_str_{is}) acquires binary values (min=0, max=1, step=1) and discrete values.
- *Continuous parameter*, take any value from the interval. The parameter precision determines the minimal value in which the continuous parameters can change. Continuous parameters will be used in the model when the strategy (u_str_{is}) acquires continuous values.

Besides governing the type of optimisation parameters, OptQuest enables to control the search as follows (Kleijnen and Wan, 2007):

- OptQuest allows different precision criteria for both the objective and the constrained simulation outputs:
    - The simplest option is to specify a fixed number of replicates
    - A more advanced option is to select the number of replicates between fixed lower and upper bounds, stopping the replication if any inferior solution is found.
- OptQuest also allows to select a relative precision
- OptQuest allows different stopping criteria; for example, stop the search after 300 min (5 h), after 500 'non improving solutions', or after certain number of iterations.

As regards the gap of the best solution found, OptQuest does not provide any information. Therefore, this information cannot be given to the user. The main reason of this limitation of information is that the metaheuristic used is neither known, commercial reasons are behind this.

AnyLogic simulation software supports multicore processors. When optimisation experiment is started, *AnyLogic* automatically detects the number of available cores and runs several iterations in parallel on different processor cores. Thereby performance is multiply increased and the experiment is performed significantly quicker than on processor with a single core.

7.2.3 *Example 7.1.* Building and Solving the SAM in the simulation software

For a better comprehension an illustrative example (*Example 7.1.*) is proposed in order to show how the SAM is built and solved in *AnyLogic*. The optimisation package in the simulation software is implemented in order to identify the values of the decision variables modelled (u_str_{is} and ti_str_{is}) that lead to the maximisation of the objective function ($max.\, kpi'_{net}$).

> <u>*Recalling the previous examples*</u>
>
> *The illustrative* ***Example 5.5*** *in Chapter 5 described a network of two enterprises. This example was proposed in order to give a better comprehension of the proposed mathematical model (SAM). Example 5.5 was not solved using computational and simulation techniques due to so far the resolution method was not described.*
>
> *The* ***Example 6.1*** *in Chapter 6 considers the same network as the described in the Example 5.5. In Example 6.1 the equations corresponding to each defined scenario (non-collaborative and collaborative) are formulated considering the SD notation. The specific equations, written in SD terminology, are those that will be introduced in the flow diagram constructed in the simulation software. Nevertheless, as the simulation software was not introduced in Chapter 6, the SAM was not solved so far.*

It is in this Chapter 7 where the examples previously raised are going to be computationally solved using AnyLogic simulation software. The way in which the collaborative scenario is constructed in *AnyLogic* is described in this section, *Example 7.1*.

The data (gathered in *Example 5.5*) and the equations raised in SD terminology (raised in *Example 6.1*) are used to solve, through the SD method, the SAM.

Example 7.1. focuses on the collaborative scenario in which both enterprises, Enterprise 1 and Enterprise 2, collaboratively participate in the decision making of identifying the strategies to activate. The information as regards the influence that the strategies, formulated by both enterprises, have on all the objectives (KPIs) is known by the two enterprises belonging to the CN. Therefore, in order to make the decision of which strategies to activate, the enterprise 1 not only considers how the activation of its own strategies influence in the objectives defined in the same enterprise 1 but also takes into account how the strategies formulated in enterprise 2 influence the objectives defined in the enterprise 1. The same occurs with the enterprise 2. Thus, in the collaborative scenario, the decision variables, u_str_{is} and ti_str_{is} are computed tacking into account not only the strategies formulated in the same enterprise, but also considering the strategies formulated by the other enterprises of the network. The decision variables u_str_{is} and ti_str_{is} are identified considering that the performance is maximised at network level ($\Delta kpi'_{net}$). It considers all the value cells of the parameter $val\_str_{is}\ \_kpi'_{ixk}$ (Table 5.5, Chapter 5).

According to the aforementioned, the equations for the collaborative scenario in both enterprises are presented in Table 7. 2.

Table 7. 2. Equations for Enterprise 1 and Enterprise 2 to model the strategies alignment process in SD from a collaborative context

Dimensions	
dimension_ixk index_KPI111 index_KPI121 index_KPI211 index_KPI221	dimension_is index_S11 index_S12 index_S21 index_S22
Budget b_1	
b1 - S11_mu - S12_mu	
Budget b_2	
b2 - S21_mu - S22_mu	

Strategy str_{11}
S11_mu = u_S11 · c_Sis.get(index_S11)
tf_S11 = ti_S11 + d4_Sis.get(index_S11)
d3_S11 = d4_Sis.get(index_S11) - d1_Sis.get(index_S11) - (2·d2_Sis.get(index_S11))
slope_S11_KPIixk = (u_S11 · val_S11_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S11)
Inf_S11_KPIixk = delay (ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11, ti_S11 + d2_Sis.get(index_S11)) - ramp (slope_S11_KPIixk[dimension_KPIixk], ti_S11 + d2_Sis.get(index_S11) + d3_S11, ti_S11 + 2·d2_Sis.get(index_S11) + d3_S11) , d1_Sis.get(index_S11))
Strategy str_{12}
S12_mu = u_S12 · c_Sis.get(index_S12)
tf_S12 = ti_S12 + d4_Sis.get(index_S12)
d3_S12 = d4_Sis.get(index_S12)- d1_Sis.get(index_S12) - (2·(d2_Sis.get(index_S12)))
slope_S12_KPIixk = (u_S12 · val_S12_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S12)
Inf_S12_KPIixk = delay (ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12, ti_S12 + d2_Sis.get(index_S12)) - ramp (slope_S12_KPIixk[dimension_KPIixk], ti_S12 + d2_Sis.get(index_S12) + d3_S12, ti_S12 + 2·d2_Sis.get(index_S12) + d3_S12) , d1_Sis.get(index_S12))
Strategy str_{21}
S21_mu = u_S21 · c_Sis.get(index_S21)
tf_S21 = ti_S21 + d4_Sis.get(index_S21)
d3_S21 = d4_Sis.get(index_S21) - d1_Sis.get(index_S21) - (2·d2_Sis.get(index_S21))
slope_S21_KPIixk = (u_S21 · val_S21_KPIixk [dimension_KPIixk]) / d2_Sis.get(index_S21)
Inf_S21_KPIixk = delay (ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21, ti_S21 + d2_Sis.get(index_S21)) - ramp (slope_S21_KPIixk[dimension_KPIixk], ti_S21 + d2_Sis.get(index_S21) + d3_S21, ti_S21 + 2·d2_Sis.get(index_S21) + d3_S21) , d1_Sis.get(index_S21))
Strategy str_{22}
S22_mu = u_S22 · c_Sis.get(index_S22)
tf_S22 = ti_S22 + d4_Sis.get(index_S22)
d3_S22 = d4_Sis.get(index_S22)- d1_Sis.get(index_S22) - (2·(d2_Sis.get(index_S22)))
slope_S22_KPIixk = (u_S22 · val_S22_KPIixk [dimension_KPIixk])/ d2_Sis.get(index_S22)
Inf_S22_KPIixk = delay (ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22, ti_S22 + d2_Sis.get(index_S22)) - ramp (slope_S22_KPIixk[dimension_KPIixk], ti_S22 + d2_Sis.get(index_S22) + d3_S22, ti_S22 + 2·d2_Sis.get(index_S22) + d3_S22) , d1_Sis.get(index_S22))
KPIs: kpi_{ixk}
curve_KPIixk = Inf_S11_KPIixk[dimension_KPIixk] + Inf_S12_KPIixk[dimension_KPIixk] + Inf_S21_KPIixk[dimension_KPIixk] + Inf_S22_KPIixk[dimension_KPIixk]
KPIixk = ∫ curve_KPIixk[dimension_KPIixk]
Curve_KPIixk_T = IF ((curve_KPIixk[dimension_KPIixk] >= Threshold_KPIixk[dimension_KPIixk]) THEN (curve_KPIixk[dimension_KPIixk] - Threshold_KPIixk[dimension_KPIixk]) ELSE(IF (curve_KPIixk[dimension_KPIixk] < 0) THEN curve_KPIixk[dimension_KPIixk] ELSE 0))
KPIixk_T = ∫ curve_KPIixk_T[dimension_KPIixk]
fulfill_KPIixk_min = IF ((KPIixk_T[dimension_KPIixk] >= KPIixk_min[dimension_KPIixk]) THEN 1 ELSE 0)
KPIs: kpi_i
KPI_1 = KPIixk_T.get(index_KPI111) · Wixk.get(index_KPI111) + KPIixk_T.get(index_KPI121) · Wixk.get(index_KPI121)
KPI_2 = KPIixk_T.get(index_KPI211) · Wixk.get(index_KPI211) + KPIixk_T.get(index_KPI221) · Wixk.get(index_KPI221)
KPIs: kpi_n
KPI_GLOBAL = (KPI_1 + KPI_2) /2

The flow diagram is generated for the collaborative scenario according to the steps proposed in Chapter 6 (Figure 6.3 and Figure 6.4) and the equations are now introduced in *AnyLogic®* simulation software (Figure 7.2). The functions of influence that the strategies (formulated in both enterprises) exert on each KPI defined in Enterprise 1 are depicted in Figure 7.3. The curves of influence that the strategies (formulated in both enterprises) exert on each KPI defined in Enterprise 2 are shown in Figure 7.4. The design of the optimisation experiment is shown in Figure 7.5.

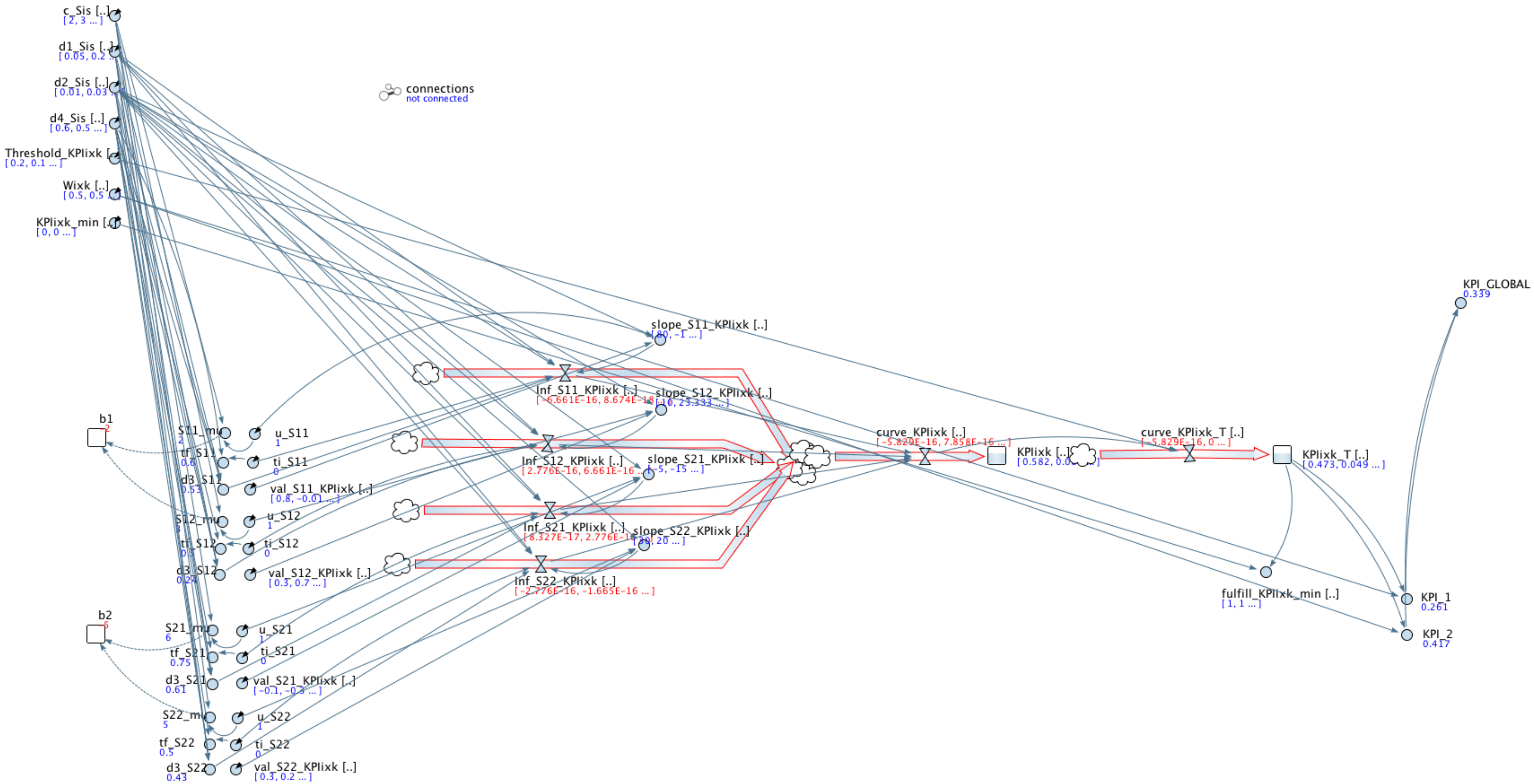


Figure 7.2. Flow Diagram: CN

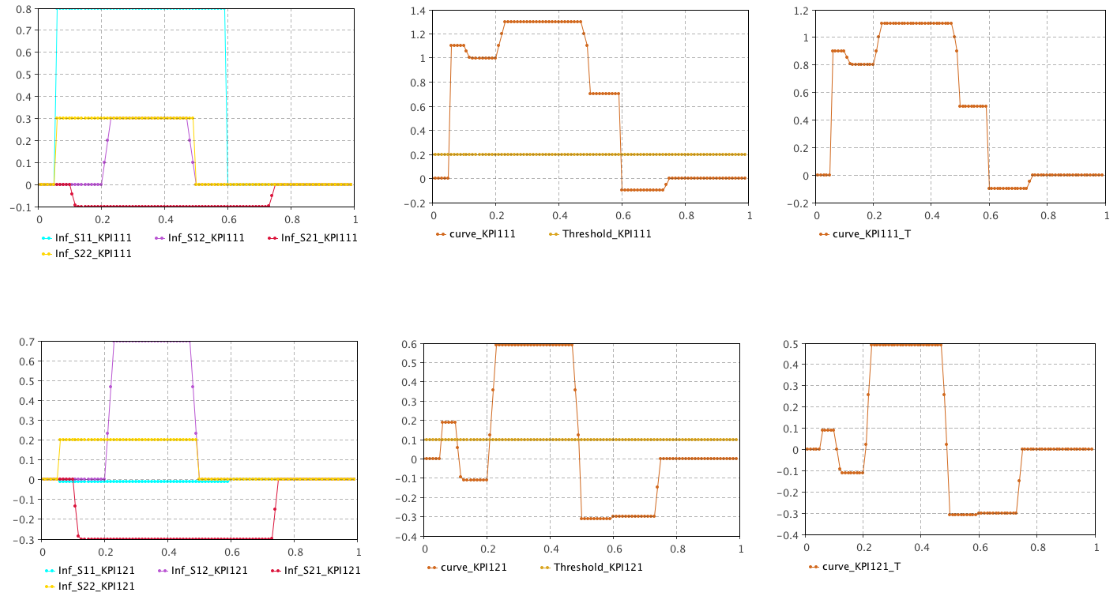


Figure 7.3. Representation of the functions of influence $f\_inf\_str_{is}\_kpi'_{111}(t)$ and $f\_inf\_str_{is}\_kpi'_{121}(t)$ that the strategies str_{11}, str_{12}, str_{21} and str_{22} exert over the kpi'_{111} and kpi'_{121} defined by Enterprise 1

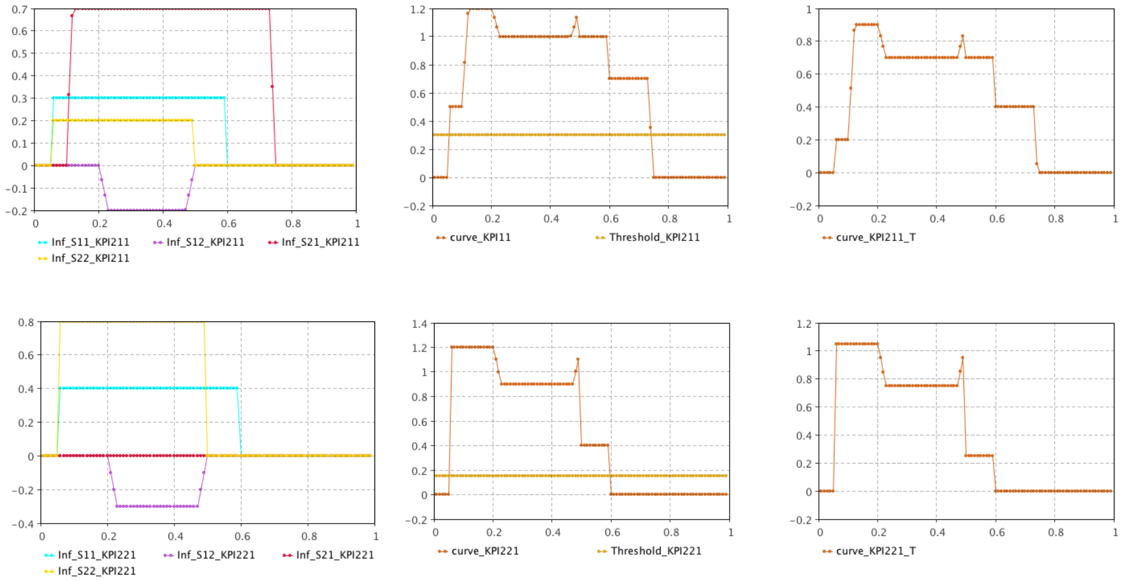


Figure 7.4. Representation of the function of influence $f\_inf\_str_{is}\_kpi'_{211}(t)$ and $f\_inf\_str_{is}\_kpi'_{221}(t)$ that the strategies str_{11}, str_{12}, str_{21} and str_{22} exert over the kpi'_{211} and kpi'_{221} defined by Enterprise 2

In the configuration of the optimisation experiment two types of parameters are defined: discrete parameters for the decision variable u_str_{is} (modelling that the strategy can acquire binary values, or activated or non-activated) and continuous for the ti_str_{is} (modelling that the strategy can be activated at any point during the simulation horizon, from 0 to the unit). Moreover, the requirements are defined corresponding to the constraints of the SAM.

The optimised solution resulting from the application of the SAM, maximising the kpi'_{net}, is shown in Figure 7.6.

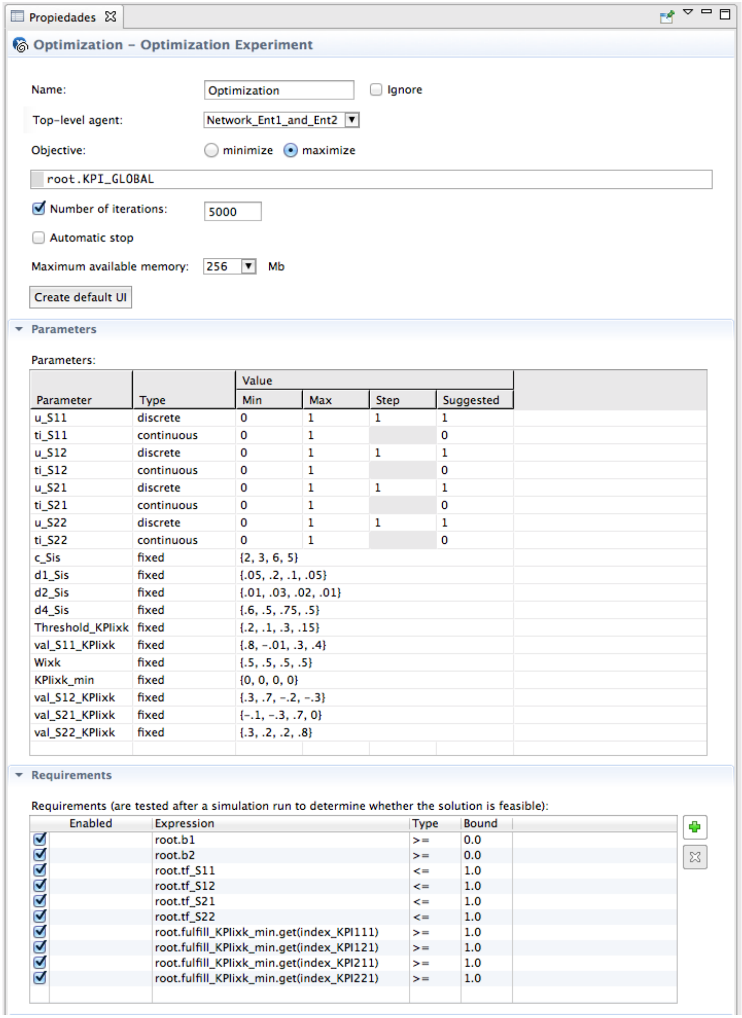


Figure 7.5. Configuration of the Optimisation Experiment in the CN

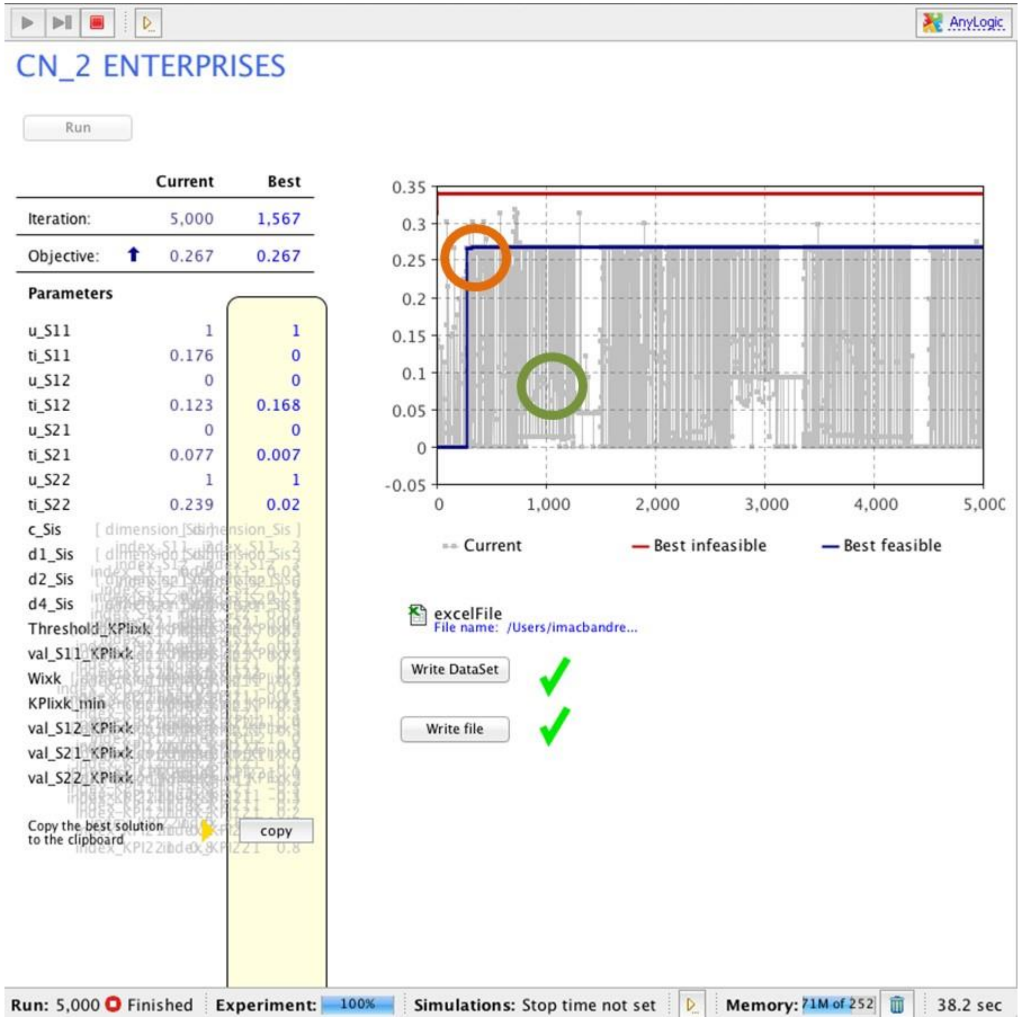
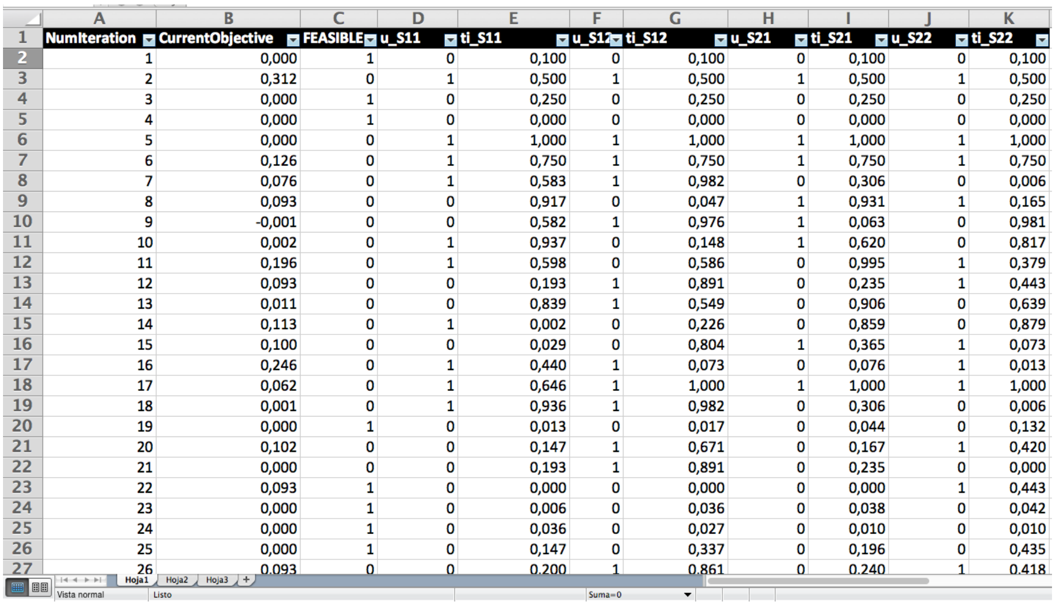


Figure 7.6. Network: Optimisation Results

In the graph depicted in the optimization user interphase (UI) (Figure 7.6) it can be observed that the objective function is maximize the network performance level. Each dot in the graph corresponds to a single simulation run. These are attempts to the optimizer to choose different points in the eight dimensional parameters space. Whenever the optimizer finds a parameter combination better than previous one the line representing the best feasible solution goes up (−). In this particular case, the optimizer is searching in a space of the eight dimensional parameters and because the optimizer does not know anything about the shape of the objective function, it would try in different parts of the parameters space. In the graph it can be seen that the optimizer found a good solution (○) but then decides to jump to somewhere else (○) to change the value of a certain parameter or a couple of parameters to look in a different part of the parameters space. The optimiser simulates another combination of parameters in space and computes the network performance level. The unsuccessful tries (○) look for a different optimization solution.

The optimisation experiment offers the optimum set of parameters, which maximise the objective function, through simulating different scenarios. The values of the parameters obtained in each iteration are gathered in the *Datasets*. These *Datasets* are stored in a spreadsheet that is obtained though using the buttons "*Write Dataset*" and "*Write File"*, located in the layout of the optimisation experiment (Figure 7.6). The table generated in the spreadsheet (Figure 7.7) gathers the data obtained in each iteration carried out in the optimisation experiment, specifically (i) the number of iteration, (ii) the value of the objective in the current iteration, (iii) the feasibility of the solution; each time the optimization engine generates a new set of values for the optimization parameters, it creates feasible solutions, satisfying the restrictions associated to the SAM; thus the space of searching is reduced, and the optimization is performed faster. *Feasible:1* indicates that the solution is feasible while *Feasible:0* indicates that the solution is not feasible, (iv) the values of the set of parameters u_str_{is}, and (v) the values of the set of parameters ti_str_{is}.



	A	B	C	D	E	F	G	H	I	J	K
1	NumIteration	CurrentObjective	FEASIBLE	u_S11	ti_S11	u_S12	ti_S12	u_S21	ti_S21	u_S22	ti_S22
2	1	0,000	1	0	0,100	0	0,100	0	0,100	0	0,100
3	2	0,312	0	1	0,500	1	0,500	1	0,500	1	0,500
4	3	0,000	1	0	0,250	0	0,250	0	0,250	0	0,250
5	4	0,000	1	0	0,000	0	0,000	0	0,000	0	0,000
6	5	0,000	0	1	1,000	1	1,000	1	1,000	1	1,000
7	6	0,126	0	1	0,750	1	0,750	1	0,750	1	0,750
8	7	0,076	0	1	0,583	1	0,982	0	0,306	0	0,006
9	8	0,093	0	0	0,917	0	0,047	1	0,931	1	0,165
10	9	-0,001	0	0	0,582	1	0,976	1	0,063	0	0,981
11	10	0,002	0	1	0,937	0	0,148	1	0,620	0	0,817
12	11	0,196	0	1	0,598	0	0,586	0	0,995	1	0,379
13	12	0,093	0	0	0,193	1	0,891	0	0,235	1	0,443
14	13	0,011	0	0	0,839	1	0,549	0	0,906	0	0,639
15	14	0,113	0	1	0,002	0	0,226	0	0,859	0	0,879
16	15	0,100	0	0	0,029	0	0,804	1	0,365	1	0,073
17	16	0,246	0	1	0,440	1	0,073	0	0,076	1	0,013
18	17	0,062	0	1	0,646	1	1,000	1	1,000	1	1,000
19	18	0,001	0	1	0,936	1	0,982	0	0,306	0	0,006
20	19	0,000	1	0	0,013	0	0,017	0	0,044	0	0,132
21	20	0,102	0	0	0,147	1	0,671	0	0,167	1	0,420
22	21	0,000	0	0	0,193	1	0,891	0	0,235	0	0,000
23	22	0,093	1	0	0,000	0	0,000	0	0,000	1	0,443
24	23	0,000	1	0	0,006	0	0,036	0	0,038	0	0,042
25	24	0,000	1	0	0,036	0	0,027	0	0,010	0	0,010
26	25	0,000	1	0	0,147	0	0,337	0	0,196	0	0,435
27	26	0,093	0	0	0,200	1	0,861	0	0,240	1	0,418

Figure 7.7. Screenshot of the spreadsheet gathering the results obtained in scenarios generated in the optimisation experiment

The optimisation experiment UI shows the latest best solution (Figure 7.6). Nevertheless, in the spreadsheet, as it gathers all the iterations, can be found different sets of solutions which maximise the objective. Amongst all the solutions generated in each scenario, those that maximise the objective (0,2666975) are bounded. Allowing identifying the set of possible values that the decision variables (u_str_{is} and ti_str_{is}) can acquire, maximising the network performance (Annex 7.1). Normally, the values for the decision variable u_str_{is} will remain the same for all the feasible and optimised solutions. Nevertheless, the decision variable ti_str_{is}, being defined as a continuous parameter, different values lead to obtain the maximum value for the objective. In order to select one of these set (or combination) of solutions [u_str_{is}, ti_str_{is}] selection rules can be applied according to the decision criteria considered in each enterprise as regards the initial time (ti_str_{is}) of activation of the strategies. A list of selection rules examples is provided in Table 7.3.

Table 7.3. Examples of Selection Rules

Selection rule	Mathematical notation
The activation time of the strategies whose decision variable $u\_str_{is}> 0$, must be as soon/ later as possible, for example during the first/later half period of the simulation horizon	$\sum_i t_i'\_str_{is} < \frac{H'}{2} \quad \forall s$ $\sum_i t_i'\_str_{is} > \frac{H'}{2} \quad \forall s$
The activation time between the strategies whose decision variable $u\_str_{is}> 0$, must be as long/short as possible	$\max \sum_{s,c} (t_i'\_str_{is} - t_i'\_str_{ic})$ $\min \sum_{s,c} (t_i'\_str_{is} - t_i'\_str_{ic})$
The activation time of an specific strategy which $u\_str_{is}> 0$, must be before/after/between a defined time:	$t_i'\_str_{is} \leq t$ $t_i'\_str_{is} > t$ $t1 < t_i'\_str_{is} < t2$

The results obtained from the optimisation experiment are graphically shown in Figure 7.8. The functions of influence depicted considering the data obtained from the optimisation experiment are shown in Figure 7.9. In this case only the functions that correspond to the strategies to be activated (u_str_{is}), which are determined by the optimization solution, are represented, considering the initial activation time (ti_str_{is}), also determined by optimization experiment.

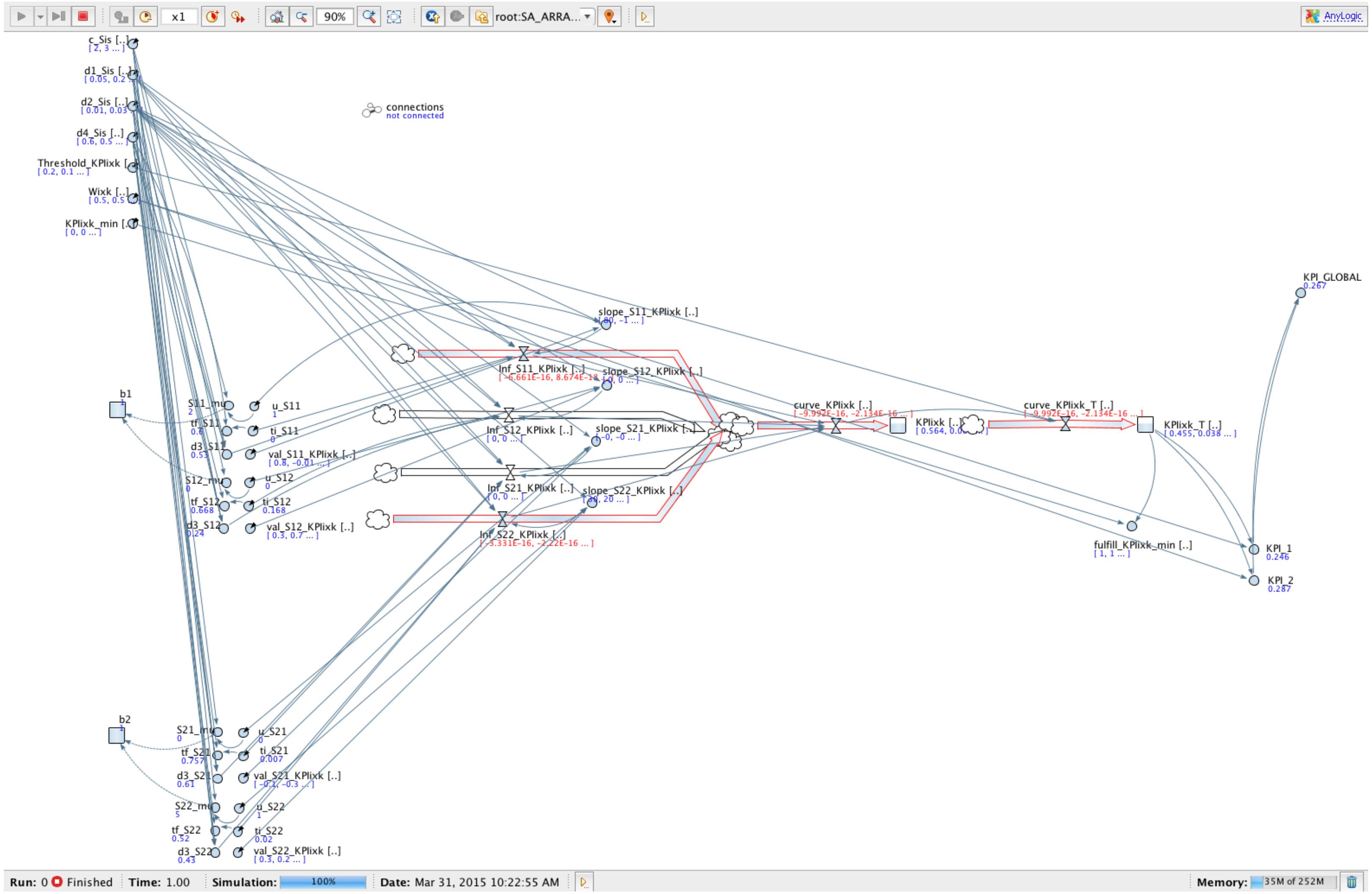


Figure 7.8. Flow diagram with the optimised results of the CN

Figure 7.9. Graphical optimisation results of the CN

7.3 Structure of the SAM input data

The use of a DMS is considered appropriate to manage the objects and information of the SAM. In the light of this, a DMS is used to structure the data as regards the parameters defined in the SAM. Different types of database managers can be found, such as Microsoft Access Database, Microsoft SQL Server, MySQL, Oracle, PostgreSQL, XML, etc. In order to structure and manage the SAM input data *Microsoft Access Database* manager is selected, the ease of its use is one of the main motivations for using it. Besides this, for the SAM developed it is not required a very powerful database, thus, *Microsoft Access Database* will allow to have the information structured.

In this section the structure of the DMS, used to gather the information necessary to feed the SAM, is shown.

The data required to support the SAM features is categorized into two groups:

- **Data related to the SAM input data.** Information necessary to identify each enterprise of the CN, as well as the strategies formulated and the KPIs defined. All the information as regards the parameters defined in the SAM is gathered.
- **Data related to the automatic SAM construction.** Information required to automatically building the SAM is gathered.

7.3.1 Database gathering the SAM input data

The DMS gathering the SAM input data is arranged considering the classification of the variables used in SD (stock, flow, parameters and auxiliary variables). The input data tables of the DMS correspond to the parameters of the SAM. Hereafter, the description of the DMS is preformed considering this classification. Generally speaking and valid for all the tables, it must be stated that some of the fields that are not described in this section, but contained in the tables, correspond to data required for the automatic generation of the SAM (7.4 Strategies Alignment Model Generator). A set of 24 tables can be distinguished, containing the data required for the application of the SAM. Next, the SAM input data tables are going to be described.

The table *Enterprises* contains general information as regards the number of enterprises (identifying each enterprise with a correlative number), the number of strategies formulated and the number of KPIs defined by each enterprise. The rest of the input data tables are referred to the table *Enterprises* (Figure 7.10).

The table *StockVariable02_BUDGETi* collects the information as regards the budget that each enterprise owns in order to invest in the activation of, part or all, the strategies previously formulated.

The table *Parameter02_c_Sis* provides information as regards the cost of activating one unit of strategy formulated in each enterprise (u_str_{is}). The tables *Parameter06_d1_Sis*, *Parameter05_d2_Sis* and *Parameter07_d4_Sis* offer information as regards the durations, characterising each strategy (str_{is}) formulated by each enterprise belonging to the network. The fields gathered in each table respectively correspond to the parameters of the SAM related with the duration of the delay ($d1\_str_{is}$), duration of the ramp ($d2\_str_{is}$) and duration of the strategy ($d4\_str_{is}$). The tables *Parameter09_KPIik_min*, *Parameter08_Wik_min* and *Parameter09_Threshold_KPIik* collect the information that characterises the KPIs defined by each enterprise. The information gathered in each table respectively is: the minimum increase determined for the kpi_{ixk} (kpi_{ixk}_min), the relevance that the kpi_{ixk} has for enterprise (w_{ixk}), and the threshold value of each kpi_{ixk} ($Threshold\_kpi_{ixk}$). Finally, the table Parameter04_val_Sis_KPIik provides the information as regards the influence that each kpi_{ixk} experiences when one unit of str_{is} is activated ($val\_str_{is}\_kpi_{ixk}$).

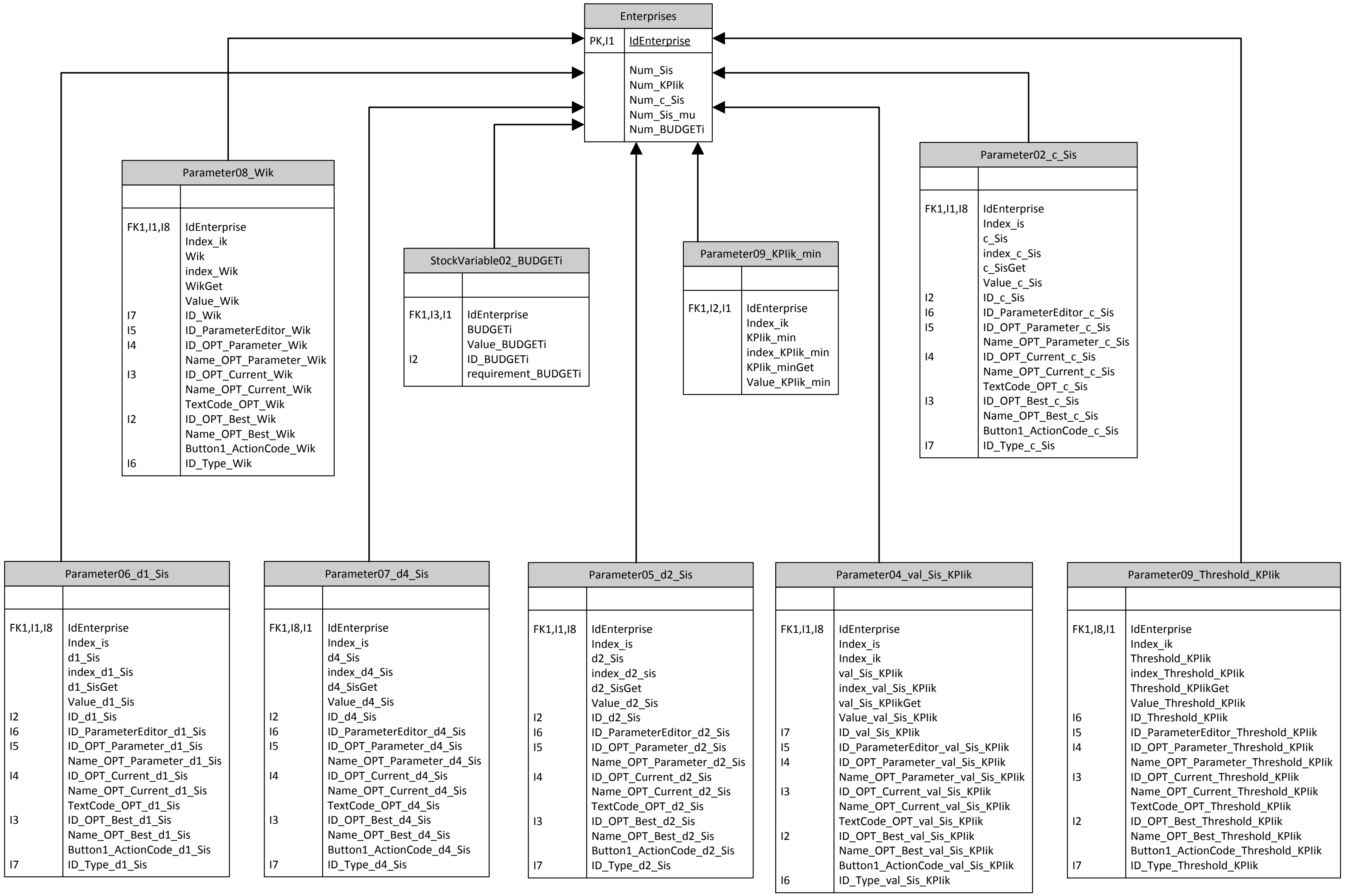


Figure 7.10. Data related to the SAM input data

Table 7.4 summarises the relationship between the information provided by the tables, above described, and the SAM input parameters.

Table 7.4. Connection between the DMS tables and model input parameters (I)

Variable in SD model	Parameter in the mathematical model (SAM)	Data Base Table	Field of the Table
c_Sis	c_str_{is}	*Parameter02_c_Sis*	*Value_c_Sis*
d1_Sis	$d_1\_str_{is}$	*Parameter06_d1_Sis*	*Value_d1_Sis*
d2_Sis	$d_2\_str_{is}$	*Parameter05_d2_Sis*	*Value_d2_Sis*
d4_Sis	$d_4\_str_{is}$	*Parameter07_d4_Sis*	*Value_d4_Sis*
KPIixk_min	Δkpi_{ixk}_min	*Parameter09_KPIik_min*	*Value_KPIik_min*
Threshold_KPIixk	$Threshold\_kpi_{ixk}$	*Parameter09_Threshold_KPIik*	*Value_Threshold_KPIik*
val_Sis_KPIixk	$val\_str_{is}\_kpi_{ixk}$	*Parameter04_val_Sis_KPIik*	*Value_val_Sis_KPIik*
Wikx	w_{ixk}	*Parameter08_Wik*	*Value_Wik*
bi	b_i	*StockV2ariable02_KPIik*	*Value_BUDGETi*

The SAM input parameters and the values associated allow to compute the other set of parameters of the model which are divided into auxiliary variables, flow variables and stock variables.

The values of the auxiliary variables are calculated from the SAM input parameters above described (see Table 7.4). A set of seven tables is defined containing information as regards the auxiliary variables of the SAM (Figure 7. 11). The table *AuxVariable01_Sis_mu* contains the information as regards the monetary units invested in the activation of str_{is}. The table *AuxVariable04_d3_Sis* gathers the information of the time period in which str_{is} is exerting the highest influence. The table *AuxVariable06_tf_Sis* provides the information of the unit of time in which str_{is} is finished. The table *AuxVariable05_KPIi* offers the information as regards the KPI defined at enterprise level and the table *AuxVariable02_GLOBAL_KPI_T* includes the information of the KPI defined at network level. The table *AuxVariable04_slope_Sis_KPIik_T* contains the information of the slope of the ramp in represented in the function that models the behaviour of the $kpi_{ixk}$when str_{is} is activated. Finally, the table *AuxVariable07_fulfill_KPIik_min* gathers the information as regards the fulfilment of the requirements defined by the enterprises in terms of achieving a minimum increase on the kpi_{ixk}_min. The formulas related to each auxiliary variable are also given in each of the tables.

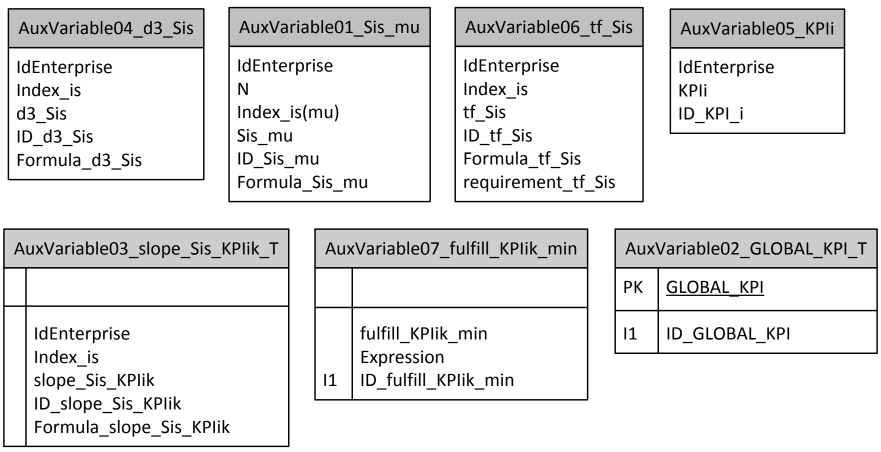


Figure 7. 11. Data related to the SAM input data: Auxiliary Variables

A set of three tables is defined containing information as regards the flow variables of the SAM (Figure 7.12). The values of the flow variables are also computed from the SAM input parameters described inTable 7.4. The table *Flow01_Inf_Sis_KPIik_T* provides the information as regards the function that models the behaviour of the $kpi_{ixk}$when str_{is} is activated. The table *Flow02_curve_KPIik* offers the information of the function that models the overall influence received by the kpi_{ixk}considering all the activated strategies. The table *Flow03_curve_KPIik_T* includes the information to represent the curve that models the behaviour of the kpi_{ixk} when the $Threshold\_kpi_{ixk}$ value is computed. The formulas related to each flow variable are also given in each of the tables.

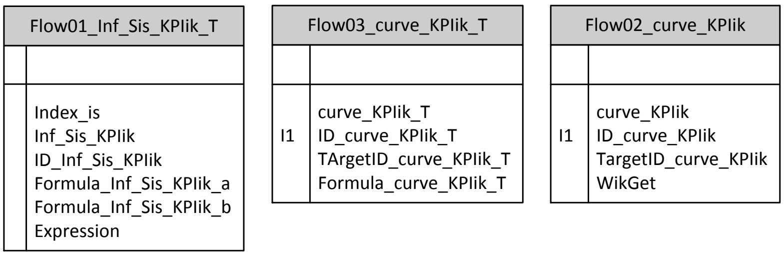


Figure 7.12. Data related to the SAM input data: Flow Variables

A set of two tables is defined containing information as regards the stock variables defined in the SAM (Figure 7.13). The values of the stock variables are computed from the flow variables (Figure 7.12). The table *StockVariable01_KPIik* provides the information of the increase observed in the kpi_{ixk} when the str_{is} is activated. The table *StockVariable03_KPIiK_T* offers the information as regards the increase experienced by the kpi_{ixk} once the $Threshold\_kpi_{ixk}$ is computed.

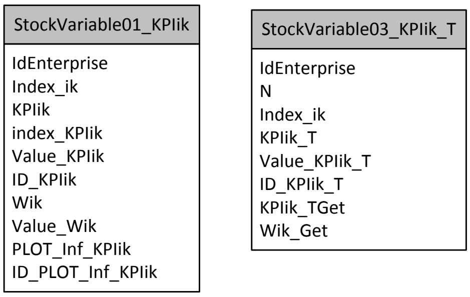


Figure 7.13. Data related to the SAM input data: Stock VariablesTable 7.5

Table 7.5 summarises the relationship between the information provided by the tables, above described (auxiliary, flow and stock variables), and the SAM input parameters.

Table 7.5. Connections between the DMS tables and SAM input parameters (II)

Variable in SD model	Parameter in the mathematical model	Data Base Table	Field of the Table
`Sis_mu`	str_{is}_mu	*AuxVariable01_ Sis_mu*	*Formula_ Sis_mu*
`d3_Sis`	$d_3\_str_{is}$	*AuxVariable04_d3_Sis*	*Formula_d3_Sis*
`tf_Sis`	tf_str_{is}	*AuxVariable06_tf_Sis*	*Formula_tf_Sis*
`slope_Sis_KPIikx`	$slope\_str_{is}\_kpi_{ixk}$	*AuxVariable03_slope_Sis_KPIik_T*	*Formula_ slope_Sis_KPIik*
`KPI_i`	Δkpi_i	*AuxVariable05_KPIi*	*KPIi*
`KPI_GLOBAL`	Δkpi_{net}	*AuxVariable02_GLOBAL_KPI_T*	*GLOBAL_KPI*
`fulfill_KPIixk_min`	Δkpi_{net}_min	*AuxVariable07_fulfill_KPIik_min*	*Expression*
`Inf_Sis_KPIixk`	$f\_inf\_str_{is}\_kpi_{ixk}(t)$	*Flow01_Inf_Sis_KPIik_T*	*Formula_Inf_Sis_KPIik_a* *Formula_Inf_Sis_KPIik_b* *Expression*
`curve_KPIixk`	$f\_kpi_{ixk}(t)$	*Flow02_curve_KPIik*	*curve_KPIik*
`curve_KPIixk_T`	$f\_kpi'_{ixk}\_T(t)$	*Flow03_curve_KPIik _T*	*Formula_curve_KPIik_T*
`KPIixk`	Δkpi_{ixk}	*StockVariable01_KPIik*	*Value_KPIik*
`KPIixk_T`	Δkpi_{ixk}_T	*StockVariable03_KPIik*	*Value_KPIik_T*

Two tables are created to collect the output data (u_str_{is} and ti_str_{is}) of the SAM (Figure 7.14). The tables *Parameter01_u_Sis* and *Parameter03_ti_Sis* are used to store the output values corresponding to the decision variables: the units of strategy [u.s] str_{is} to be activated (u_str_{is}) and the initial time of activation of str_{is} (ti_str_{is}). Both decision variables are part of the SAM parameters to be optimized in the optimisation experiment. The information required to feed the optimisation experiment is gathered in the fields *"Type_"* (for identifying if a parameter is continuous or discrete), *"Min_"* (for determining the lower bound of the parameter), *"Max_"* (for defining the upper bound of each parameter) and *"Step"* (for discrete parameters, to indicate the increment value of the parameter).

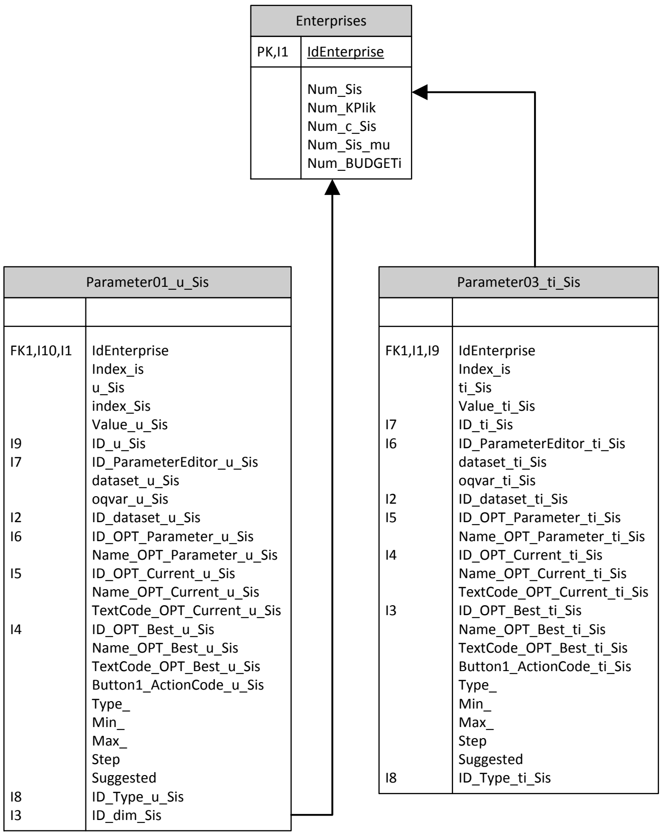


Figure 7.14. Tables used for storing SAM output data

Table 7.6 summarises the relationship between the information provided by the tables used to gather the SAM output data, and the model decision variables.

Table 7.6. Connections between tables and model output data

Variable in SD model	Parameter in the mathematical model	Data Base Table	Field of the Table
`u_Sis`	u_str_{is}	*Parameter01_u_Sis*	*Value_u_Sis*
`ti_Sis`	ti_str_{is}	*Parameter03_ti_Sis*	*Value_ti_Sis*

The input data parameters (Table 7.10, Table 7.4) are used to create the auxiliary variables, flow variables and stock variables of the SAM (Table 7.5). All these data is used as entry parameters for the SAM execution to compute the decision variables (u_str_{is} and ti_str_{is}), which correspond to the output values of the SAM (Figure 7.15).

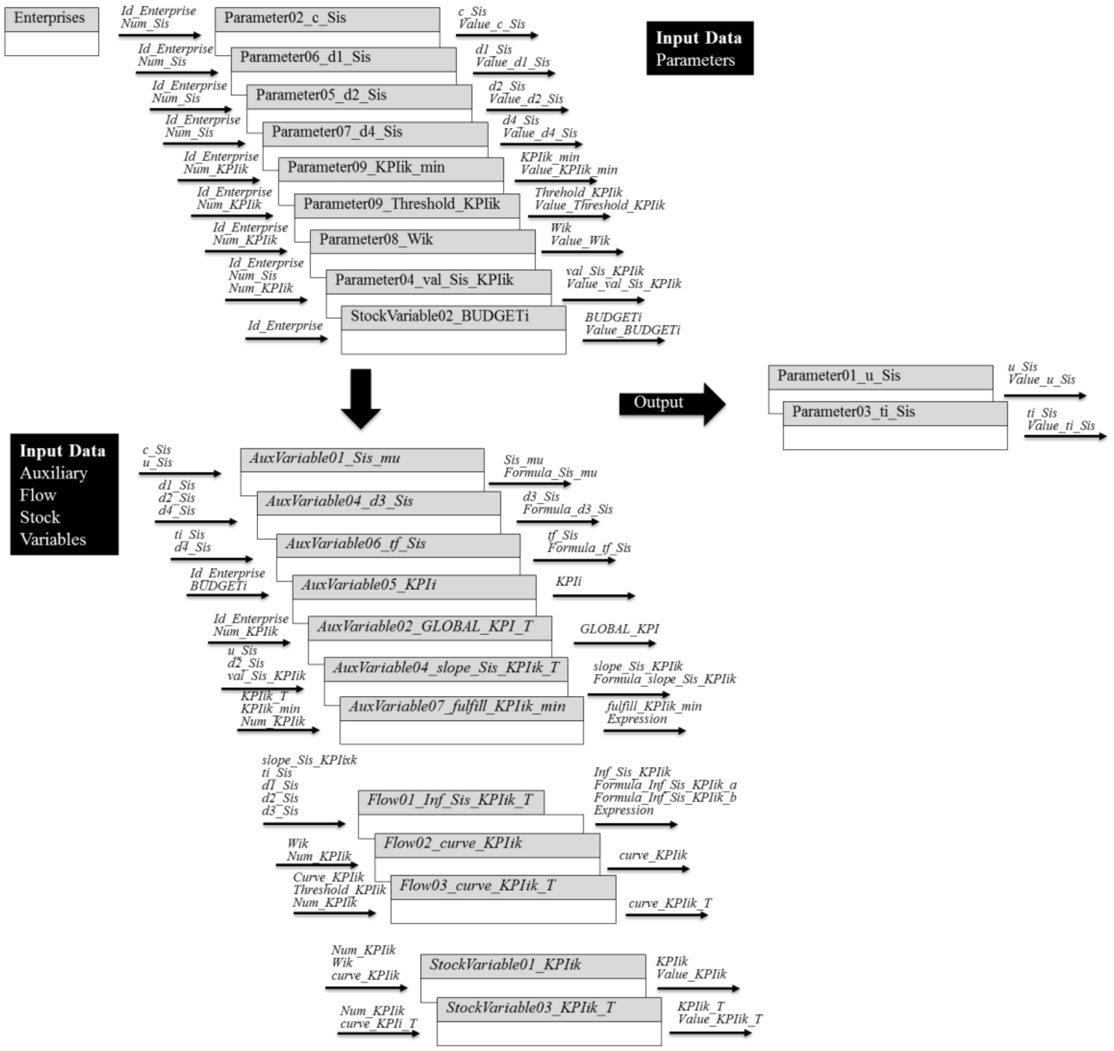


Figure 7.15. Relationship between tables of input and output data designed to implement the SAM

7.3.2 Database gathering the data to automatically build the SAM

The data related to the automatic SAM construction is stored (i) in the previous tables above described and (ii) in other tables specifically designed for gathering this type of data (Figure 7.16). The tables specifically created to automatically generate the SAM in SD simulation software (AnyLogic) contain information as regards the links. These links are specifically used in the automatic construction of the SAM to draw the relationships between the parameters, auxiliary variables, flow variables and stock variables.

Link01_slope_Sis_KPIik_with_Inf_Sis_KPIik_gen1
Name_Link_slope_Sis_KPIik_&_Inf_Sis_KPIik
ID_Link_slope_Sis_KPIik_&_Inf_Sis_KPIik
SourceID_Link_slope_Sis_KPIik_&_Inf_Sis_KPIik
TargetID_Link_slope_Sis_KPIik_&_Inf_Sis_KPIik

Link02_ti_Sis_with_Inf_Sis_KPIik_gen1
Name_Link_ti_Sis_&_Inf_Sis_KPIik
ID_Link_ti_Sis_&_Inf_Sis_KPIik
SourceID_Link_ti_Sis_&_Inf_Sis_KPIik
TargetID_Link_ti_Sis_&_Inf_Sis_KPIik

Link03_d2_Sis_with_Inf_Sis_KPIik_gen1
Link_d2_Sis_&_Inf_Sis_KPIik
Name_Link_d2_Sis_&_Inf_Sis_KPIik
ID_Link_d2_Sis_&_Inf_Sis_KPIik
SourceID_Link_d2_Sis_&_Inf_Sis_KPIik
TargetID_Link_d2_Sis_&_Inf_Sis_KPIik

Link04_d1_Sis_with_Inf_Sis_KPIik_gen1
Link_d1_Sis_&_Inf_Sis_KPIik
Name_Link_d1_Sis_&_Inf_Sis_KPIik
ID_Link_d1_Sis_&_Inf_Sis_KPIik
SourceID_Link_d1_Sis_&_Inf_Sis_KPIik
TargetID_Link_d1_Sis_&_Inf_Sis_KPIik

Link05_d2_Sis_with_slope_Sis_KPIik_gen1
Link_d2_Sis_&_slope_Sis_KPIik
Name_Link_d2_Sis_&_slope_Sis_KPIik
ID_Link_d2_Sis_&_slope_Sis_KPIik
SourceID_LInk_d2_Sis_&_slope_Sis_KPIik
TargetID_Link_d2_Sis_&_slope_Sis_KPIik

Link06_val_Sis_KPIik_with_slope_Sis_KPIik_gen1
Name_Link_val_Sis_KPIik_&_slope_Sis_KPIik
ID_Link_val_Sis_KPIik_&_slope_Sis_KPIik
SourceID_Link_val_Sis_KPIik_&_slope_Sis_KPIik
TargetID_Link_val_Sis_KPIik_&_slope_Sis_KPIik

Link07_u_Sis_with_slope_Sis_KPIik_gen1
Name_Link_u_Sis_&_slope_Sis_KPIik
ID_Link_u_Sis_&_slope_Sis_KPIik
SourceID_LInk_u_Sis_&_slope_Sis_KPIik
TargetID_Link_u_Sis_&_slope_Sis_KPIik

Link08_ti_Sis_with_tf_Sis_gen1
ti_Sis
tf_Sis
Link_ti_Sis_&_tf_Sis
Name_Link_ti_Sis_&_tf_Sis
ID_Link_ti_Sis_&_tf_Sis
SourceID_ti_Sis_&_tf_Sis
TargetID_ti_Sis_&_tf_Sis

Link09_u_Sis_with_Sis_mu_gen1
Index_is
Index_is(mu)
u_Sis
Sis_mu
Link_u_Sis_&_Sis_mu
Name_Link_u_Sis_&_Sis_mu
ID_Link_u_Sis_&_Sis_mu
SourceID_u_Sis_&_Sis_mu
TargetID_u_Sis_&_Sis_mu

Link10_c_Sis_with_Sis_mu_gen1
Index_is
Index_is(mu)
index_c_Sis
Sis_mu
Link_c_Sis_&_Sis_mu
Name_Link_c_Sis_&_Sis_mu
ID_Link_c_Sis_&_Sis_mu
SourceID_c_Sis_&_Sis_mu
TargetID_c_Sis_&_Sis_mu

Link11_Sis_mu_with_BUDGETi_gen1
Link_Sis_mu_&_BUDGETi
Name_Link_Sis_mu_&_BUDGETi
ID_Link_Sis_mu_&_BUDGETi
SourceID_Link_Sis_mu_&_BUDGETi
TargetID_Link_Sis_mu_&_BUDGETi

Link12_d4_Sis_with_d3_Sis_gen1
d4_Sis
d3_Sis
Link_d4_Sis_&_d3_Sis
Name_Link_d4_Sis_&_d3_Sis
ID_Link_d4_Sis_&_d3_Sis
SourceID_d4_Sis_&_d3_Sis
TargetID_d4_Sis_&_d3_Sis

Link13_d2_Sis_with_d3_Sis_gen1
d2_Sis
d3_Sis
Link_d2_Sis_&_d3_Sis
Name_Link_d2_Sis_&_d3_Sis
ID_Link_d2_Sis_&_d3_Sis
SourceID_d2_Sis_&_d3_Sis
TargetID_d2_Sis_&_d3_Sis

Link14_d4_Sis_with_tf_Sis_gen1
d4_Sis
tf_Sis
Link_d4_Sis_&_tf_Sis
Name_Link_d4_Sis_&_tf_Sis
ID_Link_d4_Sis_&_tf_Sis
SourceID_d4_Sis_&_tf_Sis
TargetID_d4_Sis_&_tf_Sis

Link15_KPI_i_with_GLOBAL_KPI_gen1
Link_KPI_i_&_GLOBAL_KPI
Name_Link_KPI_i_&_GLOBAL_KPI
ID_Link_KPI_i_&_GLOBAL_KPI
SourceID_Link_KPI_i_&_GLOBAL_KPI
TargetID_Link_KPI_I_&_GLOBAL_KPI

Link16_d1_Sis_with_d3_Sis_gen1
index_d1_Sis
d3_Sis
Link_d1_Sis_&_d3_Sis
Name_Link_d1_Sis_&_d3_Sis
ID_Link_d1_Sis_&_d3_Sis
SourceID_d1_Sis_&_d3_Sis
TargetID_d1_Sis_&_d3_Sis

Link17_d3_Sis_with_Inf_Sis_KPIik_gen1
Name_Link_d3_Sis_&_Inf_Sis_KPIik
ID_Link_d3_Sis_&_Inf_Sis_KPIik
SourceID_Link_d3_Sis_&_Inf_Sis_KPIik
TargetID_Link_d3_Sis_&_Inf_Sis_KPIik

Link18_Wik_with_curve_KPIik_gen1
Name_Link_Wik_&_curve_KPIik
ID_Link_Wik_&_curve_KPIik
SourceID_Link_Wik_&_curve_KPIik
TargetID_Link_Wik_&_curve_KPIik

Link19_curve_KPIik_with_curve_KPIik_T_gen1
Name_Link_curve_KPIik_&_curve_KPIik_T
ID_Link_curve_KPIik_&_curve_KPIik_T
SourceID_Link_curve_KPIik_&_curve_KPIik_T
TargetID_Link_curve_KPIik_&_curve_KPIik_T

Link20_Threshold_KPIik_with_curve_KPIik_T_gen1
Name_Link_Threshold_KPIik_&_curve_KPIik_T
ID_Link_Threshold_KPIik_&_curve_KPIik_T
SourceID_Link_Threshold_KPIik_&_curve_KPIik_T
TargetID_Link_Threshold_KPIik_&_curve_KPIik_T

Link21_KPIik_T_with_KPI_i_gen1
Name_Link_KPIik_T_&_KPI_i
ID_Link_KPIik_T_&_KPI_i
SourceID_KPIik_T_&_KPI_i
TargetID_Link_KPIik_T_&_KPI_i

Link21a_Wik_with_KPI_i_gen1
Name_Link_Wik_&_KPI_i
ID_Link_Wik_&_KPI_i
SourceID_Link_Wik_&_KPI_i
TargetID_Link_Wik_&_KPI_i

Link22_Inf_Sis_KPIik_with_curve_KPIik_gen1
Name_Link_Inf_Sis_KPIik_&_curve_KPIik
ID_Link_Inf_Sis_KPIik_&_curve_KPIik
SourceID_Link_Inf_Sis_KPIik_&_curve_KPIik
TargetID_Link_Inf_Sis_KPIik_&_curve_KPIik

Link23_KPIik_T_with_fulfill_KPIik_min_gen1
Name_Link_KPIik_T_&_fulfill_KPIik_min
ID_Link_KPIik_T_&_fulfill_KPIik_min
SourceID_Link_KPIik_T_&_fulfill_KPIik_min
TargetID_Link_KPIik_T_&_fulfill_KPIik_min

Link24_KPIik_min_with_fulfill_KPIik_min_gen1
Name_Link_KPIik_min_&_fulfill_KPIik_min
ID_Link_KPIik_min_&_fulfill_KPIik_min
SourceID_Link_KPIik_min_&_fulfill_KPIik_min
TargetID_Link_KPIik_min_&_fulfill_KPIik_min

Figure 7.16. Data related to the automatic SAM construction: Tables used for storing SAM links among the parameters, auxiliary variables, stock variables and flow variables

7.4 Strategies Alignment Model Generator

The manual modelling of the strategies alignment simulation model (in SD) could result easy with a reduced number of enterprises (i.e. a CN with two enterprises, *Example 7.1*). Nevertheless, when the modeller faces a network with a higher number of enterprises, each one defining large amounts of KPIs and formulating a high number of strategies, the amount of parameters, auxiliary variables, flow variables and stock variables exponentially increase; resulting on an increase of the size of the problem to be modelled and being difficult to manually handle.

In order to avoid this tedious task, an application that automatically generates the strategies alignment simulation model is designed. The information stored in the DMS created (7.3 Structure of the SAM input data) is used to this end. The created application is called Strategies Alignment model GENerator (SAGEN). As the models build in AnyLogic have the property of being read in XML language (*Extensible Markup Language*), SAGEN builds the SAM in an XML file, able to be read by *AnyLogic*, containing all the variables and data gathered from the enterprises in the DMS. Next sub-sections describe how the SAM is automatically created.

7.4.1 Reading simulation models in an *XML* file

First of all it has been considered that all the models built in *AnyLogic* simulation software can be read in XML language, with a specific schema. In order to reproduce this specific schema, the structure of an XML file created by *AnyLogic* is analysed. In the light of this, the SAM simulated in the *Example 7.1* is used. Some examples of XML Schema are provided in next tables. Table 7.7 shows the XML schema used to represent a Parameter. In Table 7.8, the schema to define an Auxiliary Variable in the SAM is shown. Finally Table 7.9 and Table 7.10 show the schemas corresponding to the Flow and Stock variables.

Table 7.7. XML Schema to define a Parameter

```
<Variables>
   <Variable Class="Parameter">
       <Id>1390479728653</Id>
       <Name><![CDATA[Name_of_the_Parameter]]></Name>
       <X>80</X><Y>40</Y>
       <Label><X>10</X><Y>0</Y></Label>
       <PublicFlag>false</PublicFlag>
       <PresentationFlag>true</PresentationFlag>
       <ShowLabel>true</ShowLabel>
       <Properties SaveInSnapshot="true" Dynamic="false">
           <Type><![CDATA[double]]></Type>
           <DefaultValue><![CDATA[Value_of_the_Parameter]]></DefaultValue>
           <ParameterEditor>
               <Id>1390479728651</Id>
               <Name><![CDATA[]]></Name>
               <EditorContolType alpv7value="TEXT_BOX">TEXT_BOX</EditorContolType>
               <MinSliderValue><![CDATA[0]]></MinSliderValue>
               <MaxSliderValue><![CDATA[100]]></MaxSliderValue>
               <Separator>false</Separator>
           </ParameterEditor>
       </Properties>
   </Variable>
</Variables>
```

Table 7.8. XML Schema to define an Auxiliary Variable

```
<Variables>
   <Variable Class="AuxVariable">
        <Id>1390479826989</Id>
        <Name><![CDATA[Name_of_the_Auxiliary_Variable]]></Name>
        <X>160</X><Y>60</Y>
        <Label><X>0</X><Y>-20</Y></Label>
        <PublicFlag>false</PublicFlag>
        <PresentationFlag>true</PresentationFlag>
        <ShowLabel>true</ShowLabel>
        <Properties External="false" Constant="false" Array="false">
               <Formula><![CDATA[Formula_of_the_Auxiliary_Variable]]></Formula>
               <Color/>
        </Properties>
   </Variable>
</Variables>
```

Table 7.9. XML Schema to define a Flow Variable

```
<Variables>
   <Variable Class="Flow">
        <Id>1390479682183</Id>
        <Name><![CDATA[Name_of_the_Flow_Variable]]></Name>
        <X>120</X><Y>60</Y>
        <Label><X>-45</X><Y>-20</Y></Label>
        <PublicFlag>false</PublicFlag>
        <PresentationFlag>true</PresentationFlag>
        <ShowLabel>true</ShowLabel>
        <Properties External="false" Constant="false" Array="false">
               <Formula><![CDATA[Formula_of_the_Flow_Variable]]></Formula>
               <Color/>
               <ValveIndex>1</ValveIndex>
               <Points>
                  <Point><X>0</X><Y>0</Y></Point>
                  <Point><X>100</X><Y>0</Y></Point>
                  <Point><X>200</X><Y>0</Y></Point>
               </Points>
        </Properties>
  </Variable>
</Variables>
```

Table 7.10. XML structure to define a Stock Variable

```
<Variables>
   <Variable Class="StockVariable">
        <Id>1390479604249</Id>
        <Name><![CDATA[Name_of_the_StockVariable]]></Name>
        <X>110</X><Y>60</Y>
        <Label><X>0</X><Y>-20</Y></Label>
        <PublicFlag>false</PublicFlag>
        <PresentationFlag>true</PresentationFlag>
        <ShowLabel>true</ShowLabel>
        <Properties Array="false">
               <EquationStyle>classic</EquationStyle>
               <Width>20</Width>
               <Height>20</Height>

        <InitialValue><![CDATA[Initial_Value_of_StockVariable]]></InitialValue>
               <Color/>
        </Properties>
   </Variable>
</Variables>
```

7.4.2 Building the Strategies Alignment Simulation Model in *an XML* file

SAGEN application allows building an XML file, containing the structured information considering the simulation software (AnyLogic, 2015) scheme, in terms of the enterprises, objectives, strategies and their relations to be represented in the SAM; so that the simulation software can read it.

The programing language used to build SAGEN is Pascal. This language was selected considering the need of using a programming language as close as the natural language with the aim to straightforward its use and expand the SAM in possible future developments. Lazarus (Lazarus Free Pascal, 2015) is used as an I*ntegrated Development Environment*[4] (IDE) for *Rapid Application Development*[5] (RAD) that uses Free Pascal compiler.

SAGEN generates the XML code to create the SAM in SD method. In addition, SAGEN has a friendly interface that allows the enterprises to enter the data required to feed the SAM; so that it is not necessary to open the DMS created in Access to enter the input data. Moreover, SAGEN creates a structured positioning of all objects that form the strategies alignment simulation model. This structured schema allows building readable simulation models, having always the same structure for the SAM, regardless the number of enterprises, objectives and strategies simulated. This orderly arrangement of the objects provides an enhanced comprehension of the SAM when reading it in the simulation software.

SAGEN application works as follows: Once the information has been already introduced by the enterprises, *Microsoft Access Database 2010* generates all the tables that contain all the fields necessary to create the XML file that contains the SAM to be simulated in SD in the simulation software. SAGEN is connected with *Microsoft Access Database 2010* through an *OCDBConnection*. SAGEN contains a set of procedures that allow generating the required structure to create the XML file, based on the information gathered in the DMS. The procedures are created according to the requirements of the XML schema for its reading in the simulation software (AnyLogic). The XML file automatically created in SAGEN contains the strategies alignment simulation model. This XML file can be opened in AnyLogic simulation software. The SAM is automatically created containing the flow diagram, as well as the simulation and the optimisation experiments.

[4]An *integrated development environment* (IDE) or interactive development environment is a software application that provides comprehensive facilities to computer programmers for software development. An IDE normally consists of a source code editor; build automation tools and a debugger.

[5] RAD is used to refer to alternatives to the conventional waterfall model of software development

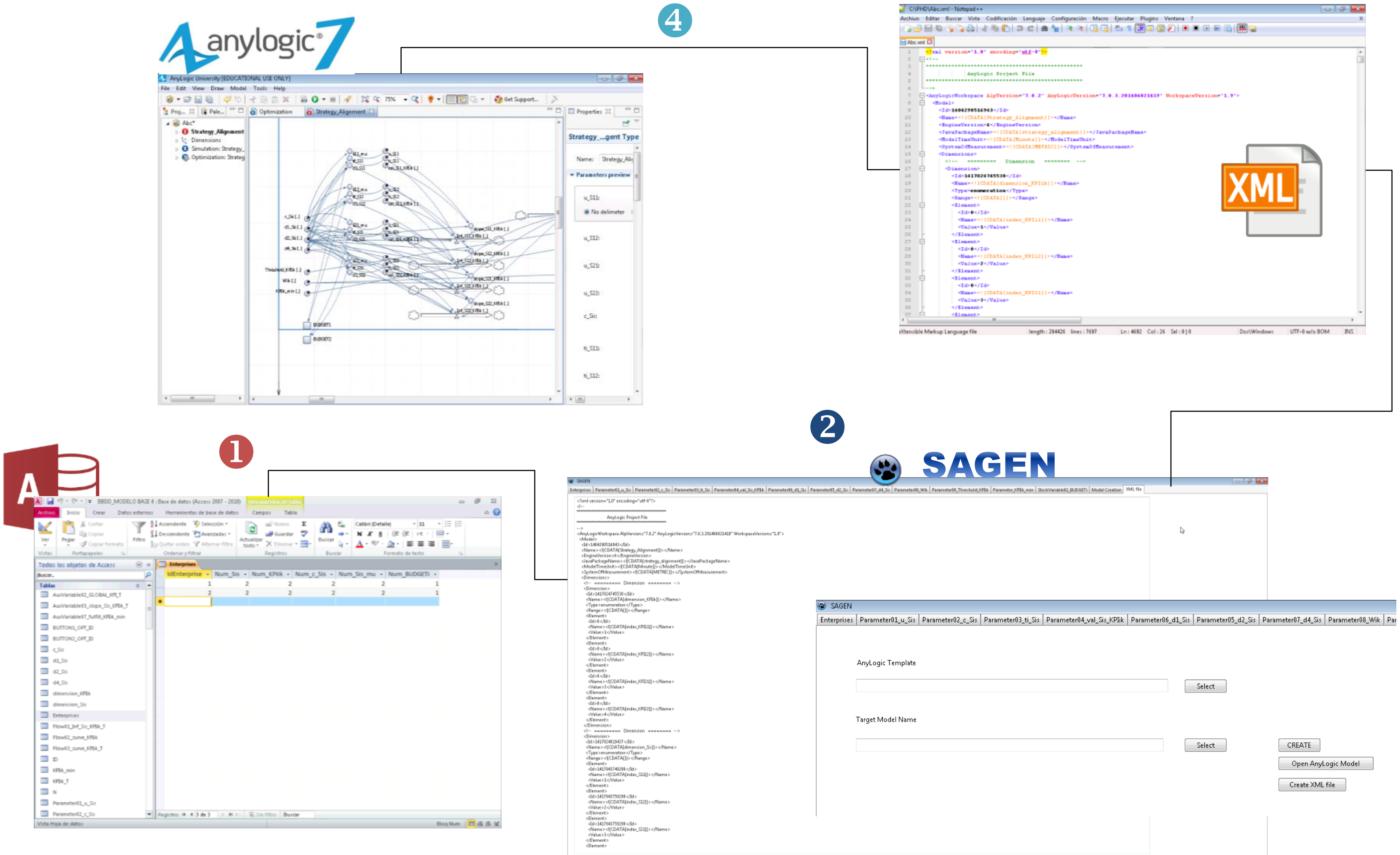


Figure 7.17. Scheme for the automatic creation of the SAM

7.4.3 *Example 7.2* Automatic creation of the SAM, using SAGEN

The data of the example initially introduced in Chapter 5, and used in the Example 7.1, is now considered to automatically generate the strategies alignment simulation model, through using the generator application SAGEN. Recalling, two enterprises are modelled each one defining two KPIs and two strategies.

Considering all the fields of the DMS actualised with the data of the example in Chapter 5, the strategies alignment simulation model is now created in SAGEN (Figure 7.18). A procedure followed to introduce the data required to automatically build the model in SAGEN application is described in Annex 7.2. The button "*CREATE*" of SAGEN interface allows to automatically creating the XML file containing all the elements to build the flow diagram, and the simulation and optimisation experiments of the simulation model of the strategies alignment. In this particular example, two are the modelled enterprises. A pop-up message informs that the XML file containing the SAM of the illustrative example is created in XML format. The button "Create XML file" enables to show in XML language the SAM in the "XML file" tag (Figure 7.19). In Annex 7.3 the complete version of the SAM in XML language, is presented.

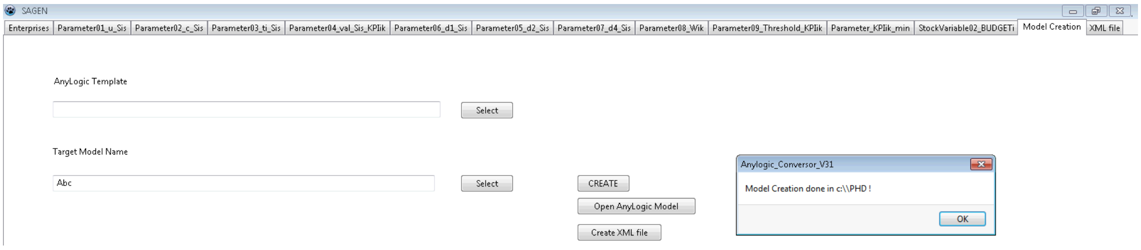


Figure 7.18. SAGEN application

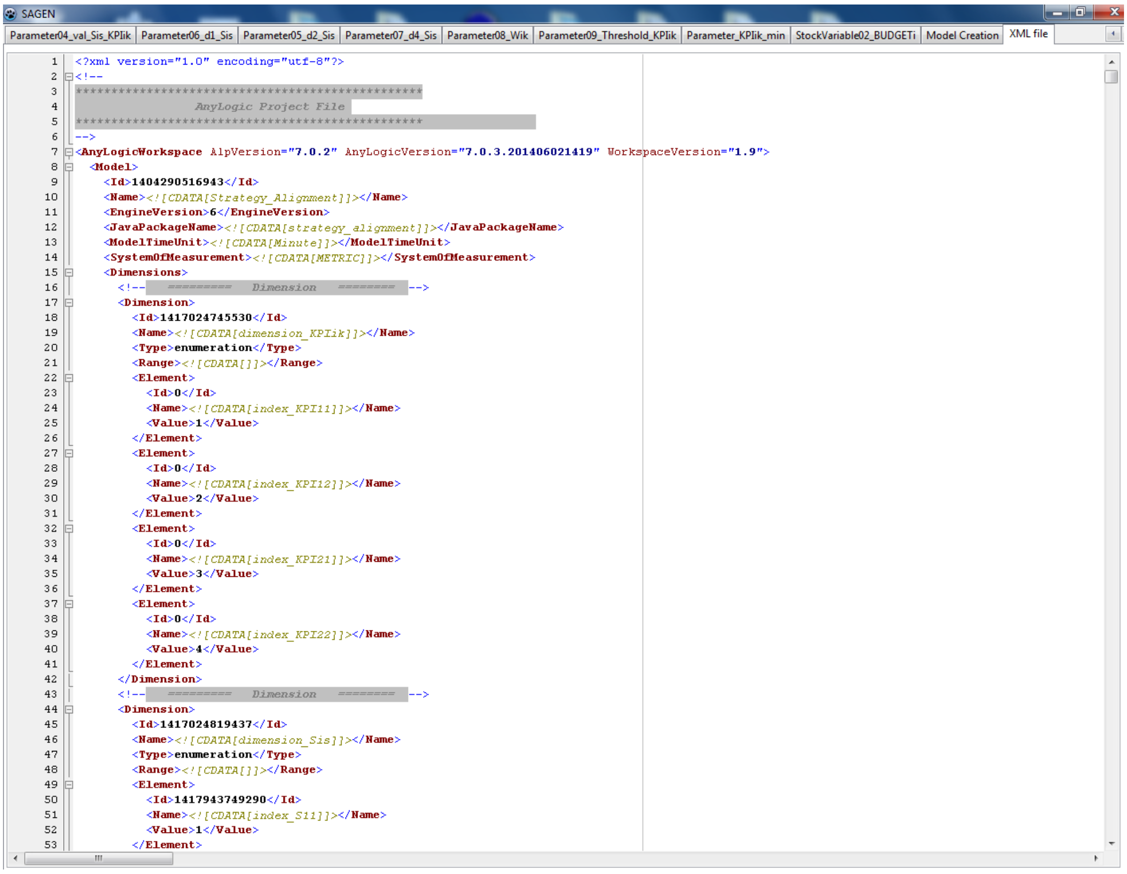


Figure 7.19. XML file: strategies alignment simulation model in XML language

When opening the generate XML file, in *the* simulation software, the flow diagram is constructed, as well as the simulation and optimisation experiments (Figure 7.20 and Figure 7.21).

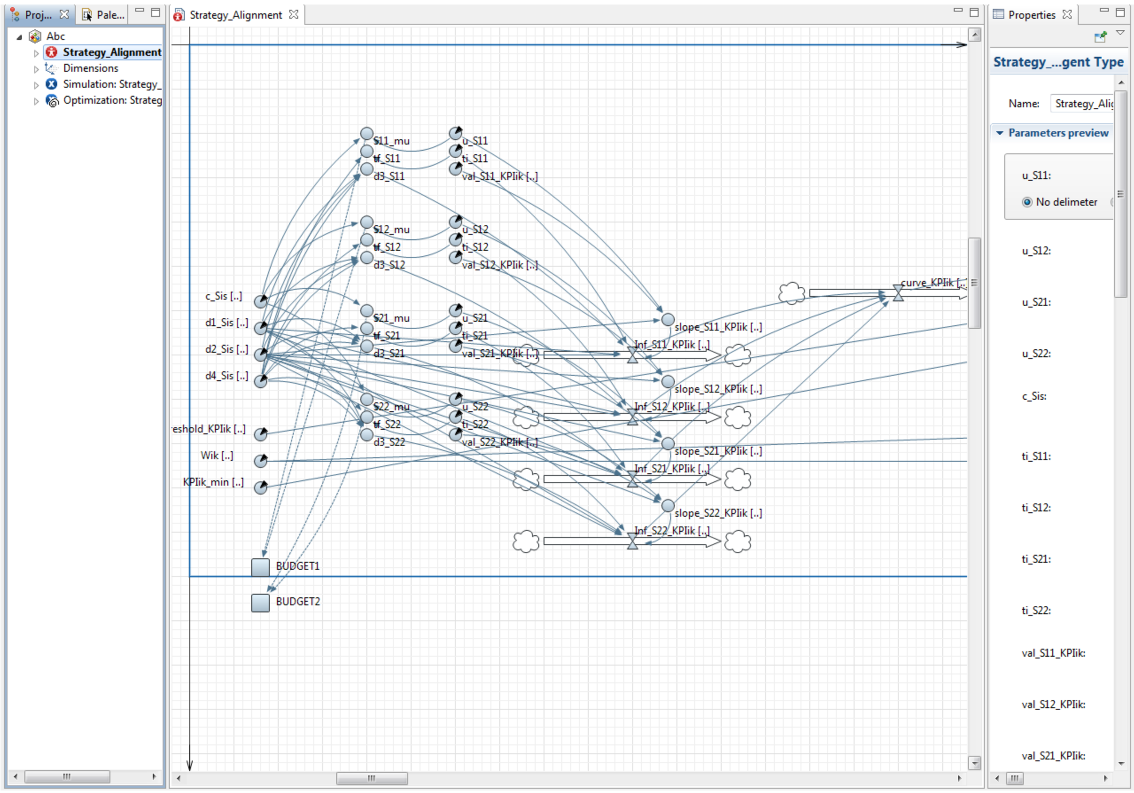


Figure 7.20. Strategies alignment model automatically build through the creation of an XML file, using SAGEN

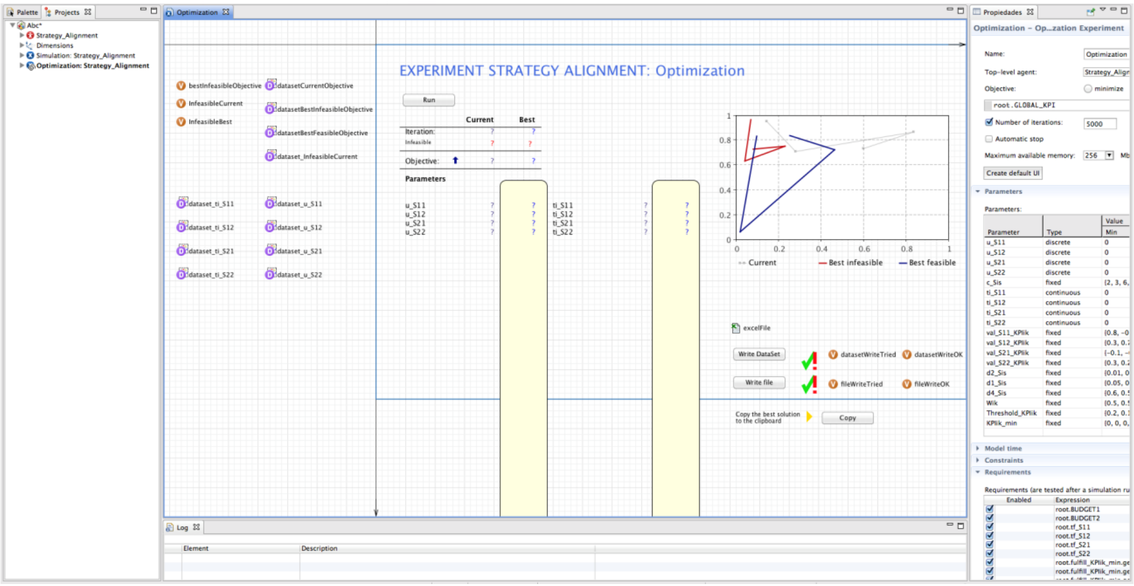


Figure 7.21. Optimisation UI derived from the automatic generation of the strategies alignment model, using SAGEN

7.5 Application Examples

In order to clarify the concepts and implement the tools presented so far, three illustrative examples are presented. The first two examples were constructed with the main aim of modelling the different types of strategies that the enterprises formulate. Thus, the first one (*Example 7.3*) introduces the modelling of strategies acquiring binary values, while the second one (*Example 7.4*) introduces the modelling of strategies acquiring continuous values. Illustrative examples of strategies are formulated. These two examples model a network that consists of two enterprises all of them constructed considering the SAGEN application. The third illustrative example (Example 7.5) models a network that consist of ten enterprises, allowing to show the usability of SAGEN application to automatically build the SAM with higher number of enterprises, objectives and strategies.

7.5.1 *Example 7.3* Defining strategies with binary values

A CN consisting of two enterprises (distributor and manufacturer) is SAM. Each enterprise defines two objectives. The achievement of the objectives is measured through the KPIs (kpi_{ixk}) each one with its corresponding weights (w_{ixk}):

- Distributor (e_1)
  - o_{11}: Increase the net demand by 10% in an exclusive market segment
    $$\Delta kpi_{111} = \Delta netDemand = \frac{netDemand_{\,t} - netDemand_{t-1}}{netDemand_{\,t}} \times 100$$
  - o_{12}: Sell all the stock of next to the expiry (100%)
    $$\Delta kpi_{121} = \Delta stockNextExpire = \frac{stockNextExpire_{t-1} - stockNextExpire_t}{stockNextExpire_{t-1}} \times 100$$
- Manufacturer (e_2)
  - o_{21}: Cut down the production costs by a 15%
    $$\Delta kpi_{211} = \Delta productionCosts = \frac{productionCosts_{\,t-1} - productionCosts_{\,t}}{productionCosts_{\,t-1}} \times 100$$
  - o_{22}: Reduce fluctuations in production
    $$\Delta kpi_{221} = \Delta productionfluctuations = \frac{productionFluctuations_{\,t-1} - productionFluctuations_{\,t}}{productionFluctuations_{\,t-1}} \times 100$$

In order to achieve the objectives each network node formulates two strategies (e_1: str_{11} and str_{12}, e_2: str_{21} and str_{22}) and defines the data related to these strategies considering the durations and costs. The enterprises have a certain budget to carry out these strategies.

- Distributor (e_1)
  - str_{11}: Promote the image of an exclusive product. The distributor has do decide whether activate or not this strategy; therefore the strategy can only adopt two values:
    - str_{11}^1: promote the image of the product in order to sell it in an exclusive market niche [1]
    - str_{11}^0: continue using the same image to reach all the audiences [0]
  - str_{12}: Acquire a support system for decision making in the process of forecasting demand. This strategy can only adopt two values:
    - str_{12}^1: acquire the support system [1]
    - str_{12}^0: continue with the procedure used so far to forecast the demand [0]
- Manufacturer (e_2)
  - str_{21}: Use lower quality packaging. The manufacturer has to decide whether activate or not this strategy, therefore the strategy can only adopt two values:
    - str_{21}^1: use lower quality materials in packaging [1]
    - str_{21}^0: continue using the same quality in packaging materials without reducing the quality [0]
  - str_{22}: Establish a collaborative production planning process with the distributor to deal with the discontinuous/variable/agitated demand and achieve continuity in the production plans. This strategy can only adopt two values:
    - str_{22}^1: establish collaboration with the distributor [1]

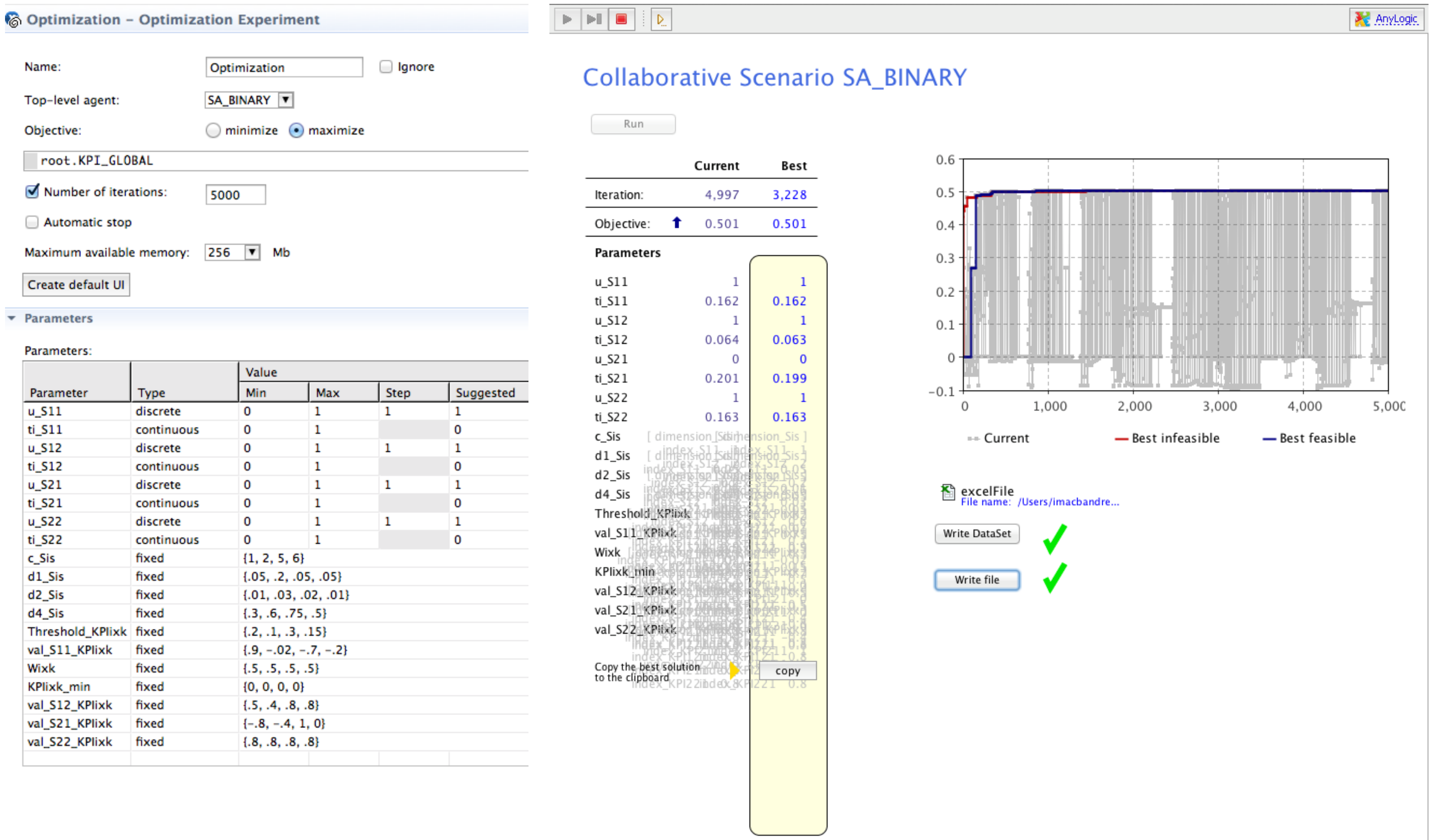
- str_{22}^{0}: continue with non-collaborative relationships to determine the production plan [0]

All the data as regards the objectives defined and strategies formulated in the *Example 7.3* is shown inTable 7.11, in which the values of influence that each strategy has on the defined KPIs are given.

In the collaborative scenario the enterprises participating take into account the influences of all the strategies formulated by the enterprises. Strategies acquiring binary values are formulated, which are defined as a *discrete parameter* in the optimisation experiment of the simulation software used (AnyLogic) (Figure 7.22a). The minimum number of units of strategies to activate will be 0 and the maximum number of units of strategies in binary strategies is 1. The total activation cost of the strategy str_{is} will be computed multiplying the cost of one unit of strategy by the number of units of strategies ($str_{is}\_mu = u\_str_{is} \cdot c\_str_{is}$). Continuing with the optimisation experiment, the results are shown in (Figure 7.22b). The optimisation experiment is a combinatory problem; therefore, the number of iterations will depend on the size of the SAM problem. In this particular case, in which the strategies defined acquire binary values (discrete parameters) the number of iterations can be defined by 5000. Finally, the flow diagram is represented in the simulation experiment considering the values obtained from the optimisation (Figure 7.23).

Table 7.11. Example 7.3: Distributor and Manufacturer Input Data

Distributor (e_1) **$b_1 = 3$**																
													kpi'_{111}		kpi'_{121}	
													w_{111}	0,5	w_{121}	0,5
													$Threshold\_kpi'_{111}$	0,2	$Threshold\_kpi'_{121}$	0,1
str_{11}	u_str_{11}	?	ti_str_{11}	?	c_str_{11}	1	$d'_1\_str_{11}$	0,05	$d'_2\_str_{11}$	0,01	$d'_4\_str_{21}$	0,3	$val\_str_{11}\_kpi'_{111}$	0,9	$val\_str_{11}\_kpi'_{121}$	-0,02
str_{12}	u_str_{12}	?	ti_str_{12}	?	c_str_{12}	2	$d'_1\_str_{12}$	0,2	$d'_2\_str_{12}$	0,03	$d'_4\_str_{21}$	0,6	$val\_str_{12}\_kpi'_{111}$	0,5	$val\_str_{12}\_kpi'_{121}$	0,4
													$val\_str_{21}\_kpi'_{111}$	-0,8	$val\_str_{21}\_kpi'_{121}$	-0,4
													$val\_str_{22}\_kpi'_{111}$	0,8	$val\_str_{22}\_kpi'_{121}$	0,8
Manufacturer (e_2) **$b2 = 6$**																
													kpi'_{211}		kpi'_{221}	
													w_{211}	0,5	w_{221}	0,5
													$Threshold\_kpi'_{211}$	0,3	$Threshold\_kpi'_{221}$	0,15
str_{21}	u_str_{21}	?	ti_str_{21}	?	c_str_{21}	5	$d'_1\_str_{21}$	0,05	$d'_2\_str_{21}$	0,02	$d'_4\_str_{21}$	0,75	$val\_str_{21}\_kpi'_{211}$	1	$val\_str_{21}\_kpi'_{221}$	0
str_{22}	u_str_{22}	?	ti_str_{22}	?	c_str_{22}	6	$d'_1\_str_{21}$	0,1	$d'_2\_str_{21}$	0,01	$d'_4\_str_{21}$	0,5	$val\_str_{22}\_kpi'_{211}$	0,8	$val\_str_{22}\_kpi'_{221}$	0,8
													$val\_str_{11}\_kpi'_{211}$	-0,7	$val\_str_{11}\_kpi'_{221}$	-0,2
													$val\_str_{12}\_kpi'_{211}$	0,8	$val\_str_{12}\_kpi'_{221}$	0,8



a) b)

Figure 7.22. Example 7.3: a) Configuration of the Optimisation Experiment in the CN b) and Results of the Optimisation Experiment in the CN

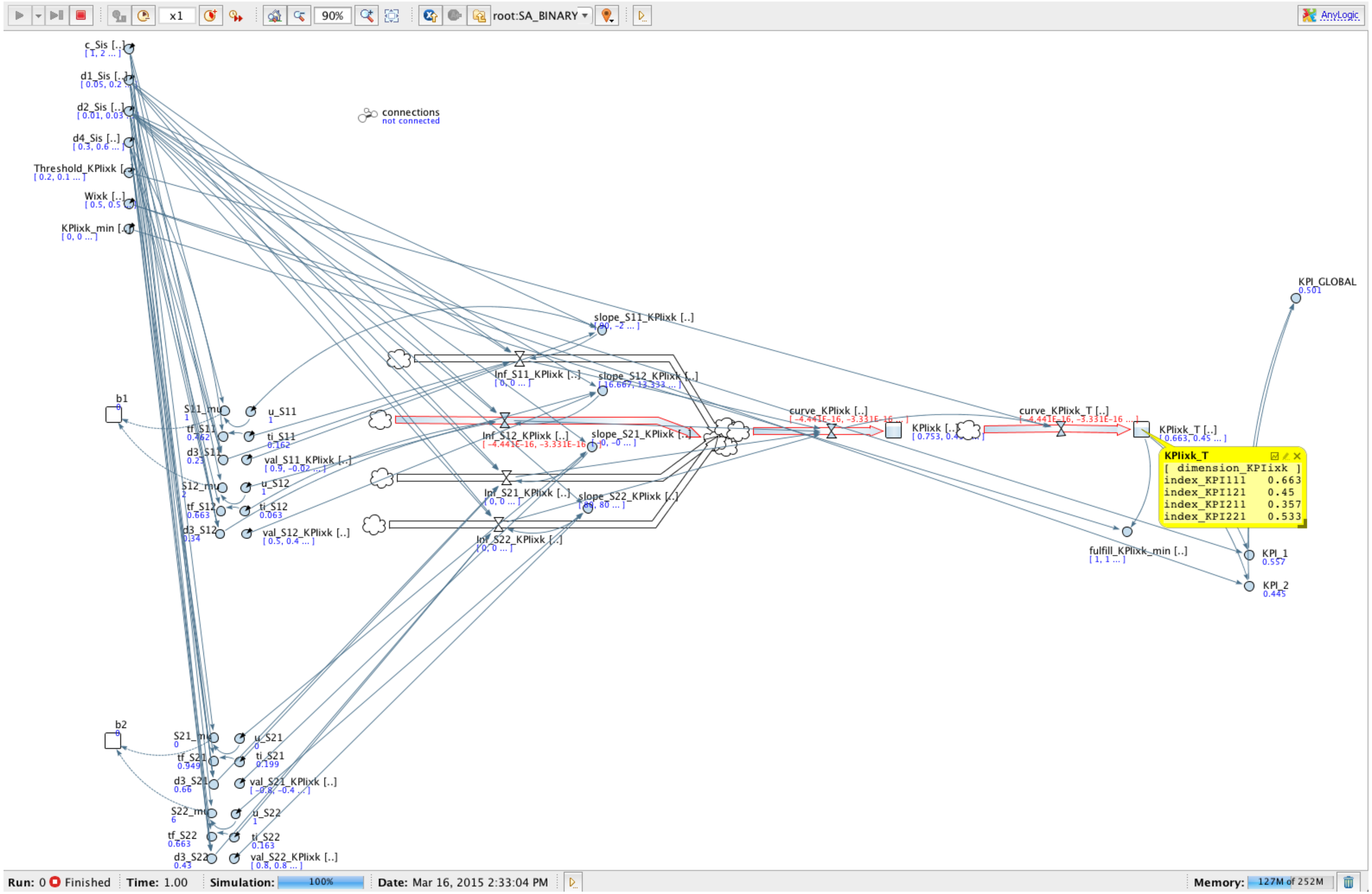


Figure 7.23. Example 7.3: Simulation experiment. Flow diagram with the optimised results

7.5.2 *Example 7.4* Defining strategies with continuous values

A CN consisting of two enterprises (manufacturer and supplier) is SAM. Each enterprise defines two objectives. The achievement of the objectives is measured through the KPIs (kpi_{ixk}) each one with its corresponding weights (w_{ixk}):

- Manufacturer (e_1)
  - o_{11}: Increase the market share in high–quality products by a 15%
    $$\Delta kpi_{111} = \Delta marketShareHQprod = \frac{marketShareHQprod_t - marketShareHQprod_{t-1}}{marketShareHQprod_t} \times 100$$
  - o_{12}: Increase the net demand by a 20%
    $$\Delta kpi_{121} = \Delta netDemand = \frac{netDemand_t - netDemand_{t-1}}{netDemand_t} \times 100$$
- Supplier (e_2)
  - o_{21}: Reduce purchase costs of raw material by a 30%
    $$\Delta kpi_{211} = \Delta RMcost = \frac{RMcost_{t-1} - RMcost_t}{RMcost_{t-1}} \times 100$$
  - o_{22}: Reduce production delays by a 100 %
    $$\Delta kpi_{121} = \Delta delays = \frac{delays_{t-1} - delays_t}{delays_{t-1}} \times 100$$

In order to achieve the objectives each enterprise formulates two strategies (e_1: str_{11} and str_{12}, e_2: str_{21} and str_{22}) and defines its related data as regards the durations and costs. The enterprises have a certain budget to carry on these strategies.

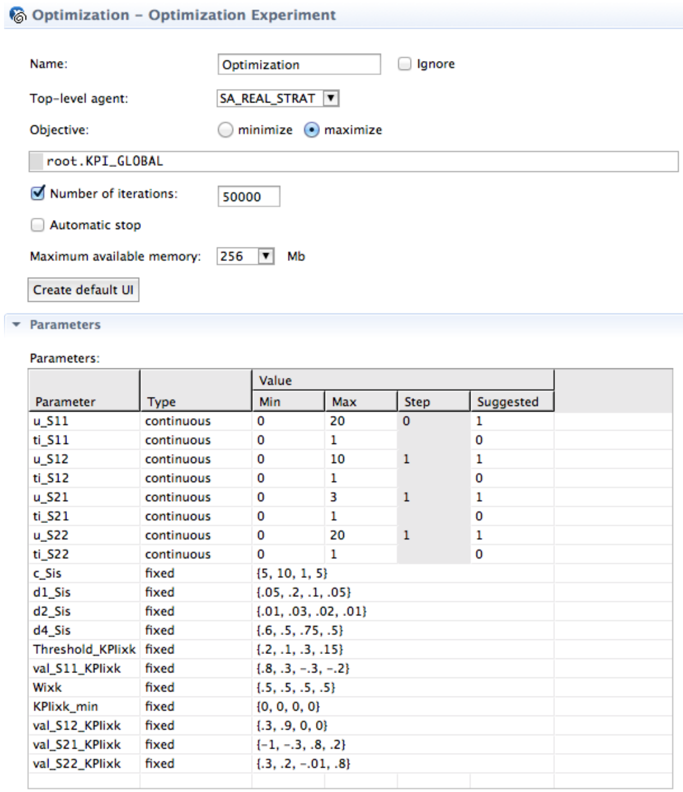
- Manufacturer (e_1)
  - str_{11}: Invest 5 m.u. in product promotions. This strategy acquires continuous values due this strategy is defined by the monetary units invested in carrying out product promotions.
    - str_{11}^1: invest a certain quantity of monetary units that will be defined by the number of units of strategies [u_str_{11}]. The cost of activating the str_{11} is defined by $str_{11}\_mu = u\_str_{11} \cdot c\_str_{11}$. In this case, $c\_str_{11} = 5$ m.u. The maximum investment will be constrained by the budget that the enterprise owns, or by a maximum amount of monetary units that the enterprise decides to invest in product promotions. This example considers a maximum investment of 100 m.u. (defined by the budget) that translated to units of strategy $u\_str_{11} = 20$.
    - str_{11}^0: do not carry out any investment in product promotions, therefore do not activate the strategy [0]
  - str_{12}: Invest 10 m.u. in market research actions. This strategy acquires continuous values due this strategy is defined by the monetary units invested in carrying out market research actions.
    - str_{12}^1: invest a certain quantity of monetary units that will be defined by the number of units of strategies [u_str_{12}]. The cost of activating the str_{12} is defined by $str_{12}\_mu = u\_str_{12} \cdot c\_str_{12}$ In this case, $c\_str_{12} = 10$ m.u. The maximum investment will be constrained by the budget that the enterprise owns, or by a maximum amount of monetary units that the enterprise decides to invest in market research actions. This example considers a maximum investment of 100 m.u. (defined by the budget) that translated to units of strategy is $u\_str_{12} = 10$.
    - str_{21}^0: do not carry out any investment in product promotions, therefore do not activate the strategy[0]
- Supplier (e_2)
  - str_{21}: Increase by 25% the reused material in the supplied product. This strategy acquires continuous values due this strategy is defined by the percentage of reused material.
    - str_{21}^1: use a certain percentage of reused material according to the number of units of strategies [u_str_{21}]. The cost of activating the str_{21} is defined by $str_{21}\_mu = u\_str_{21} \cdot$

c_str_{21}. In this case, $c\_str_{21} = 1$ m.u. The maximum investment will be constrained by legislation, stating that the extent of reused material cannot exceed the 75%, what is translated to u_str_{21}= 3 (involving a cost of 3 m.u. out of the budget that is 100 m.u.).
  - str_{21}^{0}: do not use reused material in the supplied product, therefore do not activate the strategy[0]
- str_{22}: Schedule in 1h of overtime for production. This strategy can acquire continuous values due this strategy is defined by number of overtime hours for production.
  - str_{22}^{1}: number of overtime hours scheduled for production that will be defined by the number of units of strategy [u_str_{22}]. The cost of activating the str_{22} is defined by $str_{22}\_mu = u\_str_{22} \cdot c\_str_{22}$. In this case, $c\_str_{22} = 5$ m.u. The maximum investment will be defined by the number of hours capable to schedule during the weekend (48h) in case this exceeds the budget, therefore, the budget determines the maximum number of overtime hours. This example considers a maximum amount of 48h (involving a cost of 240 m.u.). Taking into account that the budget is 100 m.u., the maximum number of overtime hours that can be scheduled are 20h of overtime for production.
  - str_{22}^{0}: do not to schedule overtime hours [0]

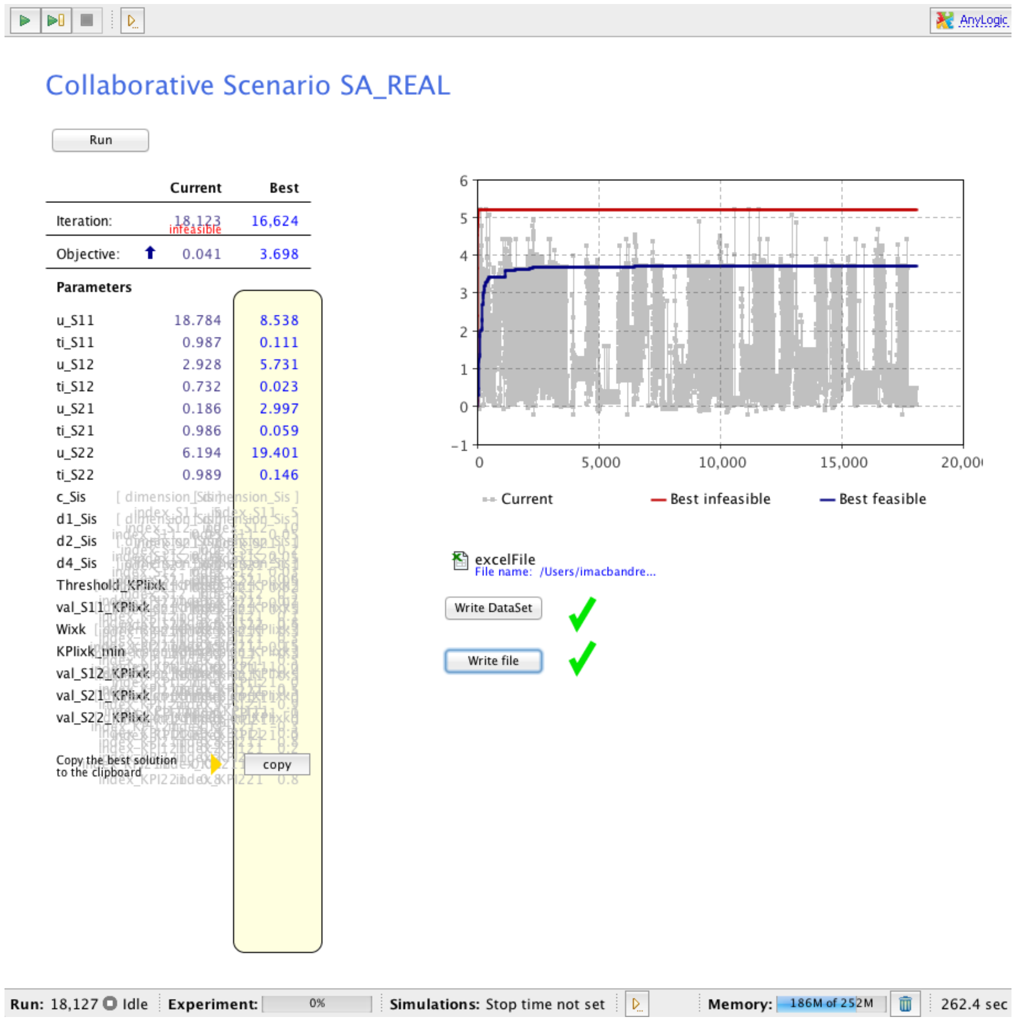
All the data as regards the objectives defined and strategies formulated in the *Example 7.4* is shown in Table 7.12, in which the values of influence that each strategy has on the defined KPIs are given. The formulated strategies acquire continuous values, which are defined as a *continuous parameter* in the optimisation experiment of the simulation software used (Figure 7.24a). The minimum number of units of strategies to activate will be 0 and the maximum will depend on the specifications that the enterprises establish for each strategy. Continuing with the optimisation experiment, the results are shown in (Figure 7.24b). The optimisation experiment is a combinatory problem, and the number of iterations depends on the size of the SAM problem. In this particular case, in which all the parameters (including the strategies) acquire continuous values the number of combinations to solve the problem increases with respect to the previous Example 7.3, in which strategies were defined as discrete values. Being all the parameters continuous, the parameter space increases; therefore, a set of 18000 iterations is considered to carry out the optimisation experiment, with the main aim of obtaining accurate optimisation results. Finally, the flow diagram is represented in the simulation experiment considering the values obtained from the optimisation (Figure 7.25).

Table 7.12. Example 7.4: Manufacturer and Supplier Input Data

Manufacturer b_1 **= 100**																
													kpi'_{111}		kpi'_{121}	
													w_{111}	0,5	w_{121}	0,5
													$Threshold\_kpi'_{111}$	0,2	$Threshold\_kpi'_{121}$	0,1
str_{11}	u_str_{11}	?	ti_str_{11}	?	c_str_{11}	5	$d'_1\_str_{11}$	0,05	$d'_2\_str_{11}$	0,01	$d'_4\_str_{21}$	0,6	$val\_str_{11}\_kpi'_{111}$	0,8	$val\_str_{11}\_kpi'_{121}$	0’3
str_{12}	u_str_{12}	?	ti_str_{12}	?	c_str_{12}	10	$d'_1\_str_{12}$	0,2	$d'_2\_str_{12}$	0,03	$d'_4\_str_{21}$	0,5	$val\_str_{12}\_kpi'_{111}$	0,3	$val\_str_{12}\_kpi'_{121}$	0,9
													$val\_str_{21}\_kpi'_{111}$	-1	$val\_str_{21}\_kpi'_{121}$	-0,3
													$val\_str_{22}\_kpi'_{111}$	0,3	$val\_str_{22}\_kpi'_{121}$	0,2
Supplier $b2$ **= 100**																
													kpi'_{211}		kpi'_{221}	
													w_{211}	0,5	w_{221}	0,5
													$Threshold\_kpi'_{211}$	0,3	$Threshold\_kpi'_{221}$	0,15
str_{21}	u_str_{21}	?	ti_str_{21}	?	c_str_{21}	6	$d'_1\_str_{21}$	0,1	$d'_2\_str_{21}$	0,02	$d'_4\_str_{21}$	0,75	$val\_str_{21}\_kpi'_{211}$	0,8	$val\_str_{21}\_kpi'_{221}$	0,3
str_{22}	u_str_{22}	?	ti_str_{22}	?	c_str_{22}	5	$d'_1\_str_{21}$	0,05	$d'_2\_str_{21}$	0,01	$d'_4\_str_{21}$	0,5	$val\_str_{22}\_kpi'_{211}$	-0,01	$val\_str_{22}\_kpi'_{221}$	0,8
													$val\_str_{11}\_kpi'_{211}$	-0,3	$val\_str_{11}\_kpi'_{221}$	-0,2
													$val\_str_{12}\_kpi'_{211}$	0	$val\_str_{12}\_kpi'_{221}$	0



a)



b)

Figure 7.24. Example 7.4: a) Configuration of the Optimisation Experiment in the CN b) and Results of the Optimisation Experiment in the CN

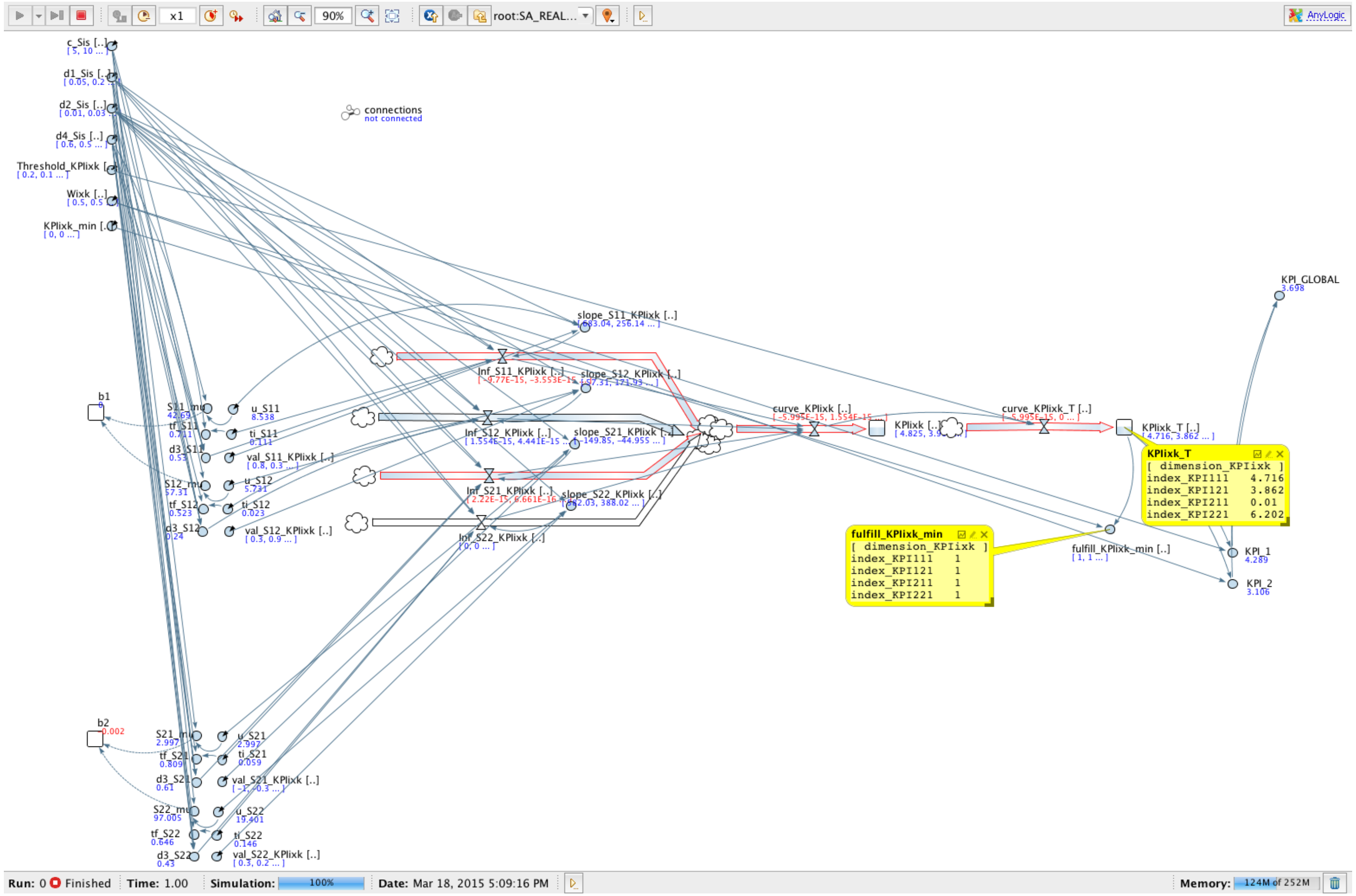


Figure 7.25. Example 7.3: Simulation experiment. Flow diagram with the optimised results

7.5.3 *Example 7.5* Automatic creation of the SAM: CN of 10 enterprises

Example 7.5 illustrates the SAM of a CN with ten enterprises. The main aim of this example is to verify the usability of the automatic generator application SAGEN. The SAM is built considering that each enterprise defines four KPIs and formulates four strategies. For the creation of this illustrative SAM no real data has been considered. The XML file generated in SAGEN application is shown presented in Annex 7.4. The generated XML file contains the information required to create the simulation SAM of strategies alignment in AnyLogic simulation software. The optimisation (Figure 7.26) and simulation experiment (Figure 7.27) is automatically generated for the illustrative example of ten enterprises.

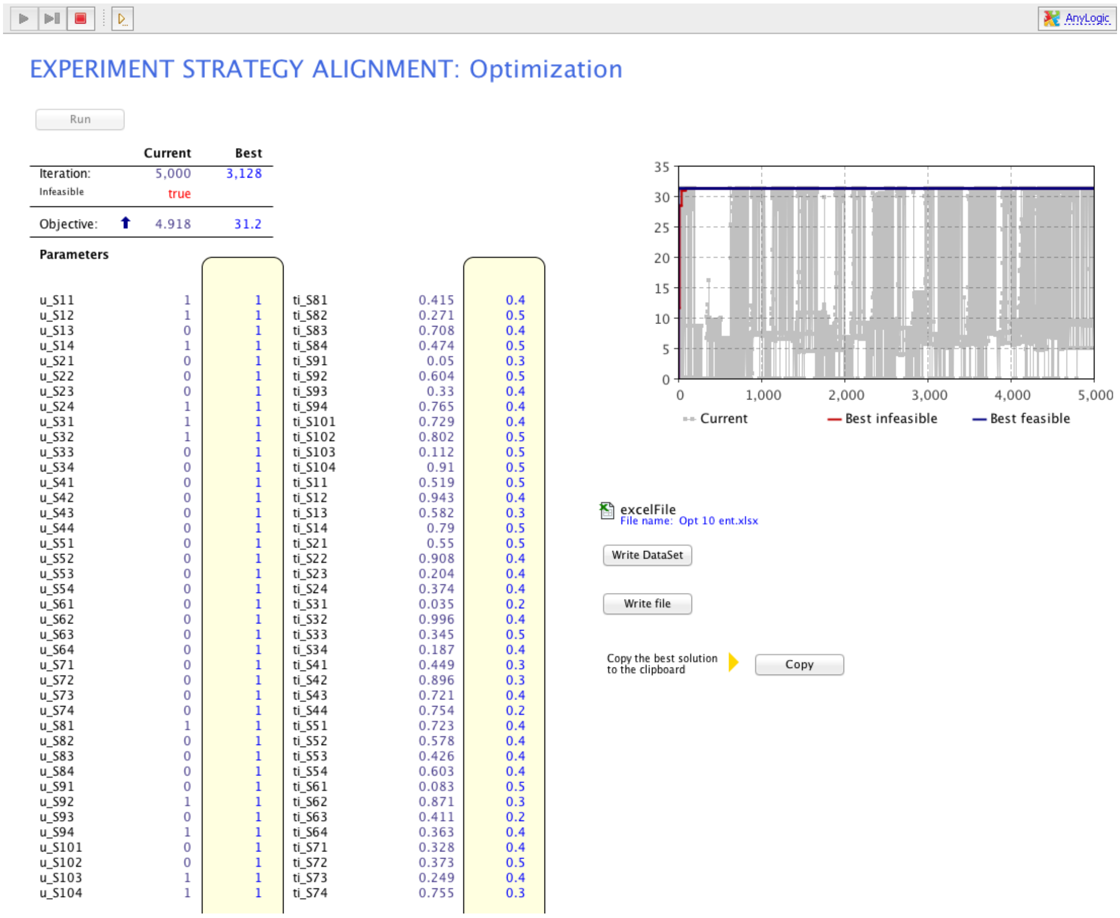


Figure 7.26. Example 7.5: Optimisation Experiment for a CN of 10 enterprises

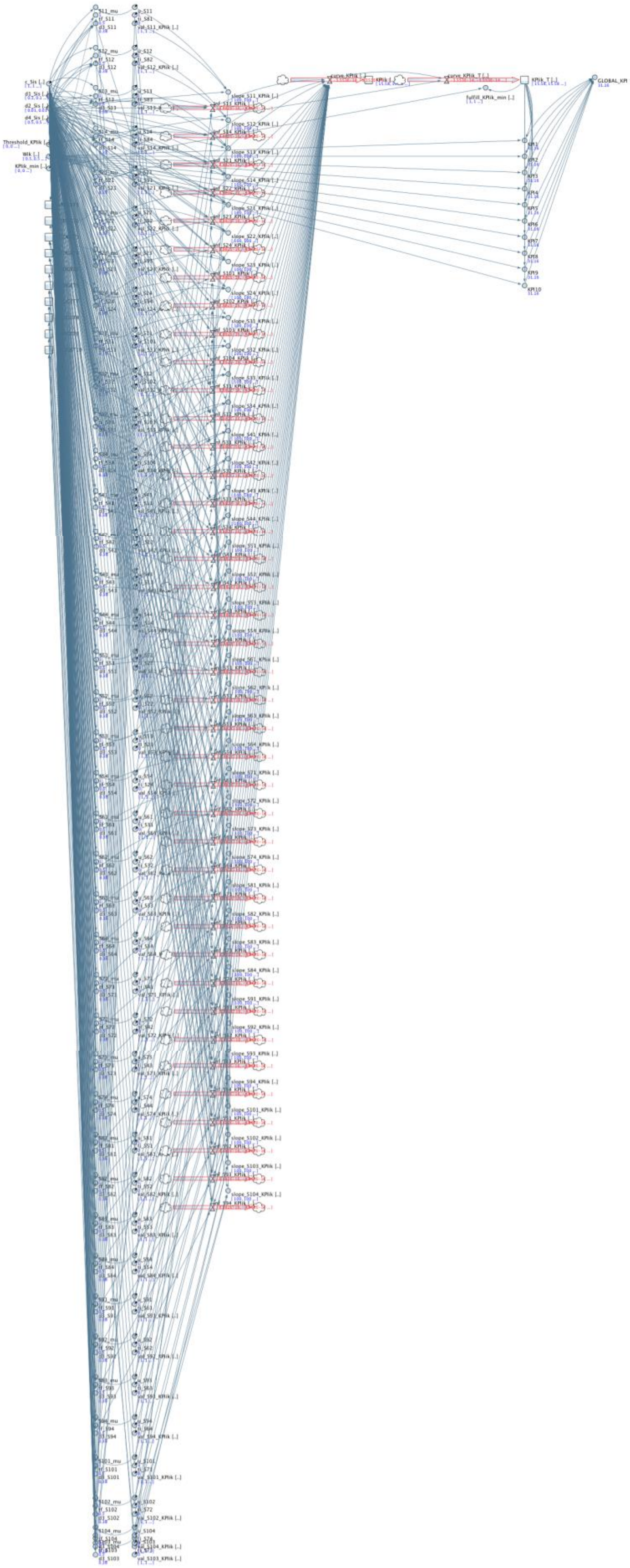


Figure 7.27. Example 7.5: Flow diagram for a CN of 10 enterprises

7.6 Chapter discussion and conclusions

This chapter describes the used tools to support the resolution of the SAM, mathematically defined in Chapter 5. The tools were selected according to the requirements resulting from the SAM and method proposed to deal with the strategies alignment processes, previously presented in Chapters 5 and 6. Accordingly, three tools are proposed:

- *S*imulation software (*AnyLogic*, 2015) to simulate the SAM based on the SD method, simulation and optimisation experiments are carried out in order to obtain the values associated with the decision variables with the main aim of maximising the network performance indicator.
- A DMS (Microsoft Access Database 2010) to gather all the information required for feeding the SAM.
- A rapid application development (SAGEN) tool to automatically build the SAM in the simulation software.

The use of computational tools allows to automatically solve the strategies alignment process, through obtaining the number of units of strategies to activate (u_str_{is}) and the time instant at which activate them (ti_str_{is}), optimising the global network performance kpi'_{net}. The examples proposed in the previous chapters were not solved due to so far there was a lack of a tool to generate a solution from a computational perspective and automated. Along this chapter the three proposed tools are described, and illustrative examples are proposed to show their implementation. The main contributions of the examples proposed are shown in Table 7.13.

Table 7.13. Contributions of the provided numerical examples

Purpose	Ex. 7.1	Ex. 7.2	Ex. 7.3	Ex. 7.4	Ex. 7.5
To show how to manually create the flow diagram	✓				
To show how each element of the SAM is replicated in the flow diagram	✓		✓	✓	✓
To represent the SAM considering a collaborative scenario (flow diagram)	✓		✓	✓	✓
To show graphically the functions of influence represented by the simulation software	✓				
To show how the Threshold value (*Threshold_KPIixk*) works when maximising the network performance.	✓				
To show how the simulation experiment is automatically built		✓			
To show how the optimisation experiment is automatically built		✓			
To show the optimisation results	✓		✓	✓	✓
To show the simulation results			✓	✓	✓
To show in an spread sheet the datasets containing all the values of the decision variables and the objective function generated in each simulation scenario, during the optimisation experiment	✓				
To show SAGEN application to automatically build the simulation SAM of strategies alignment		✓	✓	✓	✓
To show an XML file representing the SAM		✓			✓
To show examples of defined objectives and formulated strategies			✓	✓	
To model strategies that acquire discrete values	✓		✓		✓
To model strategies that acquire continuous values				✓	
To verify SAGEN application and the SAM with the representation of a large CN					✓

This chapter deals with the identification and design of a set of tools to support the resolution of the SAM, in CN context. The tools proposed enable the evaluation of utility of the model defined, as well as verify that the model and the method proposed in Chapters 5 and 6 can be implemented and solved using computer programs.

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Annex 7.1. Set of optimum solutions that maximise the objective

Accessible in: goo.gl/PMqOYd

Annex 7.2. Introduction of the data required to feed the SAM in SAGEN application

Accessible in: https://goo.gl/WpPWPi

Annex 7.3. Strategies alignment model in XML language. Modelling a CN of 2 enterprises each one defining 2 KPIs and 2 Strategies.

Accessible in: goo.gl/6nLZMY

Annex 7.4. Strategies alignment model in XML language for a CN of 10 enterprises defining 4 KPIs and formulating 4 strategies each one

Accessible in: goo.gl/UqvbD2

Chapter 8

Guideline to deal with the Strategies Alignment Process in a CN

This chapter proposes a guideline for enterprises belonging to a collaborative network (CN), which want to address the strategies alignment process. The guideline is presented as a complementary mechanism to the model, method and tools, previously described in Chapters 5, 6 and 7. Each of the phases defined in the guideline is described in detail with the main aim of supporting decision makers, of each enterprise of the network, on the task of dealing with the strategies alignment process in a CN. This chapter starts with the application context in which the Strategies Alignment Model (SAM) can be implemented. For defining the contexts of application three different dimensions are proposed: (i) type of relationship, (ii) type of network and (iii) type of decision. Focusing on the type of relationship, the SAM can be applied from the non-collaborative or collaborative perspective. Considering the collaborative scenario, three are the levels of collaboration defined, which are characterised by the different degrees of information exchange among the network enterprises. The guideline proposes three negotiation processes, corresponding to the three collaborative scenarios defined, which enable the enterprises to negotiate the solution that best fits the all the network enterprises.

8.1 Introduction

In this chapter a guideline that complements the model, method and tools developed in Chapters 5, 6 and 7, is described. The main aim of the proposed guideline is to support SMEs in the implementation process of the strategies alignment model (SAM). Besides, a negotiation process as regards the solutions generated by the SAM is proposed. The guideline considers three different levels of collaboration in the application of the SAM, which are characterised by the amount of information exchanged among the network enterprises. In the same way, three negotiation processes are proposed for its application in each of the three collaborative scenarios identified to apply the SAM.

The SAM can be applied in different contexts; thus, before presenting the guideline, a description of the contexts in which the SAM can be applied is presented (section 8.2). For defining the contexts of application three dimensions have been taken into consideration: (i) the type of relationship, (ii) the type of decision-making and (iii) the type of network. The proposed guideline is presented in section 8.3. A description of the steps that the enterprises must follow in order to deal with the strategies alignment process is presented. The main objective is to facilitate the process of gathering the required data to feed SAM and promote collaboration between partners participating in the CN. The guideline adapts to different levels of collaboration depending on the information exchanged by the enterprises. The negotiation process carried out, by the network enterprises, to reach an agreement on the solutions' provided by the SAM will depend on the collaborative scenario selected. The negotiation processes proposed support the enterprise decision makers in the process of deciding what strategies to activate and when to activate them, so that all the strategies are aligned, maximising the network performance.

8.2 SAM application contexts

Before going deeper in the presentation and description of the phases designed for the guideline proposed to apply the SAM, this section describes the contexts in which the SAM can be applied.

In order to identify the contexts in which the SAM can be used, three dimensions are considered (Figure 8.1), (i) the type of relationship: the network partners can establish non-collaborative or collaborative relationships, when dealing with the strategies alignment process; (ii) the type of decision-making, which can be centralised or decentralised, at network level; and (iii) the type of network, considering the two network topologies under study in this thesis, which are the hierarchical networks (HN) and the non-hierarchical networks (NHN).

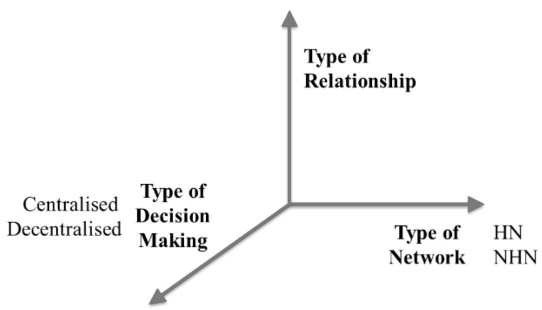


Figure 8.1. Dimensions used for defining the application of the SAM

Before focusing on defining each of the presented dimensions it has to be considered that the simulation tool, in which the SAM is modelled and solved (*AnyLogic* simulation software), is characterised by being centralised (not being distributed in each of the enterprise). With regards the information, gathered from the enterprises, is also centralised in that tool. The centralised tool can be applied by considering that:

- There is an external actor that executes the tool. There is one SAM managed by the external actor (i.e. the network manager).
- The enterprises belonging to the network jointly execute the tool. There is one SAM managed by the networked enterprises.
- The enterprises belonging to the network individually execute the tool. The tool is cloned in each enterprise; so that the same solution is obtained in each enterprise, due to the same input data is provided. There will be as many models (SAM) as number of enterprises participating in the strategies alignment process. Thus, SAM^i is the SAM implemented in the *Enterprise i*, while SAM^j is the SAM implemented in the *Enterprise j*. The same model is reproduced in each enterprise and the same set of solutions is obtained.

In order to deal with the tool centralisation, an extension of the contribution proposed in this thesis may be to build a distributed tool in which the simulation software used to solve the strategies alignment process can be run on each enterprise. That is to say, each network partner has its part of the SAM (sub-model), let's name it $SAM^i_{sub\text{-}model}$, representing the SAM of only one enterprise of the network, the *Enterprise i*. In a distributed tool, the results obtained in one enterprise (computing its part of the model, $SAM^i_{sub\text{-}model}$) are used as input in another enterprise sub-model ($SAM^j_{sub\text{-}model}$). The exchange of information would be automatically done within the system containing all the sub-models of the SAM. Therefore, the exchange of information would be made by the system, not directly by the enterprises, and this information would have the characteristic of being encrypted (the system connects all the sub-models in which the SAM is decomposed in each network enterprise). In a distributed context each enterprise owns its private information, which is not exchanged. This topic will be further treated in Chapter 12, where future research lines are described.

Once considered the centralised characteristics of the tool and the information, the three dimensions used for defining the application context of the SAM are explained next:

Dimension "Type of Relationship"

- Non-Collaborative: the enterprises do not establish collaborative relationships. There is no-exchange of information. The enterprises operate from an isolated perspective; therefore, the decision making of the strategies to activate is individually made. The SAM can be applied from a non-collaborative perspective considering each partner individually, so that the partners only take into account the information about their own objectives and strategies. In this case, the SAM is individually implemented in each Enterprise and there is neither information nor consideration of the other partners' objectives and strategies in the SAM.
- Collaborative: the enterprises establish collaborative relationships and exchange part or all the information of the objectives defined and/or the strategies formulated. The enterprises operate from a common perspective and the decision of which strategies to activate is made by considering the information of all the network partners. The degree of information exchange can be minimum, partial or complete, and depending on this degree, the level of collaboration will be:
    - Level 1 of Collaboration is characterised by the minimum exchange of information. Only the information regarding the KPIs defined is exchanged. The values of influence ($val\_str_{is}\_kpi_{ixk}$ and $val\_str_{is}\_kpi_{jxk}$) are estimated by each enterprise considering its own information and the information exchanged about the KPIs. Enterprise i estimates the impact that its strategies would have in its the objectives defined by Enterprise j, and vice versa. In this case, the network manager (if required), according to the expertise and the knowledge acquired, could assess the Enterprise i on estimating $val\_str_{is}\_kpi_{ixk}$ and $val\_str_{is}\_kpi_{jx}$.
    - Level 2 of Collaboration is characterised by the partial exchange of information. The information regarding both the objectives defined (and therefore the KPIs defined to measure them) and the data characterising the strategies (i.e. costs) as well as the ID used

to identify the strategies is exchanged. The definition of the strategies itself is not an information to exchange at this level of collaboration. Each enterprise estimates the values of influence that its own strategies have on its own KPIs (*Enterprise i* estimates $val\_str_{is}\_kpi_{ixk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{jxk}$). Both companies separately estimate the cross-impact of the strategies and KPIs. Enterprise i estimates $val\_str_{is}\_kpi_{jxk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{ixk}$. In this case, the network manager (if required), according to the expertise and the knowledge acquired, can assess the enterprises on estimating the values of influence All the values as regards the values of influence estimated by each enterprise are exchanged, besides the parameters defining the KPIs and the strategies are also exchanged.

- Level 3 of Collaboration is characterised by the complete exchange of information and the jointly estimation of all the values of influence ($val\_str_{is}\_kpi_{ixk}$, $val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{jxk}$, $val\_str_{js}\_kpi_{ixk}$). The information regarding both the objectives defined (and therefore the KPIs defined to measure them) and the strategies formulated, is exchanged. Concerning the strategies, the definition of each strategy is an information to exchange at this collaboration level. The information as regards the costs of carrying out the strategies also is exchanged. Besides this, the budged owned by all the enterprises, to be invested in the strategies activation, is also exchanged. Both companies jointly estimate the cross-impact of the strategies and KPIs. *Enterprise i* and *Enterprise j* agree the values of influences of $val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{ixk}$. In this case, the network manager (if required), according to the expertise and the knowledge acquired, can assess the enterprises on estimating the values of influence.

In the three levels of collaboration defined, the SAM is applied from a collaborative perspective. All the partners of the network are considered in the decision making of what are the strategies to activate so that being aligned. In this case the SAM is implemented from a common perspective and the enterprises do not only consider their own information as regards the strategies and KPIs but also take into account the information of other enterprises of the network.

Dimension "Type of Decision"

- Centralised: all the enterprises run the same model, that is, an only one SAM. The implementation of the SAM tool provides a single solution for all the network partners. Two situations can be considered in the centralised decision making:
  - Intervened: The decision is taken over by an external actor (i.e. the network manager), according to solution provided by the SAM. This external actor gathers the information of all the network partners, so that the information is centralised in the simulation tool, in order to run the SAM. The set of solutions obtained in the SAM are transferred to each of the network partners. It could occur that the network partners accept the optimum solution, and activate the strategies identified in the SAM optimisation experiment. If the network partners do not accept the optimum solution but accept a sub-optimal solution, a negotiation process will be started in order to agree the alternative of solution (strategies to activate that best fit all the network partners). The external actor will orchestrate this negotiation.
  - Non-Intervened: It is the same as the intervened but there is no external actor supervising the strategies alignment process; instead, the enterprises jointly collaborate and apply the SAM. All the network partners meet and exchange information as regards KPIs and strategies in order to feed the SAM. On the one hand, the optimised solution provided by the SAM can be accepted. On the other hand a sub-optimal solution can be negotiated. If the network enterprises start the negotiation process, after computing the SAM, they will jointly decide until a common and agreed alternative of solution (sub-optimal) is achieved.
- Decentralised: the SAM is executed by each of the enterprises of the network. The same model (SAM) is reproduced in all the enterprises: SAM^1 is computed in *Enterprise 1*, …, SAM^i is computed in *Enterprise i*, ..., SAM^j is computed in *Enterprise j*. The application of the SAM will be carried out from a collaborative perspective. Depending on the information exchanged

(minimum, partial or complete) the collaborative scenario will be one or another. In this case, each enterprise will carry out the whole SAM, considering all the network partners.In the decentralised context, the intra-enterprise values of influence ($val\_str_{is}\_kpi_{ixk}$ and $val\_str_{js}\_kpi_{jxk}$) estimated by each enterprise considering its own information has to be exchanged, so that all the enterprises have all the required data to feed the SAM. The values of influence estimated for the cross-impacts (inter-enterprise) of the strategies and KPIs have to be also exchanged ($val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{ixk}$). Considering all the information exchanged, each enterprise individually runs the complete SAM and obtains the set of solution alternatives. All the enterprises will obtain the same set of solutions. Nevertheless, considering the set solutions generated, each enterprise makes its own decision and selects the alternative of solution that best meet its requirements and negotiate the alternative of solution selected with the other enterprises of the network. In the decentralised context the enterprises will negotiate the solutions obtained, from the computation of the SAM in each enterprise. The enterprises maintain their positions until they arrive to a meeting point in which the solution is satisfactory for all the enterprises of the network.

Dimension "Type of Network":

- Hierarchical Network (HN), the dominant enterprise is the one that decides which strategies to activate without considering the objectives and the strategies of the other network partners. The SAM can be applied considering:
  - a non-collaborative context, in which the dominant enterprise decides which strategies to activate by considering only its defined objectives and formulated strategies. Without considering the objectives and strategies of its partners.
  - a collaborative context, in which the dominant firm is the agent in charge of running the SAM. The HN topology establishes a centralised decision-making. In the collaborative context of a HN, the dominant enterprise takes into account the objectives and strategies of the other enterprises, to carry out the model. Nevertheless, at the end the dominant enterprise is the one that has the last word on making the decision of what are the strategies to activate in its enterprise.
- Non-Hierarchical Network (NHN), all the network partners have the same "power"; therefore, there are no objectives and no strategies more important than another within the network. In the NHN, all the objectives and strategies of all the network partners are equally considered, when modelling the SAM. Within this network topology, it can be considered that:
  - The tool (AnyLogic simulation software) is centralised due to the SAM is modelled in an only simulation software,
  - The information gathered to feed the SAM simulation software is centralised in the same DMS (Microsoft Access Database),
  - There exists collaboration among the partners to decide which strategies to activate amongst all the formulated. There are three levels of collaboration that are characterised by the different degrees of information exchange: minimum, partial and the complete exchange of information, in which the values of influences are jointly estimated, and
  - The type of the decision can be made from a
    - centralised perspective if there is an external actor (such as the network manager) or if the enterprises jointly make this decision. An only one SAM will be modelled, or,
    - decentralised perspective, in which each enterprise executes the SAM and the final solution of which strategies to activate, in order to be aligned, is normally negotiated.

Combining the described dimensions, and considering a NHN topology:

- Collaborative and Centralised: SAM is applied by considering the complete exchange of information of all the partners in the SAM centralised tool. The optimal solution generated by the SAM is generally accepted by the enterprises. The solution obtained can be negotiated using an external actor. In case there is no network manager, the negotiation process is directly made by the enterprises and the enterprises jointly make the decision of the strategies to activate.

- Collaborative and Decentralised: Each enterprise computes the SAM separately. There will be as many models (SAM) as number of enterprises participating in the strategies alignment process. Thus, SAM^i is the SAM implemented in the *Enterprise i*, while SAM^j is the SAM implemented in the *Enterprise j*. The same model is reproduced in each enterprise and the same set of solutions is obtained. In order to compute the SAM in each enterprise, a minimum, partial, or complete exchange of information is to be carried out. Each enterprise obtains the same set of solutions but each enterprise can decide the alternative of solution that best fits. If the optimal solution is not selected by the enterprises, each enterprise has to communicate, to the rest of the network enterprises, the alternative of solution selected (sub-optimal solution). Starting the negotiation process until an agreement is reached in terms of the strategies to be activated.

So far, the contexts in which the SAM can be applied have been described. The description of these contexts allows giving the reader a better comprehension of the phases defined in the designed guideline. This guideline is presented in the following section, as a supporting artefact, for the network enterprises, to carry out the strategies alignment process. The proposed guideline promotes the exchange of information, the negotiation and the collaboration among the network partners, dealing with the strategies alignment process within a NHN.

8.3 Guideline Description

This section describes in detail the 12 phases that make up the proposed guideline. In each of the phases the involved roles are identified at both levels enterprise and network, for its proper development. The Strategies Alignment Guideline (SAG) is developed from a perspective, flexible enough, so that it can be adapted to any CN independently of the sector or the enterprises participating in the strategies alignment process. Figure 8.2 provides an overview of the SAG; the phases in which consist are listed and the relationships between them are shown. Through its implementation, potential users obtain support to implement the model, method and tools developed for the strategies alignment process. The main aim is to provide support to the decision making as regards the strategies to be activated, which will be characterised by having higher levels of alignment. As aforementioned, the designed SAG promotes the exchange of information, negotiation and collaboration to deal with the strategies alignment process within a NHN. Accordingly, in the SAG different levels of collaboration are considered in the application of the SAM. The enterprises will opt for a one or another collaborative scenario depending on the information exchanged. Moreover, each collaborative scenario will follow a particular the negotiation process to select and agree an alternative of solution resulting from the implementation of the SAM.

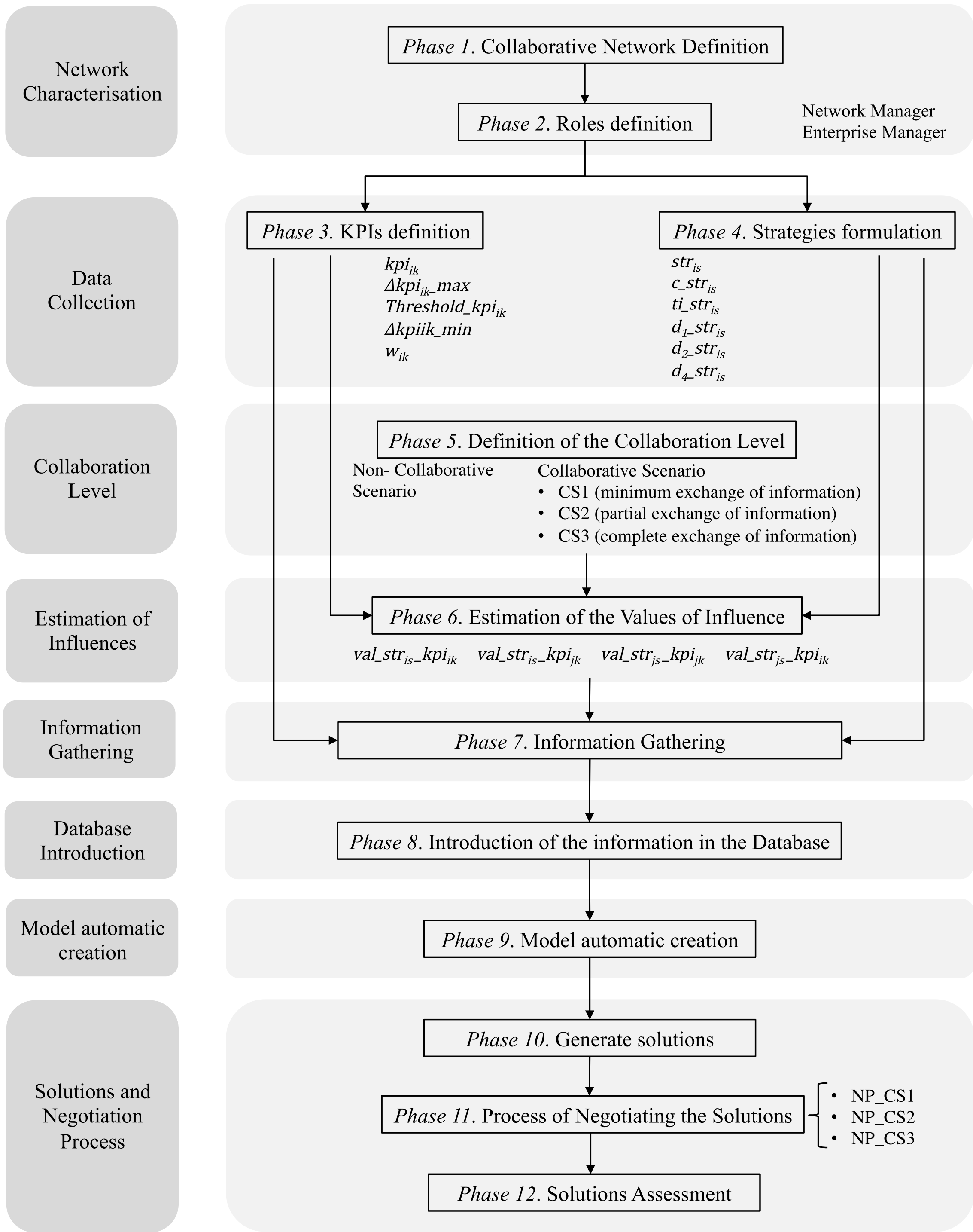


Figure 8.2. Strategies Alignment Guideline (SAG)

8.3.1 Phase 1. Collaborative Network Definition

In this first phase of the SAG, the network of enterprises object to study is defined. The enterprises willing to collaborate when carrying out the strategies alignment process are identified.

The enterprises have to decide the context in which the SAM will be applied in order to collaboratively deal with the strategies alignment process. Identifying: (i) the type of relationship, (ii) the type of decision making and (iii) the type of network (see *Section 8.2 SAM application contexts* for a better insight).

SETEP 1. Identify the Type of relationship established among the partners belonging to the defined network. Non-collaborative or collaborative relationships can be established when dealing with the strategies alignment process:

- Non-Collaborative: the enterprises do not establish collaborative relationships. There is no-exchange of information. The enterprises operate from an isolated perspective; therefore, the decision making of the strategies to activate is individually made.
- Collaborative: the enterprises establish collaborative relationships and exchange part or all the information of the objectives defined and/or the strategies formulated. The enterprises operate from a common perspective and the decision of which strategies to activate is made by considering the information of all the network partners. Different levels of collaboration are considered, which depend on the degree of information exchanged, which can be minimum, partial or complete.

STEP 2. Identify the Type of Decision-Making, which can be centralised or decentralised:

- Centralised Decision-Making: all the enterprises run the same model, that is, an only one SAM. The implementation of the SAM tool provides a single solution for all the network partners. The enterprises have also to decide if the centralised decision-making is (i) intervened by an external actor or (ii) non-intervened, so that there is no external actor supervising the strategies alignment process and the enterprises jointly collaborate and apply the SAM.
- Decentralised: the SAM is executed by each of the enterprises of the network. The same model (SAM) is reproduced in all the enterprises: SAM^1 is computed in *Enterprise 1*, …, SAM^i is computed in *Enterprise i*, ..., SAM^j is computed in *Enterprise j*

STEP 3. Characterise the Topology of Network that the enterprises, willing to deal with the strategies alignment process, belong to:

- Hierarchical Network (HN), the dominant enterprise is the one that decides which strategies to activate without considering the objectives and the strategies of the other network partners. The SAM can be applied considering a non-collaborative context or a collaborative context
- Non-Hierarchical Network (NHN), all the network partners have the same "power"; therefore, there are no objectives and no strategies more important than another within the network. In the NHN, all the objectives and strategies of all the network partners are equally considered, when modelling the SAM. Within this network topology, it can be considered that collaborative relationships are established.

8.3.2 Phase 2. Roles Identification

For the identification of the roles two levels are considered: enterprise and network level.

- Network level consists of all the enterprises participating in the CN. Aggregated information of each of the enterprises is considered.
- Enterprise level is defined in terms of each individual enterprise. Information is managed by the individual enterprises.

Network Manager. This role is held by a consultant or expert in the CNs discipline. The network manager must be an expert in the strategies alignment process. Normally, this role is performed by a participant external to the network enterprises; this, allows performing the strategies alignment process without aggravating the interests of the partners or benefiting them, in case there exist SMEs more dominant/powerful than others. The network manager works as moderator, so that he/she should be impartial to the issues under discussion, keeping distance from the contents. It is responsible for monitoring the SAG, pledging to help and encourage the enterprises to collaboratively carry out the decision of which strategies to activate in order to be aligned one another along the CN. This role is in charge of facilitating the exchange of information and supports the CN enterprises on establishing an easy communication. In the light of this, it could be stated that the network manager is the orchestrator/moderator of the strategies alignment process. The network manager has a clear knowledge on how the guideline (SAG), the SAM, the method and the tools, proposed to support the strategies alignment process, works. The network manager is responsible for (i) following all the steps of the SAG, supporting the enterprises on carrying out the strategies alignment process, and (ii) analysing the results derived from the application of the SAM and the simulation tool in which the SAM is represented.

Enterprise Manager. This role is held by the person or people linked to the decision making of the activation of strategies in en each enterprise. The enterprise manager is in charge of gathering the information required to feed the SAM, regarding the objectives defined and the strategies formulated in each enterprise. The enterprise manager must be involved in introductory sessions (what is called Kick off Meeting) in order to become familiar with the strategies alignment process and have an insight as regards the information required to participate in this collaborative process.

As explained before, three are the levels defined for the collaboration in the establishment of the strategies alignment process, which are characterised by the exchange of information. In all the levels, the network manager will support the process of exchange of information, negotiation and definitely collaboration.

Generally, The first information to be gathered by the network manager with the consensus of all the representatives of each enterprise (enterprise managers) is the horizon (noted as an H) in which the strategies alignment process is going to be carried out. That is, the time in which the set of strategies are to be activated. For its implementation, in the SAM, this duration parameter will be normalised to the unit, $H = 1$.

8.3.3 Phase 3. Performance indicators definition (KPIs)

The objectives of each enterprise are identified and the data as regards the KPIs used to measure the level of achievement of these objectives is gathered. The objectives are numbered according to the notation described for the parameters in the SAM. o_{ix} refers to the objective x defined in enterprise i.

In the SAM, the parameter defining the KPIs, used to measure the objectives, takes into account the objective that measures (kpi_{ixk}: key performance indicator k used to measure the objective x of enterprise i). In order to simplify the process of performance indicators definition, the KPIs will be numbered consecutively; therefore, a unique and sequential number for each KPI will be defined in each enterprise i. Thus the KPIs will be numbered regardless of objective that measure, as it is shown next: kpi_{ik}: key performance indicator k used to measure an objective *defined in enterprise i.* An illustrative example is proposed in Table 8.1 in order to provide a better insight as regards the simplification proposed for the strategies alignment model formulation. Table 8.1 is divided in two parts, the first part shows the notation of the KPIs considering the same notation as the initially provided in the SAM (kpi_{ixk}). The second part of Table 8.1 shows the simplification applied in the KPIs notation, considering explanation the aforementioned. The new notation presented, in this second part of Table 8.1, takes into account the simplification proposed for the strategies alignment model formulation, so that the kpi_{ik}: key performance indicator k used to measure an objective *defined in enterprise i.*

Table 8.1. Comparing the notation defined in the original SAM (kpi_{ixk}) vs. the notation used in the implementation (kpi_{ik})

		Objectives notation	Strategies notation	KPIs notation
SAM notation kpi_{ixk}	Enterprise 1	o_{11}: Increase standardisation by 5%	s_{11}: Application of standards established in all the enterprise production processes.	$kpi_{111}: increase\_standardisation\_level = \frac{standardisation_t}{standardisation_{(t-1)}}$
				$kpi_{112}: increase\_uniformity\_of\_production\_process = \frac{uniformity_t}{uniformity_{(t-1)}}$
		o_{12}: Increase by 25% the exchange of knowledge among partners	s_{12}: Implement a platform to share tacit knowledge and support discussion forums	$kpi_{121}: knowledge\_increase = \frac{knowlege\_exange_t}{knowledge\_exchange_{(t-1)}}$
				$kpi_{122}: increase\_collaborative\_webPlatform\_investment = \frac{investment\_webPlatform_t}{investment\_webPlatfor_{(t-1)}}$
	Enterprise 2	o_{21}: Increase innovation by 15%	s_{21}: Participate in research European Projects in H2020	$kpi_{211}: increase\_innovation = \frac{innovation_t}{innovation_{(t-1)}}$
				$kpi_{212}: increase\_application\_innovation\_processes = \frac{num\_innovation\_processes_t}{num\_innovation\_processes_{(t-1)}}$
		o_{22}: Increase uniqueness by 20%	s_{22}: Implement the Engineering to Order Strategy (ETO)	$kpi_{221}: increase\_uniqueness = \frac{uniqueness_t}{uniqueness_{(t-1)}}$
				$kpi_{222}: increase\_personalised\_products = \frac{num\_personalised\_products_t}{num\_personalised\_products_{(t-1)}}$
Implementation notation (the same objectives and KPIs but with different notation) kpi_{ik}	Enterprise 1	o_{11}	s_{11}	$\boldsymbol{kpi_{11}: increase\_standardisation\_level = \frac{standardisation_t}{standardisation_{(t-1)}}}$
				$\boldsymbol{kpi_{12}: increase\_uniformity\_of\_production\_process = \frac{uniformity_t}{uniformity_{(t-1)}}}$
		o_{12}	s_{12}	$\boldsymbol{kpi_{13}: knowledge\_increase = \frac{knowlege\_exange_t}{knowledge\_exchange_{(t-1)}}}$
				$\boldsymbol{kpi_{14}: increase\_collaborative\_webPlatform\_investment = \frac{investment\_webPlatform_t}{investment\_webPlatfor_{(t-1)}}}$
	Enterprise 2	o_{21}	s_{21}	$\boldsymbol{kpi_{21}: increase\_innovation = \frac{innovation_t}{innovation_{(t-1)}}}$
				$\boldsymbol{kpi_{22}: increase\_application\_innovation\_processes = \frac{num\_innovation\_processes_t}{num\_innovation\_processes_{(t-1)}}}$
		o_{22}	s_{22}	$\boldsymbol{kpi_{23}: increase\_uniqueness = \frac{uniqueness_t}{uniqueness_{(t-1)}}}$
				$\boldsymbol{kpi_{24}: increase\_personalised\_products = \frac{num\_personalised\_products_t}{num\_personalised\_products_{(t-1)}}}$

Once considered this simplification, the data, associated to the performance indicators, required to feed the SAM are listed below:

- Define and enumerate the objectives: o_{ix}
- Define and enumerate the performance indicators that measure the attainment of the previously defined objectives: kpi_{ik}
- Estimate the parameter Δkpi_{ik}^{max} as the maximum increase of kpi_{ik} estimated by the enterprise i, for the performance indicator k. The performance indicators can be defined in any unit because once defined, there will be homogenised considering the parameter Δkpi_{ik}^{max}, (see the *Example 5.2* in Chapter 5).
- Determine the parameter $Threshold\_kpi_{ik}$ as the value from which the associated kpi_{ik} is influenced when a strategy str_{is} is activated. Below $Threshold\_kpi_{ik}$ the influence of str_{is} is not observed, from $Threshold\_kpi_{ik}$, the influence exerted by str_{is} is considered.
- Determine the parameter Δkpi_{ik}_min as the minimum level of increase for the kpi_{ik} that the enterprise is willing to accept, once the $Threshold\_kpi_{ik}$ parameter is computed.
- Define the parameter w_{ik} as the weight (relevance) that kpi_{ik} has for enterprise i.

This list contains all the information required by the enterprises, to characterise the performance indicators, in order to feed the SAM. Part of the data can be easily obtained from the enterprises, such as the objectives or the performance indicators, kpi_{ik}, or the importance associated to each kpi_{ik} (w_{ik}). Nevertheless, the other parameters such as the $Threshold\_kpi_{ik}$, Δkpi_{ik}^{max} or Δkpi_{ik}_min are not as trivial as the first ones, although can be properly estimated by the enterprise managers with the aid of the network manager.

8.3.4 Phase 4. Strategies formulation

In this phase the strategies formulated in each enterprise are identified. The strategies are formulated, in each enterprise, with the main aim of reaching the objectives defined. The set of formulated strategies are potential to be activated in the future. The SAM, and the tools associated (AnyLogic simulation software, DMS and SAGEN application), will support the decision of which strategies to activate, amongst all the formulated, to obtain higher levels of alignment.

Each strategy is enumerated according to the notation considered in the SAM for the parameter str_{is}, strategy s defined by enterprise i.

A short description of the strategies is to be provided in order to easily to understand them. In case the enterprises decide to share information as regards the strategies formulated (Level 3 of collaboration), these strategies will be shortly presented to the rest of the enterprises of the network. Therefore a brief, easy and understandable description must be provided without considering specific terms. This brief description will be exchanged with the other enterprises of the network when considering the Level of collaboration 3. Each formulated strategy, if activated, will have a positive or negative influence in the KPIs achievement. After considering the strategies description, each enterprise belonging to the CN must have an idea, rather clear, on how the activation of a specific strategy, formulated in another network enterprise, affects the achievement of its defined objectives (kpi_{ik}). This information will be useful when defining the inter-enterprise values of influence.

The data, associated to the strategies, required to feed the SAM are listed below:

- Definition and enumeration of the strategies formulated in each enterprise: str_{is}. A short description will be required.
- The strategies str_{is} can be decomposed in units of strategy u_str_{is} to be activated. Definition of the parameter u_str_{is}, if applicable, as the units of strategies to be activated. A short description will

be required. In Level 3 of collaboration the definition of the u_str_{is} will be exchanged among the network enterprises.

- Define the parameter c_str_{is} as the cost, in monetary units, of activating one unit of strategy u_str_{is}.
- Define the parameter $d_1\_str_{is}$ as the delay (in time units) of influence of the strategy u_str_{is}. The time period between the initial time of activation of u_str_{is} (ti_str_{is}) and the time when the kpi_{ik} is started to be influenced by the activated str_{is} ($d_2\_str_{is}$) [t.u.]
- Define the parameter $d_2\_str_{is}$ as the time period between the u_str_{is} starts to influence the kpi_{ik} until the maximum level of influence in is achieved ($inf\_str_{is}\_kpi_{ik}$), [t.u.]
- Total duration of u_str_{is} ($d_4\_str_{is}$) [t.u.]
- Define the parameter b_i, in monetary units, as the budget that each enterprise owns to invest on the activation of the strategies.

All the parameters of duration will be normalised to the unit in the same way as it is done in the *Example 5.3* (Chapter 5), considering the horizon parameter (H).

In the SAM optimisation experiment the decision variable that refers to the units of strategies to be activated (u_str_{is}) is characterised by acquiring discrete or continuous values:

- u_str_{is} acquires *discrete* values when the formulated strategy can only achieve integer values. For example, u_str_{is}: *Buy machines to automate the production process.* Particular cases of discrete values appear when the strategies (u_str_{is}) acquire binary values, which means that the strategies can only acquire two states: activated or non-activated. For example: u_str_{is}: *Open a new distribution channel*. The activation cost depends on the units of strategies activated. In this case, the data required for the optimisation experiment will be defined as:
    - *Type: discrete*
    - *Minimum value:* is the minimum value that u_str_{is} can acquire. For the particular case of strategies acquiring binary values the minimum value will be 0
    - *Maximum value:* it is defined by the equation $\frac{b_i}{c\_str_{is}}$ and determines the maximum value that u_str_{is} can acquire. For the particular case of strategies acquiring binary values the maximum value will be 1. The maximum value of u_str_{is} is determined by the budget. As the cost of one unit of strategy is known (c_str_{is} is referred per unit of strategy, $u\_str_{is}=1$), the maximum number of units of strategy u_str_{is} can be calculated by dividing the budget for the cost of a unit of strategy. Therefore, the maximum number of units of strategies to be activated will generate a cost equal or less than the budget.
    - *Step:* is the value that determines the increase experienced by the parameter u_str_{is} in the optimisation experiment. The optimisation experiment is carried out as a combinatorial problem, giving different values to the decision variables ($ti\_ str_{is}$ and u_str_{is}). The optimisation experiment begins at the *Minimum value* (defined by the lower bound of the optimised parameter) and increments this value by a step size (defined by the *Step*) up to an upper bound (defined by *Minimum value*). In the particular example of strategies acquiring binary values, the *Step* will be defined as 1 due to the parameter u_str_{is} can only acquire the values: 0 (*Minimum value*) or 1 (*Minimum value*).
- u_str_{is} acquires *continuous* values when the formulated strategy can hold different values of intensity, acquiring real values. The activation cost depends on the units of strategies activated. For example, str_{is}: *Advertise the product on the media.* In this type of strategies the decision variable u_str_{is} can acquire any value as long as the activation cost (str_{is}_mu) does not exceed the budget (b_i) allocated for activating strategies. In this case, the data required for the optimisation experiment will be defined as:
    - *Type: continuous*
    - *Minimum value:* is the minimum value that u_str_{is} can acquire
    - *Maximum value:* It is defined by the equation $\frac{b_i}{c\_str_{is}}$, and the result is the maximum value that u_str_{is} can acquire. The maximum value of u_str_{is} is determined by the budget. As

the cost of one unit of strategy is known (c_str_{is} is referred per unit of strategy, $u\_str_{is}=1$), the maximum number of units of strategy u_str_{is} can be calculated by dividing the budget for the cost of a unit of strategy. Therefore, the maximum number of units of strategies to be activated will generate a cost equal or less than the budget.
  - *Step:* it is not required due to the parameter modelled can take any value from the interval defined by the upper (*Minimum value*) and lower bounds (*Maximum value*); therefore, any intermediate value is valid.

Generally, the parameters that characterise the decision variable that refers to the initial time of activation of each strategy, ti_str_{is}, will be defined as *continuous* due to can take any value of the parameter space between the lower and upper bounds defined by the:

- *Minimum value*, defined by the time instant 0, when the simulation starts and the
- *Maximum value*, when the simulation finishes at the time instant 1, according to the normalised horizon defined for the simulation $H=1$.

8.3.5 Phase 5. Identification of the Collaboration Level

An ideal collaborative scenario, to deal with the strategies alignment process, would be one in which the network enterprises meet to exchange all the information as regards the strategies formulated and the KPIs defined, and discuss and agree how the these strategies, potentially to be activated, would influence on the attainment of the objectives defined by each enterprise of the network.

The KPIs itself do not give sensitive information as regards the objectives defined or the strategies formulated. Thus, in case the enterprises are not willing to exchange information as regards the strategies formulated, the only information exchanged will be the one related to the KPIs. The information of the KPIs can be directly exchanged to the other enterprises or via the network manager.

As it has been stated, the enterprises can adopt three possible levels of collaboration, which differ one another, depending on the information exchanged:

- Level 1 of Collaboration: Enterprises only exchange information as regards the KPIs defined and enumerated kpi_{ik}. The parameter w_{ik} is also exchanged. Nevertheless at this stage of collaboration the parameters $Threshold\_kpi_{ik}$, Δkpi_{ik}^{max} and Δkpi_{ik}_min are supposed by each the enterprise implementing the SAM, considering them as 0. Each enterprise estimates the values of influence by only considering the information of the KPIs. Enterprise i estimates ($val\_str_{is}\_kpi_{ik}$ and $val\_str_{is}\_kpi_{jk}$) and Enterprise j estimates ($val\_str_{js}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$). The values of influence estimated, by each enterprise, are not exchanged.
- Level 2 of Collaboration: The enterprises exchange information as regards (i) the KPIs and the parameters that characterise them, and (ii) the number of strategies (only the ID of the strategies, not the definition) and the parameters that characterise them. The value estimated for the budget is also exchanged. Each enterprise estimates the values of influence that its own strategies have on its own KPIs (*Enterprise i* estimates $val\_str_{is}\_kpi_{ixk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{jxk}$). Both companies separately estimate the cross-impact of the strategies and KPIs. Enterprise i estimates $val\_str_{is}\_kpi_{jxk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{ixk}$. In this case, the network manager (if required), according to the expertise and the knowledge acquired, can assess the enterprises on estimating the values of influence All the values as regards the values of influence estimated by each enterprise are exchanged, besides the parameters defining the KPIs and the strategies are also exchanged.
- Level 3 of Collaboration: The enterprises exchange information as regards the (i) KPIs defined and the parameters that characterise them, and (ii) the definition of the strategies formulated and the parameters that characterise them. The value estimated for the budget is also exchanged. On the one hand, each enterprise estimates the intra-enterprise values of influences of its own strategies and KPIs ($val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$). On the other hand, the network enterprises

jointly estimate the cross-impact (inter-enterprise values of influence) of the strategies and KPIs. *Enterprise i* and *Enterprise j* agree the values of influences of $val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{ixk}$.

For the three levels of collaboration, and with the main aim of maintaining confidentiality, agreements among the enterprises must be established as regards the shared information, prohibiting the use of sensitive information for personal gain instead of using it to achieve win-win scenarios. In case the network partners decide to have an external control of the proper operation of the strategies alignment process considering the collaborative perspective, the network manager comes into play. The *network manager* facilitates the exchange of information task, establishing sustainable and suitable collaborative relationships. The network manager will be in charge of ensuring that the enterprises describe in a simple way the strategies formulated, solving doubts raised in terms of KPIs definition and the strategies formulation.

For the development of the SAG three are the scenarios of collaboration delimited. Depending on the degree of collaboration established and the information shared, the enterprises would have to select one scenario of collaboration or another.

In the collaborative scenario, the enterprises establish collaborative relationships and exchange information in a higher or lesser extent as regards the objectives defined and the strategies formulated. The enterprises operate from a common perspective and the decision of which strategies to activate is made by considering part or all the information of all the network partners, collaborating with other enterprises. The exchange of information can be minimum, partial or complete depending on the collaboration scenario selected.

In this phase the collaborative network enterprises have to determine the level of collaboration to be performed. The data required to feed the SAM can be seen in (Figure 8.3).

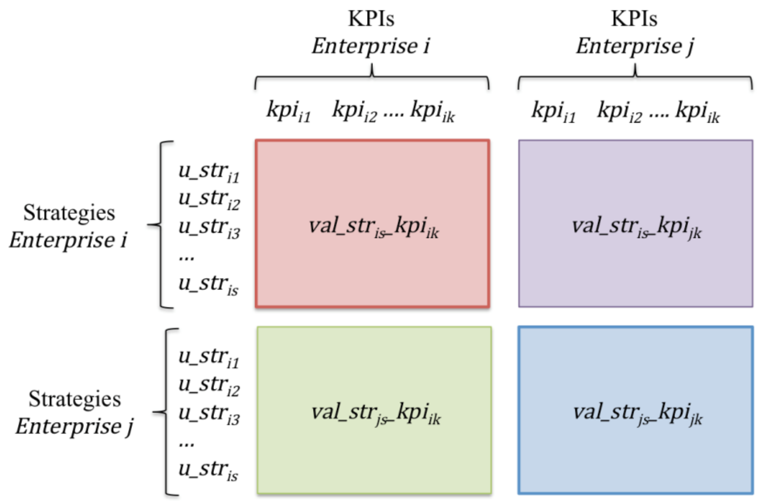


Figure 8.3. SAM Data

Depending on the information exchanged, the SAM can be applied considering a:

- Non-collaborative scenario, or a
- Collaborative scenario:
  - Collaborative Scenario 1 (CS1). Level 1 of Collaboration
  - Collaborative Scenario 2 (CS2). Level 2 of Collaboration
  - Collaborative Scenario 3 (CS3). Level 3 of Collaboration

Non-Collaborative Scenario (NCS)

In the non-collaborative scenario (NCS) (Figure 8.4) the enterprises of the network do not establish collaborative relationships. There is no-exchange of information among the network enterprises. The enterprises operate from an isolated perspective; therefore, the decision of which strategies to activate is individually made. The SAM is applied, from a non-collaborative perspective, considering each partner individually, so that the partners only take into account the information about their own objectives and strategies (Δkpi_{ik}^{max}, $Threshold\_kpi_{ik}$, Δkpi_{ik}_min, w_{ik}, c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$, b_i, $val\_str_{is}\_kpi_{ik}$, kpi_{ik}, u_str_{is}). In the NCS, the SAM is individually implemented in each Enterprise and there is neither information nor consideration of the other partners' objectives and strategies in the calculation of the SAM.

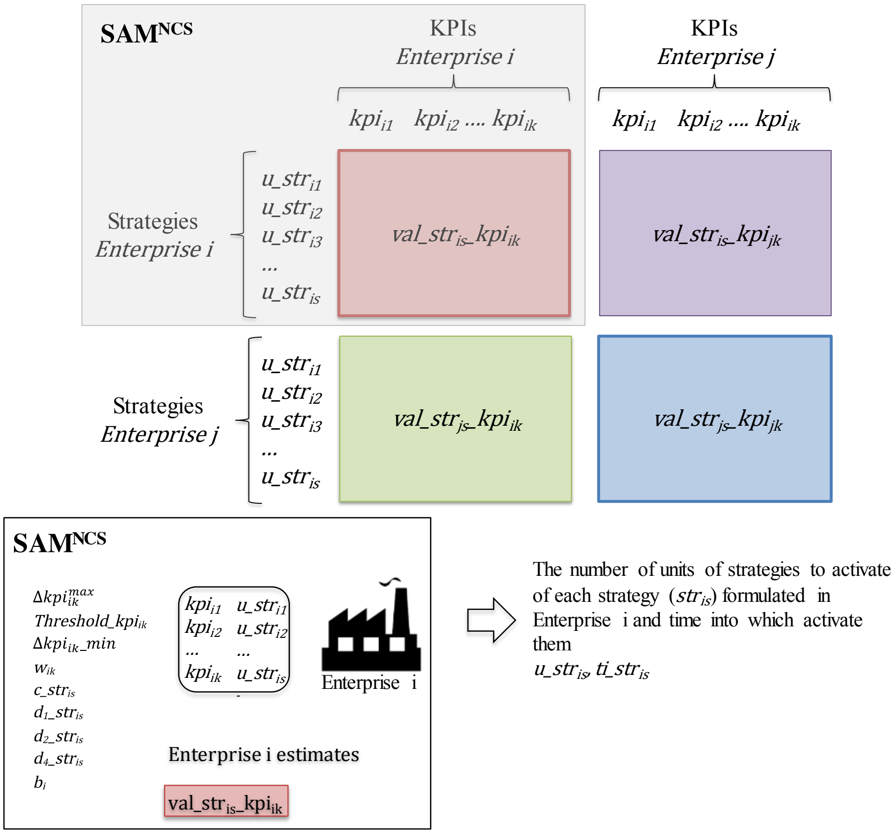


Figure 8.4. Application of SAM in a non-collaborative scenario (SAM^{NCS})

Collaborative Scenario 1 (CS1)

The Collaborative Scenario 1 (CS1), corresponding to the Level 1 of Collaboration, is characterised by the minimum exchange of information (Figure 8.5). Only the information regarding the definition of KPIs is exchanged (kpi_{ik}). Each enterprise estimates:

- The values of inter-enterprise influence $val\_str_{is}\_kpi_{ik}$, considering its own information (the KPIs defined and the strategies formulated in *Enterprise i*). *Enterprise j* does the same in order to compute its model and obtain its solution.
- The values of intra-enterprise influence $val\_str_{is}\_kpi_{jk}$ are estimated separately by each enterprise. *Enterprise i* considers the information exchanged as regards the KPIs defined in *Enterprise j* in order to estimate the value $val\_str_{is}\_kpi_{jk}$, corresponding to the impact that the strategies of *Enterprise i* would have in the objectives defined by *Enterprise j*. *Enterprise j* does the same in order to compute its model and obtain its solution.

The *Enterprise i* computes the SAM from an isolated perspective. In this case, the SAM is individually implemented in each Enterprise by only considering its own strategies and the influences they have in its own KPIs ($val\_str_{is}\_kpi_{ik}$) and the KPIs of other partners ($val\_str_{is}\_kpi_{jk}$). The information as regards the strategies formulated by other partners is not considered when calculating the SAM^{CS1}.

The parameters used as an input for the implementation of SAM^{CS1} include Δkpi_{ik}^{max}, $Threshold\_kpi_{ik}$, $\Delta kpi_{ik\_}min$, w_{ik}, c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$, b_i, $val\_str_{is}\_kpi_{ik}$, $val\_str_{is}\_kpi_{jk}$, kpi_{ik}, kpi_{jk}, u_str_{is}. When *Enterprise i* computes the SAM^{CS1} the values regarding the parameters that characterise the KPIs of *Enterprise j* (kpi_{jk}) are supposed to be 0 in SAM^{CS1} ($\Delta kpi_{jk}^{max} = 0$, $Threshold\_kpi_{jk} = 0$, $\Delta kpi_{jk\_}min = 0$), excepting w_{ik}, which is defied as $w_{ik} = 1/number\ of\ KPIs\ defined\ in\ Enterprise\ j$.

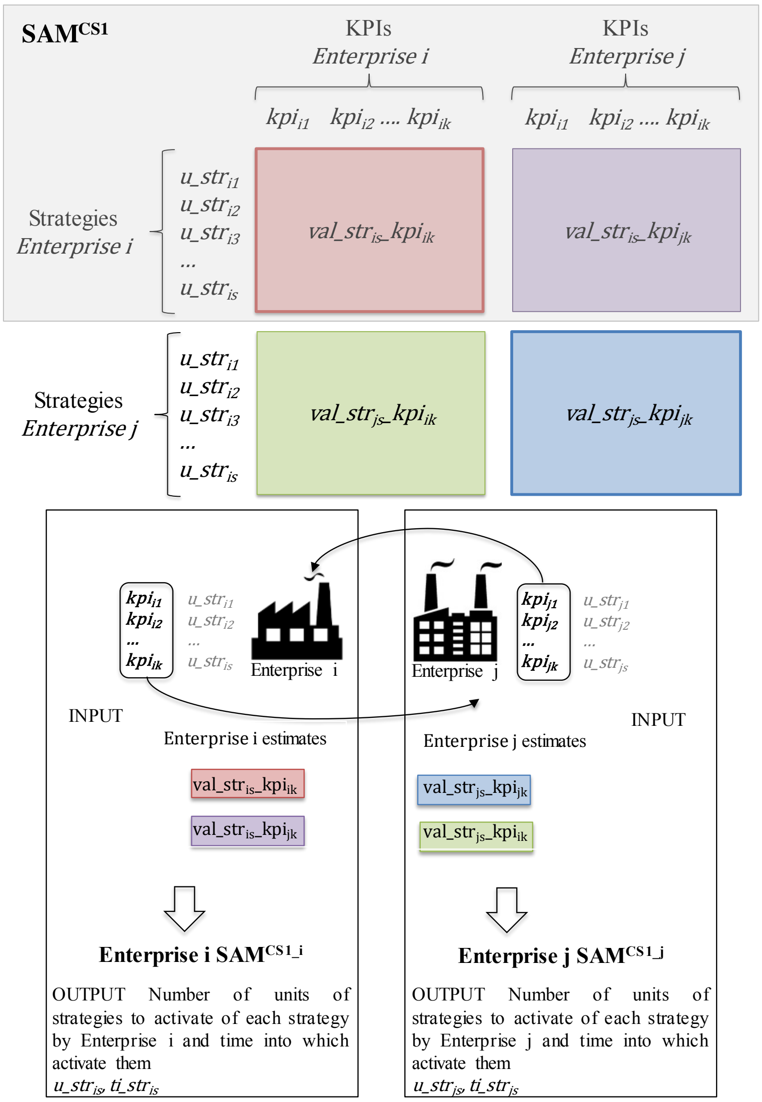


Figure 8.5. Application of SAM in the Collaborative Scenario 1 (SAM^{CS1})

Collaborative Scenario 2 (CS2)

The Collaborative Scenario 2 (CS2), corresponding to the Level 2 of Collaboration, is characterised by the exchange of partial amount of information (Figure 8.6). The information regarding the KPIs defined in each enterprise is exchanged, including Δkpi_{ik}^{max}, $Threshold\_kpi_{ik}$, $\Delta kpi_{ik\_}min$, w_{ik} and kpi_{ik}. The values of the parameters that characterise the strategies is also exchanged: c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$, b_i, but the definition of the strategies remain private (u_str_{is}). Each enterprise estimates the values of influence of its own strategies in its own KPIs (Enterprise i estimates $val\_str_{is}\_kpi_{ik}$ and Enterprise j estimates $val\_str_{js}\_kpi_{jk}$). According to the information exchanged, each company estimates the inter-enterprise influence between the strategies and the KPIs. Enterprise i estimates the values of influence that its strategies have on the KPIs defined by Enterprise j $val\_str_{is}\_kpi_{jk}$ and Enterprise j does the same considering its strategies, $val\_str_{js}\_kpi_{ik}$. The information as regards the values of influence ($val\_str_{is}\_kpi_{ixk}$, $val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{jxk}$, $val\_str_{js}\_kpi_{ixk}$) is exchanged. The enterprises compute the SAM^{CS2}

modelling all the partners of the network. The strategies and KPIs of all the partners of the network are modelled and considered for the computation of the strategies alignment process.

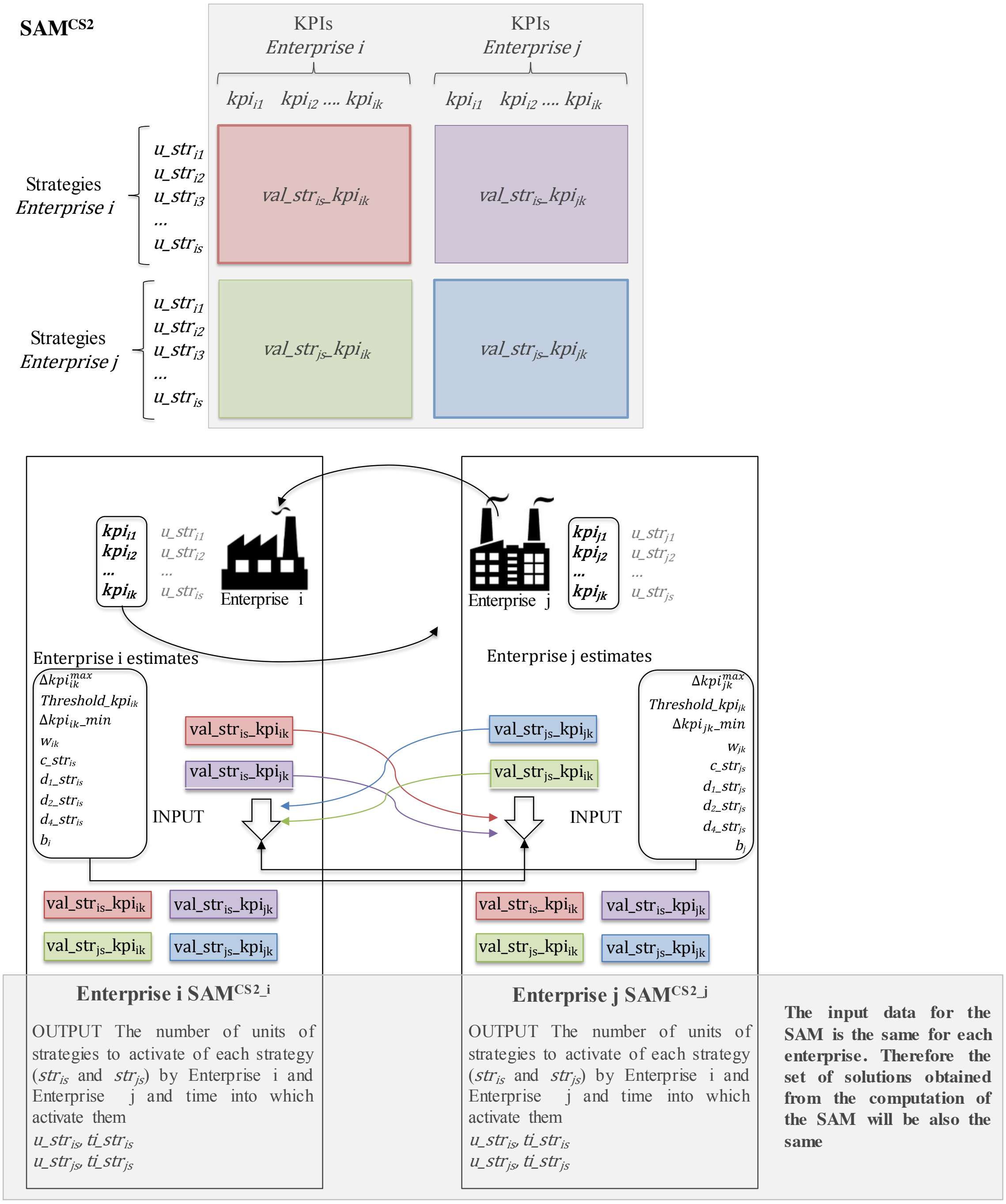


Figure 8.6. Application of SAM in the Collaborative Scenario 2 (SAM^{CS2})

Collaborative Scenario 3 (CS3)

The Collaborative Scenario 3 (CS3), corresponding to the Level 3 of Collaboration, is characterised by the exchange of both the defined KPIs and the formulated strategies (Figure 8.7). The information regarding the KPIs defined in each enterprise is exchanged, including Δkpi_{ik}^{max}, $Threshold\_kpi_{ik}$, Δkpi_{ik}_min, w_{ik} and kpi_{ik}. The values of the parameters that characterise the strategies is also exchanged: c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$, b_i and u_str_{is}. Besides the network enterprises jointly estimate the inter-enterprise values of influence ($val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{ixk}$). Each enterprise estimates the intra-enterprise values of influence of its own strategies in its own KPIs (Enterprise i estimates $val\_str_{is}\_kpi_{ixk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{jxk}$). The intra-enterprise values of influence are exchanged.

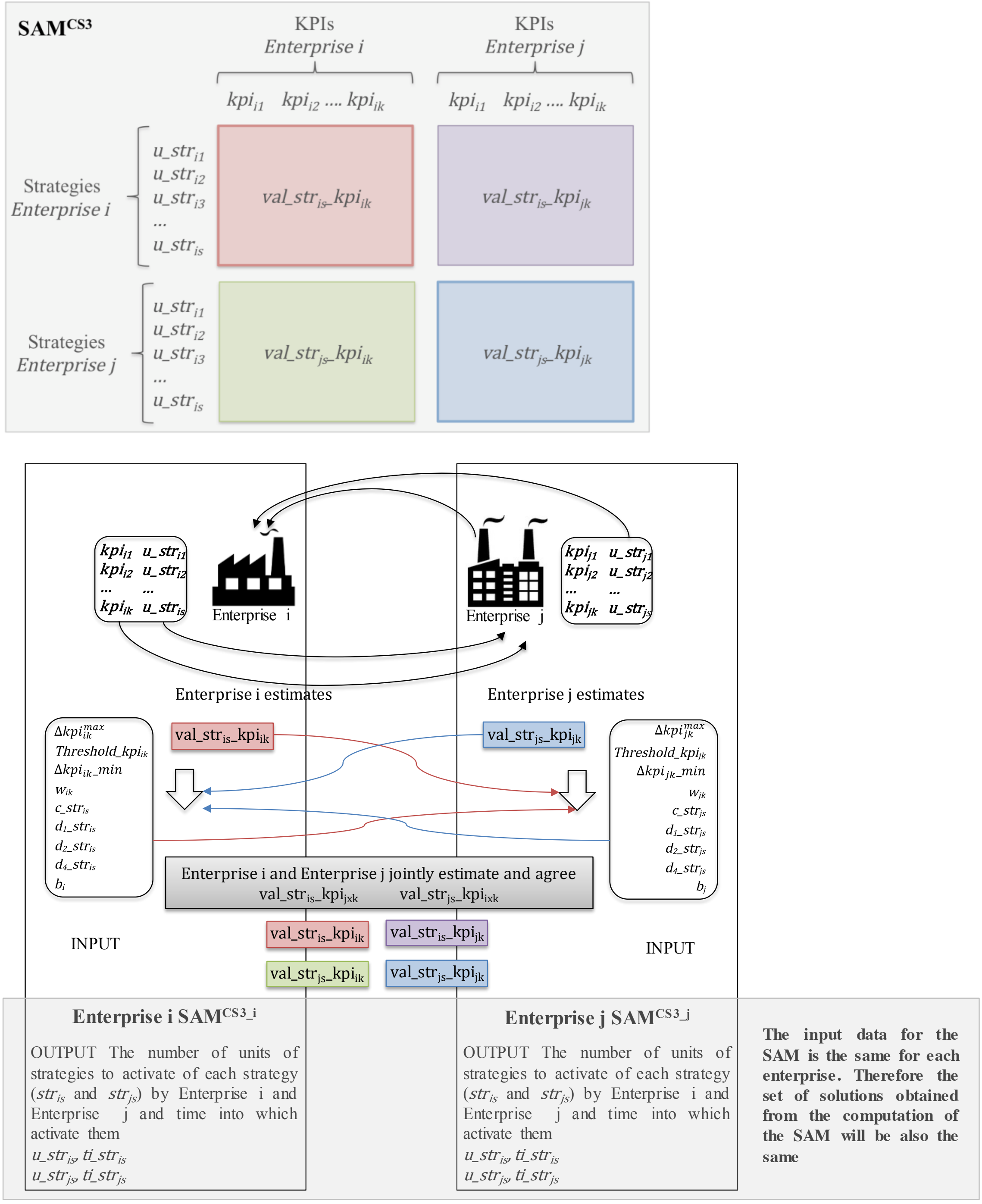


Figure 8.7. Application of SAM in the Collaborative Scenario 3 (SAM^{CS3})

The data used to compute the SAM in CS3 is the same for each enterprise. In this scenario, although the enterprises have the same data, each one computes the SAM^{CS3}. The set of solutions obtained, concerning the decision variables (u_str_{is} , ti_str_{is}) is exactly the same. Nevertheless, in order to provide a decentralised procedure for dealing with the strategies alignment process, it is considered that each enterprise computes its own model.

When implementing the SAM^{CS3} from a centralised perspective, the model will be computed (i) by one of the enterprises, in the presence of the others belonging to the network, or (ii) by an external agent known as "the network manager". In both cases the model SAM will be computed in a centralised way; obtaining also a centralised solution, which will be communicated to the network partners in order to start the negotiation of the best combination of strategies to activate in order to be aligned.

8.3.6 Phase 6. Estimation of the Values of Influence

When a formulated strategy is activated, the objectives defined receive positive or negative influences, increasing or decreasing the values associated to the KPIs. This phase provides support to the enterprises in the estimation of the values that define the influences received in the KPIs when one unit of strategy (u_str_{is}) is activated. In the light of this, the SAM proposes the parameter $val\_str_{is}\_kpi_{ik}$ to determine the influence that the activation of a specific strategy has on a defined KPI. The values related with the parameter $val\_str_{is}\_kpi_{ik}$ are estimated differently, depending on the collaboration level adopted, identified and in phase 5.

Non-Collaborative Scenario (EVI_NCS)

The enterprises only consider the information about their own defined KPIs and strategies formulated in order to estimate the extent that one unit of strategy (u_str_{is}) influences in the KPIs defined by each enterprise. In order to estimate the values of influence at the intra-enterprise level, the question to ask is proposed next:

- Enterprise i: How the activation of the strategy str_{is}, defined in enterprise i, affects on the performance levels of the kpi_{ik} defined in the same enterprise i? → $val\_str_{is}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{intra} (increase of the kpi_{ik} when the u_str_{is} of the same enterprise i is activated)

Collaborative Scenario 1 (EVI_CS1)

In this scenario the exchange of information is limited to the performance indicators defined, kpi_{ik} (Step 1 in Figure 8.8). The enterprises only consider the information about the KPIs exchanged in order to estimate the influence that one unit of strategy (u_str_{is}) has in the KPIs defined by each enterprise. At this level of collaboration, the role of the *network manager* is crucial due to it is the only agent that knows all the information as regards the strategies formulated, (u_str_{is}) and the KPIs defined (kpi_{ik}) in each of the network enterprises. The limited exchange of information that characterises this scenario makes that the enterprises individually estimate the inter-enterprise influences ($val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$) and intra-enterprise influences ($val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{ik}$) by only exchanging the information regarding the definition of the KPIs (kpi_{ik}).

Considering that, in order to estimate the values of influence at the inter-enterprise level, the enterprises only have the information of the parameters kpi_{ik}, the questions to ask are proposed next (Figure 8.8):

- Estimation of values of influence at the Intra-enterprise level:
  - Enterprise i: How the activation of the strategy str_{is}, defined in enterprise i, affects on the performance levels of the kpi_{ik} defined in the same enterprise i? → $val\_str_{is}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{intra} (increase of the kpi_{ik} when the u_str_{is} of the same enterprise i is activated)
  - Enterprise j: How the activation of the strategy str_{js}, defined in enterprise j, affects on the performance levels of the kpi_{jk} defined in the same enterprise j? → $val\_str_{js}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{intra} (increase of the kpi_{jk} when the u_str_{js} of the same enterprise j is activated)
- Estimation of values of influence at the Inter-enterprise level:
  - Enterprise i only knows the definition of the KPIs formulated in enterprise j (kpi_{jk}): How the activation of the strategy str_{is}, formulated in enterprise i, affects on the performance

level of kpi_{jk} defined in enterprise *j*? → $val\_str_{is}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{inter} (increase of the kpi_{jk} when the u_str_{is} of a different enterprise *i* is activated)

- Enterprise *j* only knows the definition of the KPIs formulated in enterprise *i* (kpi_{ik}): How the activation of the strategy str_{js}, formulated in enterprise *j*, affects on the performance level of kpi_{ik} defined in enterprise *i*? → $val\_str_{js}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{inter} (increase of the kpi_{ik} when the u_str_{js} of a different enterprise *j* is activated)

According to the information that each enterprise manager estimates as regards the values $val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{ik}$, the network manager gathers all the values estimated. The network manager knows all the strategies formulated and the KPIs defined in all the enterprises of the network; therefore it can help on the estimation of the values of influence, especially in those defined at the inter-enterprise level. Then, the network manager gathers all the information regarding inter and intra-enterprise values of influence, required to feed the SAM^{CS1} (Step 3 in Figure 8.8).

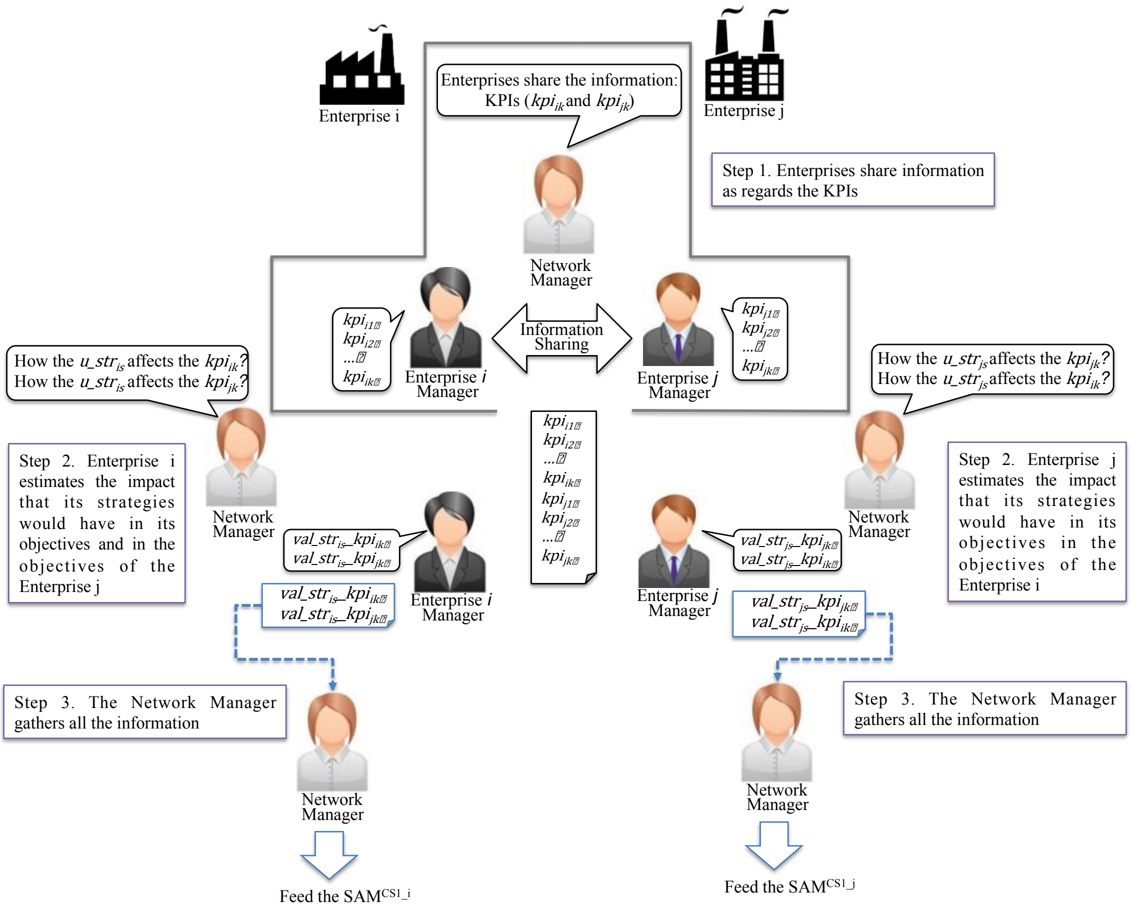


Figure 8.8. Estimation of the values of influences at the Level 1 of Collaboration: EVI_CS1

Collaborative Scenario 2 (EVI_CS2)

This level of collaboration involves the exchange of information about the KPIs defined and the parameters related to the KPIs and the strategies (Step 1 in Figure 8.9). In the Level 2 of Collaboration, when estimating $val\_str_{is}\_kpi_{ik}$ only one enterprise is involved. *Enterprise i* estimates the influence that the activation of its own strategies has on its own performance indicators (intra-enterprise influences). The values that refer to the parameters $val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{ik}$ (crossed-influences) are also individually estimated by the enterprises involved in the strategies alignment process considering the information of the KPIs exchanged. The values estimated for the inter-enterprise influences are exchanged between the network enterprises, *Enterprises i* and *j*.

The set of general questions that can be asked in each enterprise to collect the values of influence are proposed next (Figure 8.9):

- Estimation of values of influence at the Intra-enterprise level (Step 2 in Figure 8.9):
  - Enterprise *i*: How the activation of one unit of strategy u_str_{is}, defined in enterprise *i*, affects on the performance levels of the kpi_{ik} defined in the same enterprise *i*? → $val\_str_{is}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{intra} (increase of the kpi_{ik} when the u_str_{is} of the same enterprise i is activated)
  - Enterprise *j*: How the activation of one unit of strategy u_str_{js}, defined in enterprise *j*, affects on the performance levels of the kpi_{jk} defined in the same enterprise *j*? → $val\_str_{js}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{intra} (increase of the kpi_{jk} when the u_str_{js} of the same enterprise j is activated)

  The network manager can support network enterprises on the decision of estimating the parameters $val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$

- Estimation of values of influence at the Inter-enterprise level:
  - Enterprise *i*: knows the KPIs formulated in enterprise j (kpi_{jk}): How the activation of one unit of strategy u_str_{is}, formulated in enterprise *i*, affects on the performance level of kpi_{jk} defined in enterprise *j*? → $val\_str_{is}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{inter} (increase of the kpi_{jk} when the u_str_{is} of a different enterprise i is activated)
  - Enterprise *j:* knows the KPIs formulated in enterprise i (kpi_{ik}): How the activation of one unit of strategy u_str_{js}, formulated in enterprise *j*, affects on the performance level of kpi_{ik} defined in enterprise *i*? → $val\_str_{js}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{inter} (increase of the kpi_{ik} when the u_str_{js} of a different enterprise j is activated)

At the inter-enterprise level, the involved enterprise managers (i and *j*), having the support of the network manager, separately estimate the values of influence related to the parameters $val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{ik}$. Besides, each enterprise individually estimates the values of influence at the intra-enterprise level ($val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$). The enterprises exchange the estimated values of influence in order to individually carry out the SAM^{CS2} (Step 3 in Figure 8.9). The network manager gathers all the information regarding the inter and intra-enterprise values of influence, required to feed the SAM, and provides this values to each of the participating enterprises, so that each enterprise has the information enough to separately implement the SAM^{CS2}. In *Enterprise i* the SAM^{CS2_i} is implemented and in *Enterprise i* the SAM^{CS2_j} is implemented considering the values of the parameters exchanged (Step 4 in Figure 8.9).

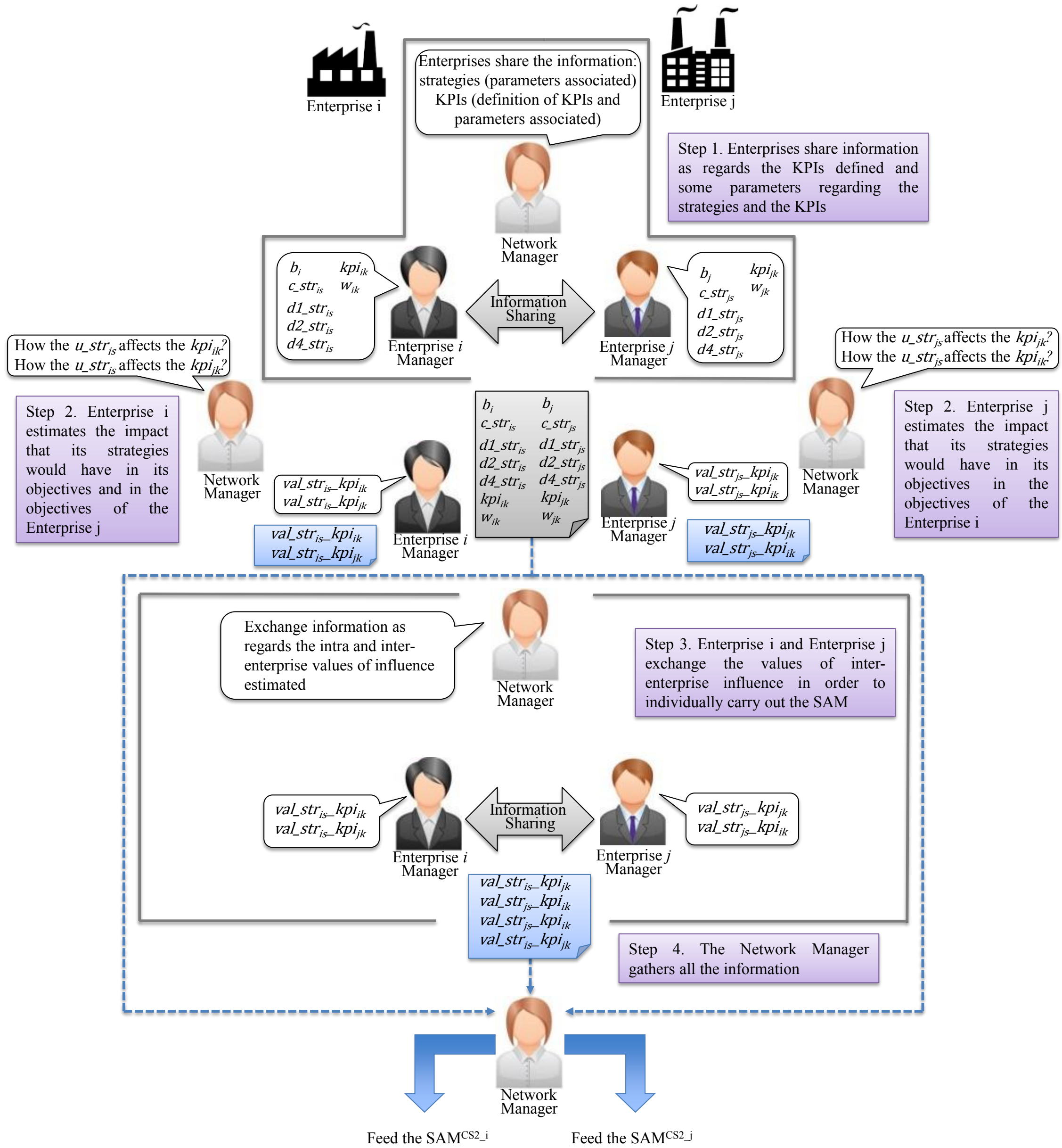


Figure 8.9. Estimation of the values of influences at the Level 2 of Collaboration: EVI_CS2

Collaborative Scenario 3 (EVI_CS3)

This level of collaboration involves a high degree of information exchange about the (i) definition of KPIs and the parameters associated, (ii) definition of the units of strategies, and the parameters associated, such as the costs of the strategies, and (iii) the budget (Step 1 in Figure 8.10). All the enterprises of the network (*i* and *j*) are involved in the jointly estimation of all the values of influence ($val\_str_{is}\_kpi_{ik}$, $val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{jk}$, $val\_str_{js}\_kpi_{ik}$) (Step 2 in Figure 8.10).

The set of general questions that can be asked in each enterprise are proposed next (Figure 8.10):

- Estimation of values of influence at the Intra-enterprise level: the enterprises are asked about the intra-enterprise influences of its own strategies and KPIs, but are also asked about the intra-enterprise influences of the strategies and KPIs defined in another network enterprise. Therefore, *Enterprise i* gives an estimation of $val\_str_{is}\_kpi_{ik}$ and considering the strategies and KPIs of the *Enterprise j*, *Enterprise i* also proposes an estimation of $val\_str_{js}\_kpi_{jk}$. *Enterprise j* proceeds in the same way:

- Enterprise *i*:
  - How the activation of one unit of strategy u_str_{is}, defined in enterprise *i*, affects on the performance levels of the kpi_{ik} defined in the same enterprise *i*? → $val\_str_{is}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{intra} (increase of the kpi_{ik} when the u_str_{is} of the same enterprise *i* is activated)
  - Knows the strategies and KPIs formulated in Enterprise *j*: How the activation of one unit of strategy u_str_{js}, defined in enterprise *j*, affects on the performance levels of the kpi_{jk} defined in the same enterprise *j*? → $val\_str_{js}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{intra} (increase of the kpi_{jk} when the u_str_{js} of the same enterprise *j* is activated)
- Enterprise *j*:
  - How the activation of one unit of strategy u_str_{js}, defined in enterprise *j*, affects on the performance levels of the kpi_{jk} defined in the same enterprise *j*? → $val\_str_{js}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{intra} (increase of the kpi_{jk} when the u_str_{js} of the same enterprise *j* is activated)
  - Knows the strategies and KPIs formulated in Enterprise *i:* How the activation of one unit of strategy u_str_{is}, defined in enterprise *i*, affects on the performance levels of the kpi_{ik} defined in the same enterprise *i*? → $val\_str_{is}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{intra} (increase of the kpi_{ik} when the u_str_{is} of the same enterprise *i* is activated)

The network manager can support network enterprises on the decision of estimating values at the intra-enterprise, $val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$. A process of negotiation will be initiated in order to agree on the values given for the parameters $val\_str_{is}\_kpi_{ik}$ and $val\_str_{js}\_kpi_{jk}$. This negotiation process will be developed in *Phase 10 The process of negotiating the solutions*.

- Estimation of values of influence at the Inter-enterprise level: *Enterprise i* estimates how the strategies formulated by other enterprises influence in its own KPIs, besides *Enterprise i* also estimates how its formulated strategies influence on the KPIs of other enterprises. *Enterprise j* proceeds in the same way:
  - Enterprise *i*
    - knows the strategies formulated in enterprise *j*: How the activation of one unit of strategy u_str_{js}, formulated in enterprise *j*, affects on the performance levels of the kpi_{ik} defined in enterprise *i*? → $val\_str_{js}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{inter} (increase of the kpi_{ik} when the u_str_{js} of a different enterprise *j* is activated)
    - knows the KPIs formulated in enterprise *j* (kpi_{jk}): How the activation of one unit of strategy u_str_{is}, formulated in enterprise *i*, affects on the performance level of kpi_{jk} defined in enterprise *j*? → $val\_str_{is}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{inter} (increase of the kpi_{jk} when the u_str_{is} of a different enterprise *i* is activated)
  - Enterprise *j*
    - knows the strategies defined in enterprise *i*: How the activation of one unit of strategy u_str_{is}, formulated in enterprise *i*, affects on the performance levels of the kpi_{jk} defined in enterprise *j*? → $val\_str_{is}\_kpi_{jk}$, used to compute the parameter Δkpi_{jk}^{inter} (increase of the kpi_{jk} when the u_str_{is} of a different enterprise *i* is activated)
    - knows the KPIs formulated in enterprise *i* (kpi_{ik}): How the activation of one unit of strategy u_str_{js}, formulated in enterprise *j*, affects on the performance level of kpi_{ik} defined in enterprise *i*? → $val\_str_{js}\_kpi_{ik}$, used to compute the parameter Δkpi_{ik}^{inter} (increase of the kpi_{ik} when the u_str_{js} of a different enterprise *j* is activated)

At both levels intra and inter-enterprise, the involved enterprise managers (*i* and *j*), having the support of the network manager, jointly agree and define all the values of influence related to the parameters $val\_str_{is}\_kpi_{ik}$, $val\_str_{js}\_kpi_{jk}$, $val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{ik}$. The network manager gathers all the information regarding the inter and intra-enterprise values of influence, required to feed the SAM and provides these values to each of the participating enterprises, so that each enterprise has the information enough to separately implement the SAM^{CS3}. In *Enterprise i* the SAM^{CS3_i} is implemented and in *Enterprise i* the SAM^{CS3_j} is implemented considering the values of the parameters exchanged (Step 3 in Figure 8.10).

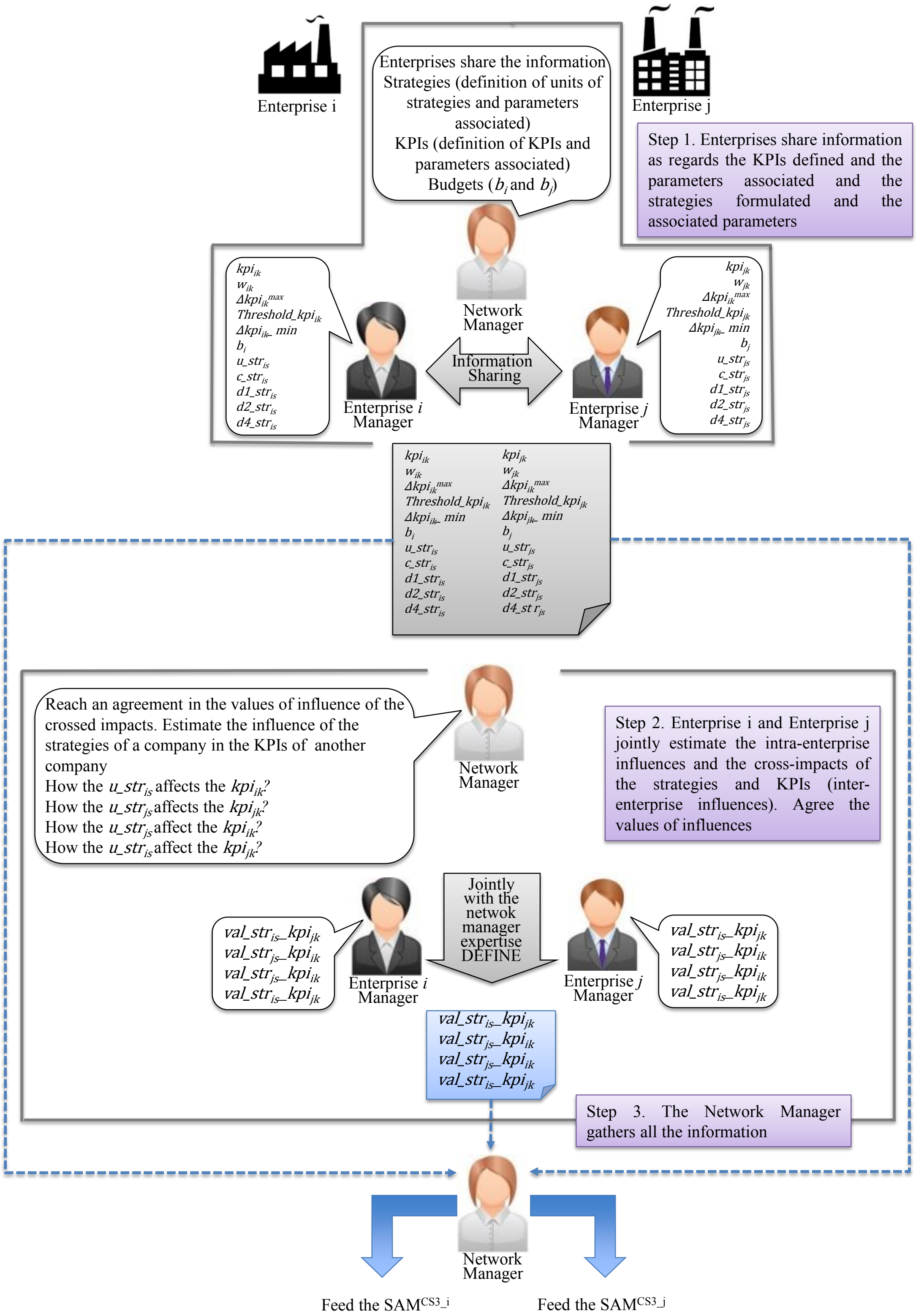


Figure 8.10. Estimation of $val\_str_{is}\_kpi_{ik}$ in the Level 3 of Collaboration: EVI_CS3

Regardless the Level of Collaboration considered, in this phase, the main drawback appears when the enterprises participating in the strategies alignment process do not have enough or appropriate information or knowledge as regards the influence that one particular unit of strategy (u_str_{is}) has on another particular KPI (kpi_{ik}). Therefore the enterprises have to face the challenge of properly estimating the requested data ($val\_str_{is}\_kpi_{ik}$) to feed the model with the main aim of obtaining accurate solutions.

In this case, the enterprise manager has an important role to accurately estimate the values of the parameter $val\_str_{is}\_kpi_{ik}$. Moreover, the network manager, as an expert in CNs, and being familiar with all the strategies (str_{is}) and KPIs (kpi_{ik}) can also help in the final decision of estimating the best value that defines the parameter $val\_str_{is}\_kpi_{ik}$.

Some of the limitations that could appear at this stage (when estimating $val\_str_{is}\_kpi_{ik}$) are briefly described next.

If the strategy u_str_{is} has been previously activated the enterprise manager will have no difficulty on estimating the value associated to the parameter $val\_str_{is}\_kpi_{ik}$. In this scenario is more than likely that the enterprise has stored the data as regards the KPI levels (Δkpi_{ik}) in the same moment in which a certain strategy (u_str_{is}) was activated. Then, the enterprise only has to retrieve the data and estimate the value $val\_str_{is}\_kpi_{ik}$.
When estimating $val\_str_{is}\_kpi_{ik}$, this value only considers that one strategy u_str_{is} influences one kpi_{ik}.

At this point, it is worth to mention that, in real networks obtaining this information ($val\_str_{is}\_kpi_{ik}$) is not as simple as retrieving the data stored of the KPI levels Δkpi_{ik} at previous periods. The values of the KPI levels (Δkpi_{ik}) stored could be influenced not only by one strategy (the strategy for which the influence is studied, u_str_{is}) but also by other strategies activated at the same time: in the same enterprise ($u\_str_{is} + u\_str_{ir}$) or in other enterprises of the network (i.e. u_str_{js}). Therefore, the increase of the KPI levels (Δkpi_{ik}) could be influenced by the activation of various strategies (i.e. $u\_str_{is} + u\_str_{ir} + u\_str_{js}$) and not as the result of the activation of a specific strategy.

In order to overcome this limitation, the increase of the KPI level (Δkpi_{ik}) is obtained as a marginal value. Accordingly, if an enterprise wants to estimate $val\_str_{is}\_kpi_{ik}$ when one unit of strategy u_str_{is} is activated, the enterprise can consider that the Δkpi_{ik} is the result of computing the sum of the values of influence of all the strategies activated at the same moment ($\sum_s val\_str_{is}\_kpi_{ik} + \sum_s val\_str_{js}\_kpi_{ik}$), which affected the level of the kpi_{ik}. Considering marginal values for the parameter Δkpi_{ik} permits this aggregation.

Concerning the influences of the strategies activated in other enterprises. Lets suppose that the strategy (u_str_{js}), to which the *enterprise i* wants to study the influence, has been previously activated by another enterprise of the network (enterprise j). It is more than likely that the enterprise *i*, which is now trying to figure out $val\_str_{js}\_kpi_{ik}$, did not know when the strategy of enterprise *j* was activated, so that the enterprise *i* does not know how the strategy activated, in the past, by enterprise *j* affected the KPIs of the enterprise *i*.

Real scenarios are even more complex, and it can occur that the strategy u_str_{is} has not been previously activated. In the light of this two are the main options proposed to define $val\_str_{is}\_kpi_{ik}$: (i) estimate the value considering the experience acquired and the tacit and explicit knowledge or (ii) wait until the strategy str_{is} (str_{js} for other enterprises of the network) is activated, and measure the increase or decrease of the KPIs per one unit of strategy activated (u_str_{is}).
So far, it has been considered that the kpi_{ik} is influenced by only one strategy. Nevertheless, it could happen that one kpi_{ik} is influenced by two or more strategies. In order to estimate the influences of two or more strategies that have no been previously activated, but that are supposed to be activated at the same time (i.e.

i.e. str_{i1} and sti_{i2}), the situation can be modelled considering that the two strategies merge in only one, creating a new strategy, i.e. str_{i3} Therefore the numerical value estimated that registers the increase or decrease of the kpi_{ik} when one unit of these two strategies are activated is represented by: $val\_str_{i3}\_kpi_{ik}$. This way of modelling the influence of two strategies can be extended to a determined number of strategies.

Considering the above described, this phase, in which the values of influence are to be identified, is characterised by the incomplete and uncertain information. Therefore, the task of estimating a numerical value to the parameter $val\_str_{is}\_kpi_{ik}$ has associated an uncertainty, as well. This uncertainty must be overcome as much as possible in the SAM. The SAM has a mathematical structure requiring quantitative values. In order to deal with this uncertainty from a quantitative perspective, stochastic methods could be applied, treating the parameter $val\_str_{is}\_kpi_{ik}$ as random.

Nevertheless, when there is not enough numeric information available to determine the values of influence that the strategies have on the KPIs, qualitative approaches can be used, substituting the quantitative ones during the phase of Estimation of the Values of Influence (phase 6). The enterprises might prefer to give qualitative values, to model the influence of the strategies upon the KPIs, in order not to feel pressured into defining quantitative ones, which seem to be more accurate. The qualitative values will be transformed into quantitative ones in order to feed the model, due to the SAM is mathematically raised and the parameter $val\_str_{is}\_kpi_{ik}$ is introduced as a real number.

In order to support the process of estimating the value $val\_str_{is}\_kpi_{ik}$, from a qualitative perspective, the *Likert scale* [6] on base 10 is proposed. For the definition of the influence, proportional values should be used. Working with proportions between KPIs to estimate the values of influence simplifies work for enterprises. In Likert Scale, if there is a lineal proportion between the extreme values and the null values, the values of the first row will be used. Exponential and logarithmic proportions have been also considered (Table 8.2). The company will be asked as regards if the proportion within the scale is linear logarithmic or exponential. For example, considering a lineal proportion, if $val\_str_{is}\_kpi_{ik} = 5$ and $val\_str_{ir}\_kpi_{ik} = 10$, the influence of str_{ir} is twice the influence of str_{is} upon kpi_{ik}.

When using quantitative values for the parameter $val\_str_{is}\_kpi_{ik}$ the enterprises have to estimate also the maximum value that the kpi_{ik} can achieve when a particular strategy str_{is} is activated. This maximum value that the kpi_{ik} acquires allows estimating the parameter $val\_str_{is}\_kpi_{ik}$ in absolute values.

Two questions have to be formulated in this case:

1. Which is the increase that the kpi_{ik} experiences when the strategy str_{is} is activated?
2. Which would be the maximum increase that the kpi_{ik} gets to experience when the strategy str_{is} is activated?
3. Which is the proportion used, within the scale, to estimate the values of influence: linear, logarithmic or exponential?

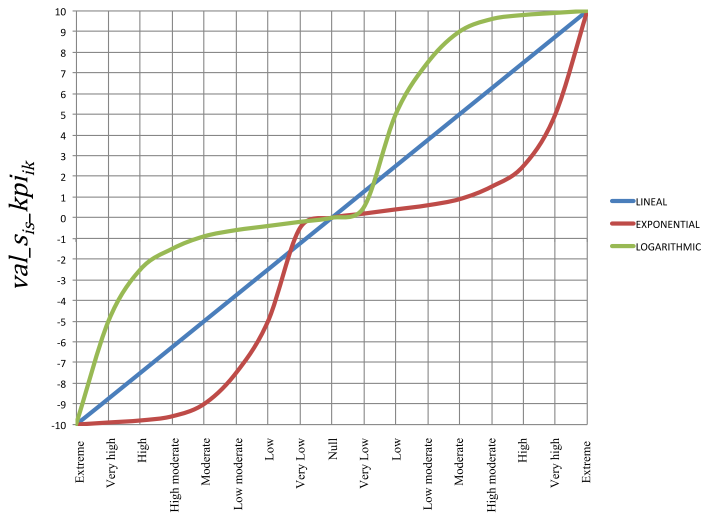
With the first question the value $val\_str_{is}\_kpi_{ik}$ is estimated but then this number must be considered in absolute value, therefore the second question is raised. Normally, the enterprises will use the lineal scale.

[6] A **Likert scale** is a psychometric scale commonly involved in research that employs questionnaires. It is the most widely used approach to scaling responses in qualitative survey research

Table 8.2. Likert Scale for estimating the parameter $val\_str_{is}\_kpi_{ik}$

	Extreme	Very high	High	High moderate	Moderate	Low moderate	Low	Very Low	Null	Very Low	Low	Low moderate	Moderate	High moderate	High	Very high	Extreme
LINEAL	-10	-8,75	-7,5	-6,25	-5	-3,75	-2,5	-1,25	0	1,25	2,5	3,75	5	6,25	7,5	8,75	10
EXPONENTIAL	-10	-9,9	-9,8	-9,6	-9	-7,5	-5	-0,5	0	0,2	0,4	0,6	0,9	1,5	2,5	5	10
LOGARITHMIC	-10	-5	-2,5	-1,5	-0,9	-0,6	-0,4	-0,2	0	0,5	5	7,5	9	9,6	9,8	9,9	10

Graphical representation



In order to estimate the values of influence the methodology proposed by (da Piedade Francisco, Azevedo, and Almeida 2012) can be used. These authors propose to follow the approach of performance prediction considering the use of predictive measurements to manage the results of inter-organisational processes and performance targets set by the CN. This paradigm of performance prediction allows managing performance pro-actively using feed forward and feedback control. Therefore, tools that consider performance estimation are used based on a data fusion approach, with a proper combination of leading and lagging measurements, which make it possible to use forecasting methods and tools to achieve good predictions. Predictive performance management represents the ability to control a system based not only on present and past measurements, but also taking into account future performance behaviours. (da Piedade Francisco, Azevedo, and Almeida 2012) propose the performance predictive engine (PPE) tool. In the CN context, the prospective performance measurement (Westphal et al., 2007) can be considered as one of the pioneers in the predictive performance management for CN.

8.3.7 Phase 7. Information Gathering

In order to gather all the information retrieved in the Phases 3, 4 and 6 a template has been designed. This template will be distributed among the enterprises participating in the strategies alignment process in order to gather all the information required to feed the SAM. When the enterprises define the values for the parameters characterising the strategies, KPIs and budget, these data do not necessarily have to be real. Nevertheless the data must be related to each other. For example if the $c\_str_{is} = 1$ and the $c\_str_{rs} = 3$, means that the real cost of str_{rs} is three times higher than the real cost of str_{is}. The budget will also be defined according to the proportion of values considered by the enterprises. The enterprises have to proceed in the same way, defining proportional values, to define all the information gathered in the proposed template.

Two types of templates, simplified and complete, are proposed. Depending on the data availability in each enterprise it will be used one template or another. If the enterprise has enough information as regards all the data required to feed the SAM the Complete Template will be used (Table 8.3). In this template, it will be gathered information as regards:

- Strategy ID
- Strategy Definition (u_str_{is})
- Strategy Cost [m.u] (c_str_{is})
- Strategy delay [t.u] ($d1\_str_{is}$)
- Time that the strategy takes to generate the maximum increase in the KPI [t.u] ($d2\_str_{is}$)
- Total Strategy Length [t.u]($d4\_str_{is}$)
- KPI ID
- KPI Definition (kpi_{ik})
- KPI weight (w_{ik})
- KPI Threshold value ($Threshold\_kpi_{ik}$)
- KPI_min (kpi_{ik}_min)
- KPI_max (kpi_{ik}_max)

The data recorded in the Complete Template will allow representing the curve that models the influence of str_{is}on the kpi_{ixk} in the same way as proposed in Chapter 5 (Figure 8.11).

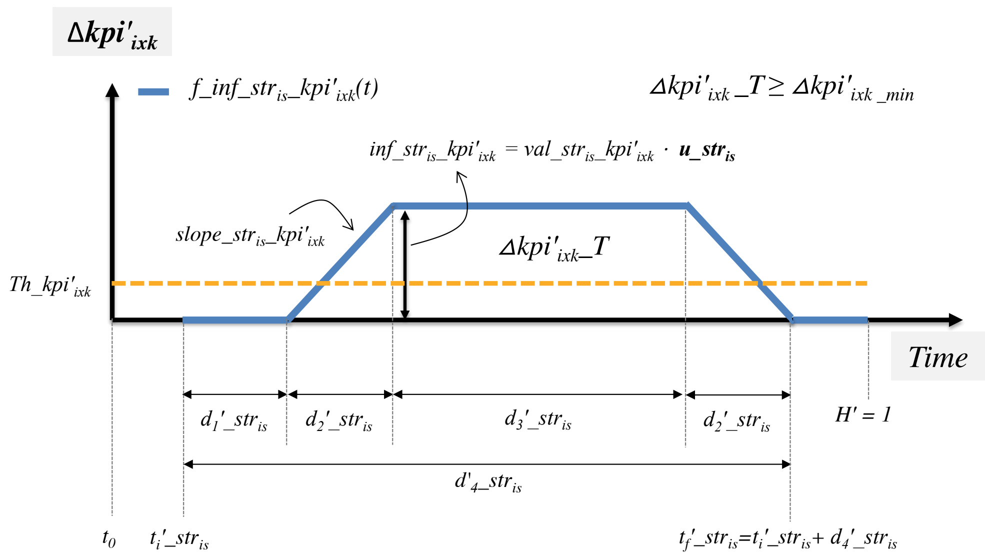


Figure 8.11. Curve that models the influence of str_{is}on the kpi'_{ixk}: $f\_inf\_str_{is}\_kpi'_{ixk}\ (t)$

On the other hand, if the enterprise does not have enough information as regards all the data required to feed the SAM the Simplified Template will be used (Table 8.4). In this template, it will be gathered information as regards:

- Strategy ID
- Strategy Definition (u_str_{is})
- Strategy Cost [m.u] (c_str_{is})
- Total Strategy Length [t.u] ($d4\_str_{is}$)
- KPI ID
- KPI Definition (kpi_{ik})
- KPI weight (w_{ik})

The rest of values will be supposed and considered as minimum values

- Strategy delay [t.u]: $d1\_str_{is} = 0$
- Time that the strategy takes to generate the maximum increase in the KPI [t.u]: $d2\_str_{is} = 0{,}0001$
- KPI Threshold value: $Threshold\_kpi_{ik} = 0$
- KPI_min: $kpi_{ik}\_min = 0$
- KPI_max: $kpi_{ik}\_max = 0$

Considering the data recorded in the Simplified Template the representation of the curve that models the influence of str_{is} on the kpi_{ixk} will be simplified according to the Figure 8.12.

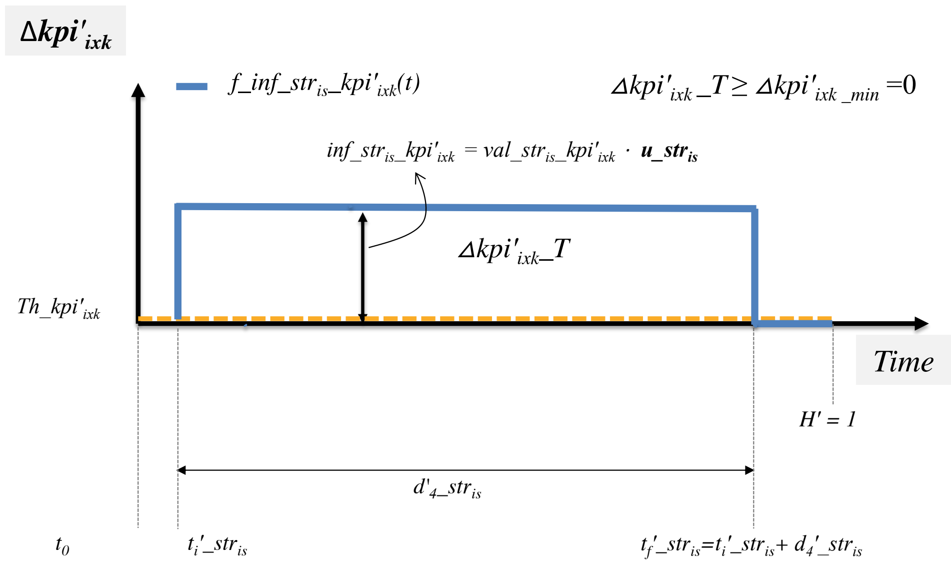


Figure 8.12. Simplified representation of $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$

Table 8.3. Complete template to gather information for the SAM

							KPIs defined in Enterprise i				KPIs defined in Enterprise j			
						KPI ID	kpi$_{i1}$	kpi$_{i2}$	…	kpi$_{ik}$	kpi$_{j1}$	kpi$_{j2}$	…	kpi$_{jk}$
						KPI Definition	Definition of kpi$_{i1}$	Definition of kpi$_{i2}$	…	Definition of kpi$_{ik}$	Definition of kpi$_{j1}$	Definition of kpi$_{j2}$	…	Definition of kpi$_{jk}$
						kpi_max	kpi$_{i1}$_max	kpi$_{i1}$_ max	…	kpi$_{ik}$_ max	kpi$_{i1}$_ max	kpi$_{j2}$_ max	…	kpi$_{jk}$_ max
						KPI weight	w$_{i1}$	w$_{i2}$	…	w$_{ik}$	w$_{j1}$	w$_{j2}$	…	w$_{jk}$
						Threshold value	Threshold_kpi$_{i1}$	Threshold_kpi$_{i2}$	…	Threshold_kpi$_{ik}$	Threshold_kpi$_{i1}$	Threshold_kpi$_{j2}$	…	Threshold_kpi$_{jk}$
						kpi_min ➔	kpi$_{i1}$_min	kpi$_{i1}$_min	…	kpi$_{ik}$_min	kpi$_{i1}$_min	kpi$_{j2}$_min	…	kpi$_{jk}$_min
	Strategy ID	Strategy Definition	Strategy Cost [m.u] (c_str$_{is}$)	Strategy delay [t.u] (d$_1$_str$_{is}$)	Time that the strategy takes to generate the maximum increase in the KPI [t.u] (d$_2$_str$_{is}$)	Total Strategy Length [t.u] (d$_4$_str$_{is}$) 🡣								
Strategies defined in the Enterprise i (bi)	u_str$_{i1}$	Definition of u_str$_{i1}$	c_str$_{i1}$	d$_1$_str$_{i1}$	d$_2$_str$_{i1}$	d$_4$_str$_{i1}$	val_str$_{i1}$_kpi$_{i1}$	val_str$_{i1}$_kpi$_{i2}$	…	val_str$_{i1}$_kpi$_{ik}$	val_str$_{i1}$_kpi$_{j1}$	val_str$_{i1}$_kpi$_{j2}$	…	val_str$_{i1}$_kpi$_{jk}$
	u_str$_{i2}$	Definition of u_str$_{i2}$	c_str$_{i2}$	d$_1$_str$_{i2}$	d$_2$_str$_{i2}$	d$_4$_str$_{i2}$	val_str$_{i2}$_kpi$_{i1}$	val_str$_{i2}$_kpi$_{i2}$	…	val_str$_{i2}$_kpi$_{ik}$	val_str$_{i2}$_kpi$_{j1}$	val_str$_{i2}$_kpi$_{j2}$	…	val_str$_{i2}$_kpi$_{jk}$
	…	…	…	…	…	…	…	…	…	…	…	…	…	…
	u_str$_{is}$	Definition of u_str$_{is}$	c_str$_{is}$	d$_1$_str$_{is}$	d$_2$_str$_{is}$	d$_4$_str$_{is}$	val_str$_{is}$_kpi$_{i1}$	val_str$_{is}$_kpi$_{i2}$	…	val_str$_{is}$_kpi$_{ik}$	val_str$_{is}$_kpi$_{j1}$	val_str$_{is}$_kpi$_{j2}$	…	val_str$_{is}$_kpi$_{jk}$
Strategies defined in the Enterprise j (bj)	u_str$_{j1}$	Definition of u_str$_{j1}$	c_str$_{j1}$	d$_1$_str$_{j1}$	d$_2$_str$_{j1}$	d$_4$_str$_{j1}$	val_str$_{j1}$_kpi$_{i1}$	val_str$_{j1}$_kpi$_{i2}$	…	val_str$_{j1}$_kpi$_{ik}$	val_str$_{j1}$_kpi$_{j1}$	val_str$_{j1}$_kpi$_{j2}$	…	val_str$_{j1}$_kpi$_{jk}$
	u_str$_{j2}$	Definition of u_str$_{j2}$	c_str$_{j2}$	d$_1$_str$_{j2}$	d$_2$_str$_{j2}$	d$_4$_str$_{j2}$	val_str$_{j2}$_kpi$_{i1}$	val_str$_{j2}$_kpi$_{i2}$	…	val_str$_{j2}$_kpi$_{ik}$	val_str$_{j2}$_kpi$_{j1}$	val_str$_{j2}$_kpi$_{j2}$	…	val_str$_{j2}$_kpi$_{jk}$
	…	…	…	…	…	…	…	…	…	…	…	…	…	…
	u_str$_{js}$	Definition of u_str$_{js}$	c_str$_{js}$	d$_1$_str$_{js}$	d$_2$_str$_{js}$	d$_4$_str$_{js}$	val_str$_{js}$_kpi$_{i1}$	val_str$_{js}$_kpi$_{i2}$	…	val_str$_{js}$_kpi$_{ik}$	val_str$_{js}$_kpi$_{j1}$	val_str$_{js}$_kpi$_{j2}$	…	val_str$_{js}$_kpi$_{jk}$

Table 8.4. Simplified Template to gather information for the SAM

					KPIs defined for Enterprise i				**KPIs defined for Enterprise j**			
				KPI ID	kpi_{i1}	kpi_{i2}	...	kpi_{ik}	kpi_{j1}	kpi_{j2}	...	kpi_{jk}
				KPI Definition	Definition of kpi_{i1}	Definition of kpi_{i2}	…	Definition of kpi_{ik}	Definition of kpi_{j1}	Definition of kpi_{j2}	…	Definition of kpi_{jk}
				KPI weight →	w_{i1}	w_{i2}	…	w_{ik}	w_{j1}	w_{j2}	…	w_{jk}
	Strategy ID	Strategy Definition	Strategy Cost [m.u] (c_str_{is})	Strategy Length [t.u] ($d_4\_str_{is}$) ↓								
Estrategies defined by the Eneterprise i (bi)	str_{i1}	Definition of str_{i1}	c_str_{i1}	$d_4\_str_{i1}$	$val\_str_{i1}\_kpi_{i1}$	$val\_str_{i1}\_kpi_{i2}$	…	$val\_str_{i1}\_kpi_{ik}$	$val\_str_{i1}\_kpi_{j1}$	$val\_str_{i1}\_kpi_{j2}$	...	$val\_str_{i1}\_kpi_{jk}$
	str_{i2}	Definition of str_{i2}	c_str_{i2}	$d_4\_str_{i2}$	$val\_str_{i2}\_kpi_{i1}$	$val\_str_{i2}\_kpi_{i2}$	…	$val\_str_{i2}\_kpi_{ik}$	$val\_str_{i2}\_kpi_{j1}$	$val\_str_{i2}\_kpi_{j2}$	...	$val\_str_{i2}\_kpi_{jk}$
	...	…	…	…	...	...	...	...	...	...	...	...
	str_{is}	Definition of str_{is}	c_str_{is}	$d_4\_str_{is}$	$val\_str_{is}\_kpi_{i1}$	$val\_str_{is}\_kpi_{i2}$	…	$val\_str_{is}\_kpi_{ik}$	$val\_str_{is}\_kpi_{j1}$	$val\_str_{is}\_kpi_{j2}$	...	$val\_str_{is}\_kpi_{jk}$
Estrategies defined by the Eneterprise j (bj)	str_{j1}	Definition of str_{j1}	c_str_{j1}	$d_4\_str_{j1}$	$val\_str_{j1}\_kpi_{i1}$	$val\_str_{j1}\_kpi_{i2}$	…	$val\_str_{j1}\_kpi_{ik}$	$val\_str_{j1}\_kpi_{j1}$	$val\_str_{j1}\_kpi_{j2}$	...	$val\_str_{j1}\_kpi_{jk}$
	str_{j2}	Definition of str_{j2}	c_str_{j2}	$d_4\_str_{j2}$	$val\_str_{j2}\_kpi_{i1}$	$val\_str_{j2}\_kpi_{i2}$	…	$val\_str_{j2}\_kpi_{ik}$	$val\_str_{j2}\_kpi_{j1}$	$val\_str_{j2}\_kpi_{j2}$	...	$val\_str_{j2}\_kpi_{jk}$
	...	…	...	...	...	...	...	...	...	...	...	...
	str_{js}	Definition of str_{js}	c_str_{js}	$d_4\_str_{js}$	$val\_str_{js}\_kpi_{i1}$	$val\_str_{js}\_kpi_{i2}$	…	$val\_str_{js}\_kpi_{ik}$	$val\_str_{js}\_kpi_{j1}$	$val\_str_{js}\_kpi_{j2}$	...	$val\_str_{js}\_kpi_{jk}$

8.3.8 Phase 8. Introduction of the data in the Database

Before introducing the data in the DMS it must be ensured that:

- The parameters related to KPIs ($\Delta kpi'_{ixk}$) are homogenised
- The parameters related to durations and time H', $d'_1\_str_{is}$, $d'_2\_str_{is}$, $d'_4\_str_{is}$, $d'_3\_str_{is}$, $t'_i\_str_{is}$ and $t'_f\_str_{is}$ are normalised
- The parameter value $val'\_str_{is}\_kpi_{ik}$ has been estimated considering proportional values

Generally, all the data introduced must proportional one each other. The parameters required to feed the SAM are gathered in a DMS specifically designed *Microsoft Access 2010*. The DMS is characterised by being centralised in an external repository where public and private data are managed to guarantee confidentiality (Figure 8.13). The external centralised DMS (Alfaro et al. 2010) is a managed by the external network manager.

The introduction of the data in the DMS can be carried out through SAGEN application, offering a friendly user interphase (see Annex 7.2)

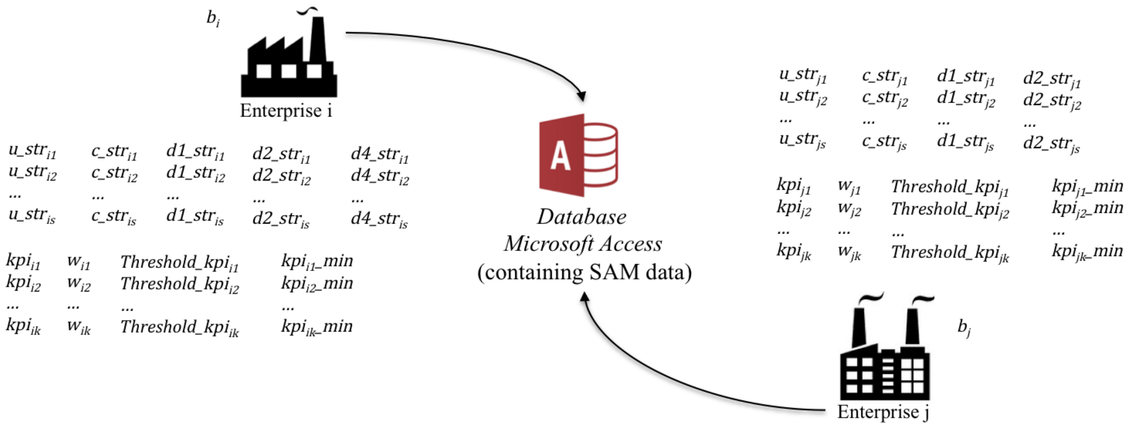


Figure 8.13. External centralised DMS

8.3.9 Phase 9. SAM automatic creation

Automatic creation of the model through SAGEN application, using the data of the DMS connected. SAGEN automatically generates the flow diagram in the simulation software (Figure 8.14).

Through SAGEN, the flow diagram of the strategies alignment process and the simulation and optimisation experiments are automatically created in the simulation software.

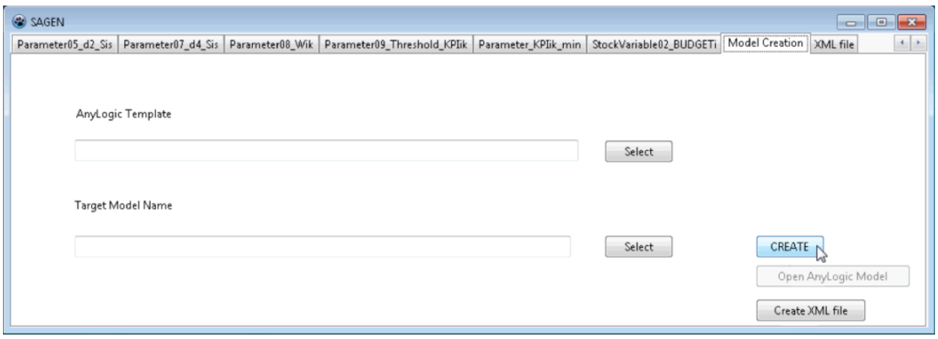


Figure 8.14. SAGEN: SAM Automatic creation

8.3.10 Phase 10. Generate solutions

The optimisation experiment build in AnyLogic generate the solutions, as regards the decision variables u_str_{is} (units of strategies to activate) and ti_str_{is} (the range of time in which to initiate the activation of a strategy) that optimise the network performance (kpi'_{net}).

A set of solutions is provided, from which the enterprises will have to identify the ones that best fits to their needs.

The optimisation experiment offers the optimum set of parameters, which consist of the decision variables u_str_{is} and ti_str_{is} defined in the SAM, that maximise the objective function ($max\ kpi'_{net}$),. Multiple iterations are run, simulating different scenarios, in order to obtain the maximum value of performance at network level, kpi_{net}. The values of the parameters (u_str_{is} and ti_str_{is}) obtained in each iteration are gathered in the *Datasets*. These *Datasets* are stored in a spreadsheet. The table generated in the spreadsheet (Figure 8.15) gathers the data obtained in each iteration carried out in the optimisation experiment including (i) the number of iteration, (ii) the value of the objective in the current iteration, (iii) the feasibility of the solution, identifying that the restrictions associated to the SAM are satisfied. *Feasible:1* indicates that the solution is feasible while *Feasible:0* indicates that the solution is not feasible, (iv) the values of the set of parameters u_str_{is}, and (v) the values of the set of parameters ti_str_{is}.

	A	B	C	D	E	F	G	H	I	J	K
1	NumIteration	CurrentObjective	FEASIBLE	u_S11	ti_S11	u_S12	ti_S12	u_S21	ti_S21	u_S22	ti_S22
2	1	0,000	1	0	0,100	0	0,100	0	0,100	0	0,100
3	2	0,312	0	1	0,500	1	0,500	1	0,500	1	0,500
4	3	0,000	1	0	0,250	0	0,250	0	0,250	0	0,250
5	4	0,000	1	0	0,000	0	0,000	0	0,000	0	0,000
6	5	0,000	0	1	1,000	1	1,000	1	1,000	1	1,000
7	6	0,126	0	1	0,750	1	0,750	1	0,750	1	0,750
8	7	0,076	0	1	0,583	1	0,982	0	0,306	0	0,006
9	8	0,093	0	0	0,917	0	0,047	1	0,931	1	0,165
10	9	-0,001	0	0	0,582	1	0,976	1	0,063	0	0,981
11	10	0,002	0	1	0,937	0	0,148	1	0,620	0	0,817
12	11	0,196	0	1	0,598	0	0,586	0	0,995	1	0,379
13	12	0,093	0	0	0,193	1	0,891	0	0,235	1	0,443
14	13	0,011	0	0	0,839	1	0,549	0	0,906	0	0,639
15	14	0,113	0	1	0,002	0	0,226	0	0,859	0	0,879
16	15	0,100	0	0	0,029	0	0,804	1	0,365	1	0,073
17	16	0,246	0	1	0,440	1	0,073	0	0,076	1	0,013
18	17	0,062	0	1	0,646	1	1,000	1	1,000	1	1,000
19	18	0,001	0	1	0,936	1	0,982	0	0,306	0	0,006
20	19	0,000	1	0	0,013	0	0,017	0	0,044	0	0,132
21	20	0,102	0	0	0,147	1	0,671	0	0,167	1	0,420
22	21	0,000	0	0	0,193	1	0,891	0	0,235	0	0,000
23	22	0,093	1	0	0,000	0	0,000	0	0,000	1	0,443
24	23	0,000	1	0	0,006	0	0,036	0	0,038	0	0,042
25	24	0,000	1	0	0,036	0	0,027	0	0,010	0	0,010
26	25	0,000	1	0	0,147	0	0,337	0	0,196	0	0,435
27	26	0,093	0	0	0,200	1	0,861	0	0,240	1	0,418

Hoja1 Hoja2 Hoja3 +
Vista normal Listo Suma=0

Figure 8.15. Spreadsheet gathering the solutions generated in the optimisation experiment

The negotiation of selecting and finally implementing the solution is proposed in the next Phase 11.

8.3.11 Phase 11. The process of negotiating the solutions

The process of negotiating the solutions will be initiated provided that the enterprises, participating in the process of strategies alignment, disagree with the optimal solution given by the simulation software, AnyLogic, in which the SAM is solved. Normally, when the enterprises decide to apply a "Centralised" *decision* for the application of the SAM, the solution adopted by all the enterprises will be the optimal solution given by the SAM. When the Type of decision carried out in the application SAM is "Decentralised", a negotiation process will be commonly required. In the decentralised scenario, there will be as many SAMs as network enterprises. Each network partner implements the strategies alignment model, SAM^i. Each enterprise will select the alternative of solution, that bets fits to its requirements, from all the set of solutions provided by the optimisation experiment computed in the simulation software AnyLogic, in which the SAM is solved. The network partners' exchange the solution proposals generated by the SAM resolution. The enterprises develop iterative processes for exchanging information, which facilitate the negotiation and the achievement of agreements to support the process of identifying what are the strategies to activate and in which time frame. In each iterative process, each network enterprise analyses the proposals made by the other network partners. The partners negotiate the alternative of solution that generates a performance as close to the optimum for each partner. Minimum and maximum boundaries of performance have to be defined by each enterprise, and the alternative of solution will be among these margins defined. The negotiation process will stop when the enterprises (i) achieve some goal or (ii) when arrive to the minimum number of proposals and counterproposals, previously agreed.

When the network partners negotiate, participants receive equal treatment. It is not expected that the participants with more power, or better qualities, receive greater performance levels (profit) compared to the partners that have less power. Nevertheless, when computing the SAM, which focuses on the maximisation of the network performance, it will occur that a member of the CN get major benefits at the expense of the loss of benefits from other network partners.

Depending on the collaborative scenario selected, the enterprises will proceed differently when carrying out the negotiation process. Next, three negotiation processes are described, coinciding with the three collaborative scenarios defined:

- Negotiation Process CS1 (NP_CS1)
- Negotiation Process CS2 (NP_CS2)
- Negotiation Process CS3 (NP_CS3)

Negotiation Process CS1 (NP_CS1)

Hereafter, the negotiation process carried out by the enterprises that decide to establish the CS1 (NP_CS1) is described. In Figure 8.16 an scheme of the negotiation process carried out by the enterprises that decide to establish the CS1 (NP_CS1) is shown. The NP_CS1 will allow enterprises to negotiate the solutions (values of the decision variables $u\_str_{is}^{CS1}$, $ti\_str_{is}^{CS1}$) obtained in the application of the SAM when establishing the CS1. Before describing the steps of negotiation, Table 8.5 is presented with the parameters used in the NP_CS1. A description of these parameters is also given.

Table 8.5. Parameters used in NP_CS1

Notation	Definition
kpi_{ik}	Key performance indicator defined in *Enterprise i*
$val\_str_{is}\_kpi_{ik}$	Estimated Intra-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{ik} defined by *Enterprise i*
$val\_str_{is}\_kpi_{jk}$	Estimated Inter-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{jk} defined by *Enterprise j*
n	Number assigned to the alternative selected for the resolution of the SAM, considering the results of CS1 (SAM^{CS1_i}), this number is assigned consecutively to the selected alternatives $n=[1, 2, ..., n]$
m	Number assigned to the iteration. This number will coincide with the number assigned to the alternative selected $m=n$
m_max	Maximum number of iterations agreed by the partners to negotiate alternatives of solution
SAM^{NCS_i}	Strategies Alignment Model computed in *Enterprise i* considering the NCS
SAM^{CS1_i}	Strategies Alignment Model computed in *Enterprise i* considering the CS1
$SAM^{CS1\_i\_n}$	Simulation of the Strategies Alignment Model computed in *Enterprise i* considering the CS1 using the values selected in the alternative n $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$
kpi_{net}^{NCS}	Value of the Key performance indicator at network level kpi_{net} considering the results of NCS
kpi_{i}^{NCS}	Value of the kpi_i (defined at the enterprise level) computing the influences of the strategies activated in *Enterprise i*, considering the results of NCS
$u\_str_{is}^{NCS}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) obtained in the NCS
$ti\_str_{is}^{NCS}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) obtained in the NCS
$kpi_{i}^{CS1\_n}$	Value of the kpi_i computing the influences of the strategies activated in *Enterprise i*, considering the results of CS1 corresponding to the alternative n
$u\_str_{is}^{CS1\_n}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) obtained by *Enterprise i* when

Notation	Definition
	computing the CS1 corresponding to the alternative n
$ti\_str_{is}^{CS1\_n}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) obtained by *Enterprise i* when computing the CS1 corresponding to the alternative n
$\Delta kpi_i^{CS1\_j\_n}$	Increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j* considering the results of CS1 ($u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$) corresponding to the alternative n
$kpi_i^{CS1\_n}\_real$	Value of the kpi_i computing the influences of the strategies activated in *Enterprise i* ($u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$) and the strategies activated in *Enterprise j* ($u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$), considering the results of CS1 corresponding to the alternative n
$kpi_{net}^{CS1\_n}$	Value of the Key performance indicator at network level kpi_{net} considering the results of CS1 corresponding to the alternative n
CCx^i	Criterion Choice x of *Enterprise i*
$\Delta^{min} kpi_i^{CS1\_j}$	Minimum increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j*, considering the results of CS1, defined by *Enterprise i*
$\min\_kpi_i^{CS1}\_real$	Minimum value identified for $kpi_i^{CS1}\_real$, defined by *Enterprise i,* considering the results of CS1
α	1 if the criteria choice defined by *Enterprise i* is fulfilled 0 if the criteria choice defined by *Enterprise i not* is fulfilled
β	1 if the criteria choice defined by *Enterprise j* is fulfilled 0 if the criteria choice defined by *Enterprise j not* is fulfilled

Next, the steps required for the NP_CS1 are listed and described:

STEP 1. Calculation of the SAM in the NCS (*SAM^{NCS_i}*). Application of the SAM considering the NCS. Each enterprise of the network individually applies the SAM in the NCS by only taking into account the information about their own objectives and strategies, and computes:

- The values of the KPI at enterprise level
  - *Enterprise i*: kpi_i^{NCS}
  - *Enterprise j*: kpi_j^{NCS}
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i*: $u\_str_{is}^{NCS}$, $ti\_str_{is}^{NCS}$
  - *Enterprise j*: $u\_str_{js}^{NCS}$, $ti\_str_{js}^{NCS}$

The KPI at network level is computed from the sum of the KPIs obtained at the enterprise level, $kpi_{net}^{NCS} = kpi_i^{NCS} + kpi_j^{NCS}$.

STEP 2. Exchange the information as regards the KPIs (kpi_{ik}).

- *Enterprise i*: exchanges information as regards its defined KPIs with the *Enterprise j* → kpi_{ik}
- *Enterprise j*: exchanges information as regards its defined KPIs with the *Enterprise i* → kpi_{jk}

STEP 3. Estimation of values of influence ($val\_str_{is}\_kpi_{ik}$).

- *Enterprise i*:
  - *Intra*-enterprise values of influence: $val\_str_{is}\_kpi_{ik}$
  - *Inter-enterprise* values of influence: $val\_str_{is}\_kpi_{jk}$
- *Enterprise j*:
  - *Intra*-enterprise values of influence: $val\_str_{js}\_kpi_{jk}$
  - *Inter-enterprise* values of influence: $val\_str_{js}\_kpi_{ik}$

STEP 4. Calculation of the SAM in the CS1 (*SAM^{CS1_i}*). Application of the SAM considering the CS1. Each enterprise implements its own *SAM^{CS1_i}* using the information estimated. The solution of the *SAM^{CS1_i}* corresponding to the alternative n is obtained, including:

- The values of the KPIs at enterprise level
  - *Enterprise i*: $kpi_i^{CS1\_n}$
  - *Enterprise j*: $kpi_j^{CS1\_n}$
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i*: $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$
  - *Enterprise j*: $u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$

The resolution of the SAM^{CS1_i} provides a set of solutions. One or more solutions will be optimal, while others are close to the optimal (considering them suboptimal solutions). Each solution provided by SAM^{CS1_i} will be considered as an alternative. There will be as much alternatives as solutions. n is the maximum number of alternatives of solution.

Depending on the strategies to activate in *Enterprise i*, $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$ (corresponding to the alternative of solution n), the kpi_j will be decreased or increased ($\Delta kpi_j^{CS1\_i\_n}$). In the same way, depending on the strategies activated in *Enterprise j* ($u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$) the kpi_i will be decreased or increased ($\Delta kpi_i^{CS1\_j\_n}$). Therefore:

- *Enterprise i*: $kpi_i^{CS1\_n}\_real = kpi_i^{CS1\_n} + \Delta kpi_i^{CS1\_j\_n}$
- *Enterprise j*: the $kpi_j^{CS1\_n}\_real = kpi_j^{CS1\_n} + \Delta kpi_j^{CS1\_i\_n}$

The KPI at network level is computed from the sum of the KPIs obtained at the enterprise level, $kpi_{net}^{CS1\_n} = kpi_i^{CS1\_n}\_real + kpi_j^{CS1\_n}\_real$.

STEP 5. Selection of the Criteria Choice (CCx^i). Relate the output of the SAM with the goals defined by each enterprise. In this phase the negotiation rules are defined.

The selection of the Criteria Choice refers to the decision on the acceptability of an alternative of solution. The most interesting principles of selection are:

- Optimisation. An optimal alternative is one that may prove to be the greatest of all possible alternatives.
  - Alternative with the highest level of objectives achievement
  - Alternative with the lower cost that allows achieving the level of objectives required
  - Alternative with the highest ratio of achieving the objectives against the cost, maximising the efficiency
- Suboptimisation. Considering the impact on the global system, kpi_{net}. The solution that is optimal from the point of view of the network, may be suboptimal from the point of view of each network enterprise. The alternative of optimal solution, at the network level, could imply the reduction of the business performance at enterprise level (kpi_i). It can also occur on the contrary, that an optimal solution from the point of view of the enterprise (kpi_i) may be suboptimal at the network level global (kpi_{net}) and for other network partners (kpi_j). Whenever a solution is proposed, potential effects should be analyzed at both levels the enterprise and the network. When selecting a suboptimal solution, if no significant adverse effects appear, the solution can be considered optimal from the point of view of the system.
- Enough goodness or "Satisfaction". The enterprises decisions involve complacency, assigning a satisfactory solution being this "less than best case". In order to satisfy the aspirations of the decision-maker, she/he defines its goals, and then looks for the alternative of solutions that allow to achieve these goals. The companies analyse the situation of both the non-collaborative scenario (NCS) and the collaborative scenario (CS1, CS2 or CS3) and sets a criterion of choice in order to obtain the solution that fits their goals.

Some examples for the criteria choice definition are proposed next, considering the context of the CS1:

CC1. Minimum increase accepted for the kpi_i at *Enterprise i* level derived from the influence of the strategies activated in other enterprises (i.e. *Enterprise j*) ($\Delta^{min}kpi_i^{CS1\_j}$). Taking into account the difference between the $kpi_i^{CS1\_n}$ and $kpi_i^{CS1\_n}\_real$, *Enterprise i* defines the minimum increase accepted in its kpi_i when *Enterprise j* activates its strategies ($\Delta^{min}kpi_i^{CS1\_j}$). Thus,

$$\alpha = \begin{cases} 1 \leftrightarrow \sum_j \Delta kpi_i^{CS1\_j\_n} \geq \Delta^{min}kpi_i^{CS1_j} \\ 0 \end{cases}$$

CC2. Minimum real value accepted for the KPIs at enterprise level ($min\_kpi_i^{CS1}\_real$). Taking into account the difference between the kpi_i^{NCS} and $kpi_i^{CS1\_n}\_real$, *Enterprise i* defines the minimum value accepted in its kpi_i ($\min\_kpi_i^{CS1}\_real$). Thus,

$$\alpha = \begin{cases} 1 \leftrightarrow kpi_i^{CS1\_n}\_real \geq min\_kpi_i^{CS1}\_real \\ 0 \end{cases}$$

CC3. The KPI at Enterprise level obtained in the CS1, considering the influences of the strategies formulated by other Enterprises of the network, $kpi_i^{CS1\_n}\_real = kpi_i^{CS1\_n} + \Delta kpi_i^{CS1\_j\_n}$ must be higher than the KPI at Enterprise level obtained in the NCS, kpi_i^{NCS}.

$$\alpha = \begin{cases} 1 \leftrightarrow kpi_i^{CS1\_n} + \Delta kpi_i^{CS1\_j\_n} \geq kpi_i^{NCS} \\ 0 \end{cases}$$

An illustrative example of the criteria choice selected and defined in each enterprise, CCx^i, is proposed. The compliance or not of the CCx^i, $\alpha = \{0,1\}$, is determined by considering the data of the illustrative example defined in Table 8.6:

- *Enterprise i:*
  - *CC1^i^*. $\Delta^{min}kpi_i^{CS1\_j} = 1{,}6$; in this case $\alpha = 0$, due to $\Delta kpi_i^{CS1\_j\_n} = 1{,}5$
  - *CC2^i^*. $min\_kpi_i^{CS1}\_real = 5$; in this case $\alpha = 1$, due to $kpi_i^{CS1\_n}\_real = 5{,}8$
  - *CC3^i^*. $kpi_i^{CS1\_n}\_real = kpi_i^{CS1\_n} + \Delta kpi_i^{CS1\_j\_n} = 5{,}8$; in this case $\alpha = 1$, due to $kpi_i^{NCS} = 5$
- *Enterprise j:*
  - *CC1^j^*. $\Delta^{min}kpi_j^{CS1\_i} = 1{,}5$; in this case $\beta = 1$, due to $\Delta kpi_j^{CS1\_i\_n} = 1{,}5$
  - *CC2^j^*. $min\_kpi_j^{CS1}\_real = 12$; in this case $\beta = 0$, due to $kpi_j^{CS1\_n}\_real = 11{,}5$
  - *CC3^j^*. $kpi_j^{CS1\_n}\_real = kpi_j^{CS1\_n} + \Delta kpi_j^{CS1\_i\_n} = 11{,}5$; in this case $\beta = 0$, due to $kpi_j^{NCS} = 12$

Table 8.6. CS1: Alternative of solution n

	Enterprise i			*Enterprise j*		
	kpi_i		str_{is}	kpi_j		str_{js}
Minimum values defined for the CC	$\Delta^{min}kpi_i^{CS1\_j}$	1,6		$\Delta^{min}kpi_j^{CS1\_i}$	1,5	
	$min\_kpi_i^{CS1}\_real$	5		$min\_kpi_j^{CS1}\_real$	12	
SAM in NCS	kpi_i^{NCS}	5	$u\_str_{is}^{NCS}$ $ti\_str_{is}^{NCS}$	kpi_j^{NCS}	12	$u\_str_{js}^{NCS}$ $ti\_str_{js}^{NCS}$
SAM in CS1	$kpi_i^{CS1\_n}$	4,3	$u\_str_{is}^{CS1\_n}$ $ti\_str_{is}^{CS1\_n}$	$kpi_j^{CS1\_n}$	10	$u\_str_{js}^{CS1\_n}$ $ti\_str_{js}^{CS1\_n}$
	$\Delta kpi_i^{CS1\_j\_n}$	1,5		$\Delta kpi_j^{CS1\_i}\_n$	1,5	
	$kpi_i^{CS1\_n}\_real$	5,8		$kpi_j^{CS1\_n}\_real$	11,5	
	kpi_{net}^{NCS}	17				
	$kpi_{net}^{CS1\_n}$	17,3				

In the example, the main idea to be taken into account is that even sometimes the results are not as the expected ones and the CC is not met (either when $\alpha = 0$ or $\beta = 0$), the $kpi_{net}^{CS1\_n}$ is fulfilled considering that:

$$kpi_{net}^{CS1\_n} \geq kpi_{net}^{NCS}$$

STEP 6. Agreement on the definition of the stopping rule of the Iterative Process. Examples of rules to stop the iterative process are defined hereafter:

- After a certain number of iterations agreed by all the parties, defined by m_max
- When $kpi_{net}^{CS1\_n}$ is higher than the kpi_{net}^{NCS}
- When a certain value of $kpi_{net}^{CS1\_n}$ is achieved
- When $\alpha = 1$ and $\beta = 1$
- Defining a significant difference between the alternatives. Determine if an alternative of solution is significantly higher.
  - When $\Delta kpi_i^{CS1\_j\_n}$ is between an upper and lower bound defined by the enterprises
  - When $kpi_i^{CS1\_n}\_real$ is between an upper and lower bound defined by the enterprises
- Etc.

STEP 7. Select an alternative of solution *n* (a solution of the *SAM^CS1_i^ and SAM^CS1_j^*): the implementation of the SAM in AnyLogic simulation software generate the set of solutions, considering the CS1. *Enterprise i* selects an alternative of solution *n*: $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, and *Enterprise j* selects an alternative of solution *n*: $u\_str_{js}^{CS1\_n}$ and $ti\_str_{js}^{CS1\_n}$. *n* is the number assigned to the alternative selected, this number is assigned consecutively to the selected alternatives *n= [1, 2, ..., n]*. The first alternative to select will normally be that one that gives to each enterprise the optimum value of the KPI at enterprise level, max. $kpi_i^{CS1\_n}$. The first alternative selected will coincide with the first iteration of the negotiation process, therefore $n = m$.

STEP 8. Simulate the SAM^{CS1_i} using the values of the alternative selected (*n*)

After selecting the alternative of solution *n*, each Enterprise simulates the $SAM^{CS1\_i\_n}$:

- *Enterprise i* simulates the $SAM^{CS1\_i\_n}$ using the alternative of solution selected, $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, obtaining $kpi_i^{CS1\_n}$ and $\Delta kpi_j^{CS1\_i\_n}$
- *Enterprise j* simulates the $SAM^{CS1\_j\_n}$ using the alternative of solution selected, $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, obtaining $kpi_j^{CS1\_n}$ and $\Delta kpi_i^{CS1\_j\_n}$

STEP 9. Exchange the values of increase offered by the enterprises: $\Delta kpi_i^{CS1\_j\_n}$. This value is equal to the increase of the kpi_i (defined by the *Enterprise i*) derived from the influences of the strategies activated in *Enterprise j*, considering the results of CS1:

- *Enterprise i* exchanges with *Enterprise j* the value of $\Delta kpi_j^{CS1\_i\_n}$
- *Enterprise j* exchanges with *Enterprise i* the value of $\Delta kpi_i^{CS1\_j\_n}$

In the alternative of solution *n* (which corresponds to the iteration *m*), depending on the strategies to activate in *Enterprise i* ($u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$), the kpi_j will be decreased or increased ($\Delta kpi_j^{CS1\_i\_n}$). The same occurs with *Enterprise j*; thus, depending on the strategies activated in *Enterprise j* ($u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$) the kpi_i will be decreased or increased ($\Delta kpi_i^{CS1\_j\_n}$). Therefore:

- *Enterprise i*: $kpi_i^{CS1\_n}\_real = kpi_i^{CS1\_n} + \Delta kpi_i^{CS1\_j\_n}$
- *Enterprise j*: $kpi_j^{CS1\_n}\_real = kpi_j^{CS1\_n} + \Delta kpi_j^{CS1\_i\_n}$

Step 9.1. If *Enterprise i*: $\alpha = 1$ and *Enterprise j*: $\beta = 1$ →Negotiation Finished

Collaborative Solution in iteration *m*=*n*: $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, $u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$

Step 9.2. If *Enterprise i*: $\alpha = 0$ and *Enterprise j*: $\beta = 0$ → Negotiation Finished
Non Collaborative Solution in iteration *m*=*n*: $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, $u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$

Step 9.3. If *Enterprise i*: $\alpha = 0$ and *Enterprise j*: $\beta = 1$ or
Enterprise i: $\alpha = 1$ and *Enterprise j*: $\beta = 0$ and
The stopping rule of the Iterative Process is not met → Repeat Step 7, 8 and 9

Step 9.4. If *Enterprise i*: $\alpha = 0$ and *Enterprise j*: $\beta = 1$ or
Enterprise i: $\alpha = 1$ and *Enterprise j*: $\beta = 0$ and
The stopping rule of the Iterative Process is met → Negotiation Finished
Non Collaborative Solution in iteration *m*=*n*: $u\_str_{is}^{CS1\_n}$, $ti\_str_{is}^{CS1\_n}$, $u\_str_{js}^{CS1\_n}$, $ti\_str_{js}^{CS1\_n}$

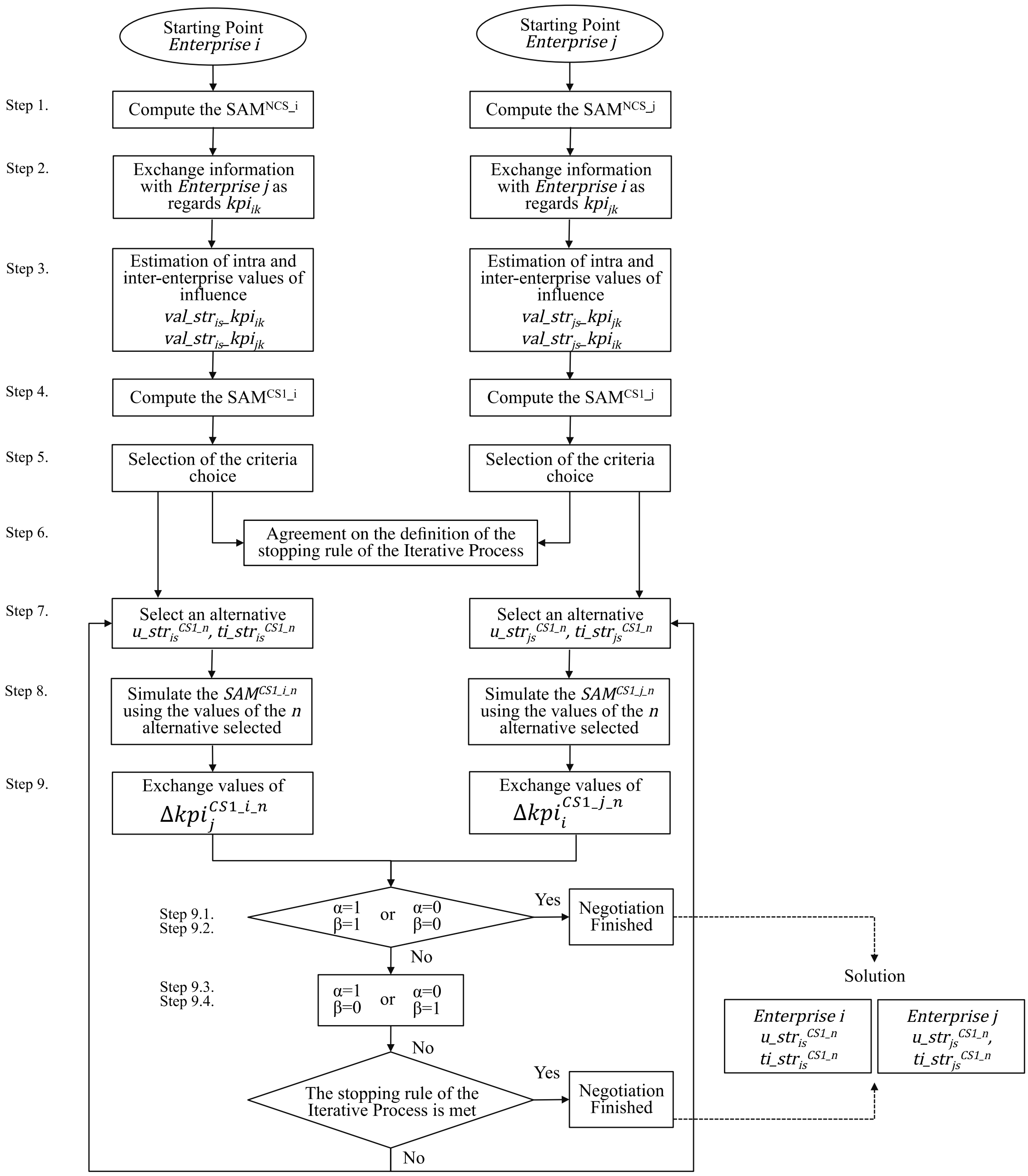


Figure 8.16. Negotiation Process CS1

Negotiation Process CS2 (NP_CS2)

Hereafter, the negotiation process carried out by the enterprises that decide to establish the CS2 (NP_CS2) is described. In Figure 8.17 an scheme of the negotiation process carried out by the enterprises that decide to establish the CS2 (NP_CS2) is shown. The NP_CS2 will allow enterprises to negotiate the solutions (values of the decision variables: u_str_{is} , ti_str_{is}) obtained in the application of the SAM when establishing the CS2. Before describing the steps of negotiation, in Table 8.7 the parameters used in the NP_CS2 are presented. A description of these parameters is also given.

Table 8.7. Parameters used in NP_CS2

Notation	Definition
kpi_{ik}	Key performance indicator defined in *Enterprise i*
$val\_str_{is}\_kpi_{ik}$	Estimated Intra-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{ik} defined by *Enterprise i*
$val\_str_{is}\_kpi_{jk}$	Estimated Inter-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{jk} defined by *Enterprise j*
n	Number assigned to the alternative selected for the solution of SAM considering the results of CS2 (SAM^{CS2_i}), this number is assigned consecutively to the selected alternatives $n=[1, 2, ..., n]$
m	Number assigned to the iteration. This number will coincide with the number assigned to the alternative selected $n=m$
m_max	Maximum number of iterations agreed by the partners to negotiate alternatives of solution
SAM^{NCS_i}	Strategies Alignment Model computed in *Enterprise i* considering the NCS
SAM^{CS2_i}	Strategies Alignment Model computed in *Enterprise i* considering the CS2
$SAM^{CS2\_i\_n}$	Simulation of the Strategies Alignment Model computed in *Enterprise i* considering the CS2 using the values selected in the alternative n: $u\_str_{is}^{CS2\_n}$, $ti\_str_{is}^{CS2\_n}$, $u\_str_{js}^{CS2\_n}$, $ti\_str_{js}^{CS2\_n}$
kpi_{net}^{NCS}	Value of the Key performance indicator at network level kpi_{net} considering the results of NCS
kpi_{i}^{NCS}	Value of the kpi_i (defined at the enterprise level) computing the influences of the strategies activated in *Enterprise i*, considering the results of NCS
$u\_str_{is}^{NCS}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) obtained in the NCS
$ti\_str_{is}^{NCS}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) obtained in the NCS
kpi_{net}^{CS2}	Value of the Key performance indicator at network level kpi_{net} considering the results of CS2
kpi_{i}^{CS2}	Value of the kpi_i defined at the enterprise level, considering the results of CS2
$u\_str_{is}^{CS2}$	Set of solutions for the value of the units of strategy str_{is} to be activated (u_str_{is}) in *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2})
$ti\_str_{is}^{CS2}$	Set of solutions for the value of the initial time of activation of strategy str_{is} (ti_str_{is}) formulated in *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2})
$kpi_{i}^{CS2\_i\_n}$	Value of the kpi_i (defined at the enterprise level) computing the influences of the strategies activated in all the network enterprises (*Enterprise i* and *Enterprise j*) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$kpi_{j}^{CS2\_i\_n}$	Value of the kpi_j (defined at the enterprise level) computing the influences of the strategies activated in all the network enterprises (*Enterprise i* and *Enterprise j*) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$u\_str_{is}^{CS2\_i\_n}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) in *Enterprise i* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$ti\_str_{is}^{CS2\_i\_n}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) formulated in *Enterprise i* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$u\_str_{js}^{CS2\_i\_n}$	Value of the units of strategy str_{js} to be activated (u_str_{js}) in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$ti\_str_{js}^{CS2\_i\_n}$	Value of the initial time of activation of strategy str_{js} (ti_str_{js}) formulated in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment

Notation	Definition
	Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$kpi_{net}^{CS2\_i\_n}$	Value of the kpi_{net} (defined at the network level) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (SAM^{CS2_i}), corresponding to the alternative n
$\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}}$	Increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 ($u\_str_{js}^{CS2\_i\_n}$, $ti\_str_{js}^{CS2\_i\_n}$) corresponding to the alternative n
$\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}}$	Increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j* obtained by *Enterprise j* when computing the Strategies Alignment Model considering the CS2 ($u\_str_{js}^{CS2\_j\_n}$, $ti\_str_{js}^{CS2\_j\_n}$) corresponding to the alternative n
CCx^i	Criterion Choice x of *Enterprise i*
$\Delta^{min} kpi_i^{CS2\_j}$	Minimum increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j*, considering the results of CS2, defined by *Enterprise i*
$\alpha^{CS2\_i\_n}$	1 if the negotiation rule defined by *Enterprise i* is fulfilled, considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS2_i} 0 if the negotiation rule defined by *Enterprise i not* is fulfilled considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS2_i}
$\alpha^{CS2\_j\_n}$	1 if the negotiation rule defined by *Enterprise i* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS2_j} 0 if the negotiation rule defined by *Enterprise i not* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS2_j}
$\beta^{CS2\_i\_n}$	1 if the negotiation rule defined by *Enterprise j* is fulfilled, considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS2_i} 0 if the negotiation rule defined by *Enterprise j not* is fulfilled considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS2_i}
$\beta^{CS2\_j\_n}$	1 if the negotiation rule defined by *Enterprise j* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS2_j} 0 if the negotiation rule defined by *Enterprise j not* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS2_j}

Next, the steps required for the NP_CS2 are listed and described:

STEP 1. Calculation of the SAM in the NCS (SAM^{NCS_i}). Application of the SAM considering the NCS. Calculation of the KPIs at enterprise level considering that each enterprise of the network individually applies the SAM in the NCS by only taking into account the information about their own objectives and strategies, and computes:

- The values of the KPI at enterprise level
  - *Enterprise i*: kpi_i^{NCS}
  - *Enterprise j*: kpi_j^{NCS}
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i*: $u\_str_{is}^{NCS}$, $ti\_str_{is}^{NCS}$
  - *Enterprise j*: $u\_str_{js}^{NCS}$, $ti\_str_{js}^{NCS}$

The KPI at network level is computed from the sum of the KPIs obtained at the enterprise level, $kpi_{net}^{NCS} = kpi_i^{NCS} + kpi_j^{NCS}$.

STEP 2. Exchange the information as regards the parameters to feed the model.

As regards the KPIs:

- *Enterprise i*: exchanges information as regards its defined KPIs with the *Enterprise j* → kpi_{ik}, w_{ik}, $Threshold\_kpi_{ik}$, kpi_{ik}_min
- *Enterprise j*: exchanges information as regards its defined KPIs with the *Enterprise i* → kpi_{jk}, w_{jk}, $Threshold\_kpi_{jk}$, kpi_{jk}_min

The strategies itself are not exchanged but the number of strategies formulated by each enterprise and the parameters that characterise this strategies are exchanged, allowing each enterprise to compute the SAM^{CS2}

- *Enterprise i*: exchanges information with the *Enterprise j* as regards (i) the number of strategies formulated by codifying them (Strategy ID), for example u_str_{i1}, u_str_{i2}, … , u_str_{is}, and (ii) the parameters associated c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$
- *Enterprise j*: exchanges information with the *Enterprise i* as regards (i) the number of strategies formulated by codifying them (Strategy ID), for example u_str_{j1}, u_str_{j2}, … , u_str_{js}, and (ii) the parameters associated c_str_{js}, $d_1\_str_{js}$, $d_2\_str_{js}$, $d_4\_str_{js}$

Information as regards the budget is also exchanged

- *Enterprise i*: exchanges information of the b_i with the *Enterprise j*
- *Enterprise j*: exchanges information of the b_j with the *Enterprise i*

The parameters related to the cost and budget will be relative/proportional one another. The budget and other costs will be associated to a real value, but it will not necessary be the real monetary value itself. This allows enterprises to maintain their confidentiality as regards the values of costs and budget.

STEP 3. Estimation of values of influence ($val\_str_{is}\_kpi_{ik}$).

- *Enterprise i* estimates:
  - *Intra*-enterprise values of influence: $val\_str_{is}\_kpi_{ik}$
  - *Inter-enterprise* values of influence: $val\_str_{is}\_kpi_{jk}$
- *Enterprise j* estimates:
  - *Intra*-enterprise values of influence: $val\_str_{js}\_kpi_{jk}$
  - *Inter-enterprise* values of influence: $val\_str_{js}\_kpi_{ik}$

STEP 4. Exchange the information as regards the values of influence ($val\_str_{is}\_kpi_{ik}$).

- *Enterprise i*: exchanges information as regards the values of influence estimated with the *Enterprise j* → $val\_str_{is}\_kpi_{ik}$, $val\_str_{is}\_kpi_{jk}$
- *Enterprise j*: exchanges information as regards the values of influence estimated with the *Enterprise i* → $val\_str_{js}\_kpi_{jk}$, $val\_str_{js}\_kpi_{ik}$

STEP 5. Calculation of the SAM in the CS2 (SAM^{CS2_i}). Application of the SAM considering the CS2. Each enterprise calculates its own SAM^{CS2_i} using the information estimated. As all the enterprises have the same input values, the set of results obtained will be also the same in each enterprise ($u\_str_{is}^{CS2}$, $ti\_str_{is}^{CS2}$, $u\_str_{js}^{CS2}$, $ti\_str_{js}^{CS2}$). Calculation of the KPIs at enterprise and network level considering the solution of the SAM^{CS2}. Obtaining,

- The value of the KPI at network level
  - *Enterprise i* and *Enterprise j*: kpi_{net}^{CS2}
- The values of the KPIs at enterprise level
  - *Enterprise i* and *Enterprise j*: kpi_i^{CS2} and kpi_j^{CS2}
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i* and *Enterprise j*: $u\_str_{is}^{CS2}$, $ti\_str_{is}^{CS2}$, $u\_str_{js}^{CS2}$, $ti\_str_{js}^{CS2}$

The resolution of the Strategies Alignment Model in each of the enterprises, SAM^{CS2_i} and SAM^{CS2_j}, provides a set of solutions. One or more solutions will be optimal, while others are close to the optimal (considering them suboptimal solutions). Each solution provided by SAM^{CS2} will be considered as an alternative, there will be as much alternatives as solutions. n is the maximum number of solution alternatives. The alternative of solutions are obtained, from the computation of SAM^{CS2} in each enterprise, are:

- The value of the KPI at network level:
  - *Enterprise i:* $kpi_{net}^{CS2\_i\_n}$
  - *Enterprise j:* $kpi_{net}^{CS2\_j\_n}$
- The values of the KPIs at enterprise level
  - *Enterprise i:* $kpi_i^{CS2\_i\_n}$ and $kpi_j^{CS2\_i\_n}$
  - *Enterprise j*: $kpi_i^{CS2\_j\_n}$ and $kpi_j^{CS2\_j\_n}$
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i:* $u\_str_{is}^{CS2\_i\_n}$, $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$, $ti\_str_{js}^{CS2\_i\_n}$
  - *Enterprise j*: $u\_str_{is}^{CS2\_j\_n}$, $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$, $ti\_str_{js}^{CS2\_j\_n}$

STEP 6. Selection of the Criteria Choice (*CCx^i*). Relate the output of the SAM with the objectives. Definition of the negotiation the rules.

CC1. Minimum increase accepted for the KPI at Enterprise level (kpi_i) derived from the influence of the strategies activated in other enterprises ($\Delta^{min} kpi_i^{CS2\_j}$). Thus,

$$\alpha^{CS2\_i\_n} = \begin{cases} 1 \leftrightarrow \sum_j \Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}} \geq \Delta^{min} kpi_i^{CS2\_j} \\ 0 \end{cases}$$

$$\alpha^{CS2\_j\_n} = \begin{cases} 1 \leftrightarrow \sum_j \Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}} \geq \Delta^{min} kpi_i^{CS2\_j} \\ 0 \end{cases}$$

CC2.The value of the KPI at enterprise level defined by *Enterprise i*, $kpi_i^{CS2\_i\_n}$ and obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS2 (*SAM^{CS2_i}*) corresponding to the alternative *n* must be higher than the value of the KPI at enterprise level defined by *Enterprise i*, $kpi_i^{CS2\_j\_n}$ and obtained by *Enterprise j* corresponding to the alternative *n*. Thus,

$$\alpha^{CS2\_j\_n} = \begin{cases} 1 \leftrightarrow kpi_i^{CS2\_i\_n} \geq kpi_i^{CS2\_j\_n} \\ 0 \end{cases}$$

CC3. The KPI at network level obtained in the alternative *n* proposed by *Enterprise i* must by higher than the value of the KPI at network level obtained in the alternative *n* proposed by *Enterprise j.*

$$\alpha^{CS2\_j\_n} = \begin{cases} 1 \leftrightarrow kpi_{net}^{CS2\_i\_n} \geq kpi_{net}^{CS2\_j\_n} \\ 0 \end{cases}$$

An example of the criteria choice selected and defined in each enterprise, *CCx^i*, is proposed. The compliance or not of the *CCx^i*, $\alpha = \{0,1\}$, is determined by considering the data of the illustrative example defined in Table 8.8:

- *Enterprise i:*
  - *$CC1^i$*. $\Delta^{min} kpi_i^{CS2\_j}$ *= 1,6*; in this case
    - $\alpha^{CS2\_i\_n} = 1$, due to $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}} = 2$, normally *Enterprise i* will select an alternative that increases its KPIs (defined at enterprise level) the minimum required. Therefore, enterprises will focus on $\alpha^{CS2\_j\_n}$
    - $\alpha^{CS2\_j\_n} = 0$, due to $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}} = -1$
  - *$CC2^i$*. $kpi_i^{CS2\_i\_n}$ *=6;* in this case $\alpha^{CS2\_j\_n} = 0$, due to $kpi_i^{CS2\_j\_n} = 4$

  - $CC3^i$. $kpi_{net}^{CS2\_i\_n} = 19{,}5$; in this case $\alpha^{CS2\_j\_n} = 1$, due to $kpi_{net}^{CS2\_j\_n} = 19$
- *Enterprise j:*
  - $CC1^j$.$\Delta^{min} kpi_j^{CS2\_i}$ =*1,5*; in this case
    - $\beta^{CS2\_i\_n} = 1$, due to $\Delta kpi_j^{CS2\_i\_n\_SAM^{CS2\_i}} = 1{,}5$
    - $\beta^{CS2\_j\_n} = 1$, due to $\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_j}} = 3$, normally *Enterprise j* will select an alternative that increases its KPIs (defined at enterprise level) the minimum required. Therefore, enterprises will focus on $\beta^{CS2\_i\_n}$
  - $CC2^j$. $kpi_j^{CS2\_j\_n}$ =*15;* in this case $\beta^{CS2\_i\_n} = 0$, due to $kpi_j^{CS2\_i\_n} = 13{,}5$
  - $CC3^j$. $kpi_{net}^{CS2\_j\_n} = 19$; in this case $\beta^{CS2\_i\_n} = 0$, due to $kpi_{net}^{CS2\_i\_n} = 19{,}5$

Table 8.8. CS2: Alternative of solution n

	Enterprise i			*Enterprise j*		
	kpi_i		str_{is}	kpi_j		str_{js}
Minimum values defined for the CC	$\Delta^{min} kpi_i^{CS2\_j}$	1,6		$\Delta^{min} kpi_j^{CS2\_i}$	1,5	
SAM in NCS	kpi_i^{NCS}	5	$u\_str_{is}^{NCS\_n}$ $ti\_str_{is}^{NCS\_n}$	kpi_j^{NCS}	12	$u\_str_{js}^{NCS\_n}$ $ti\_str_{js}^{NCS\_n}$
SAM in CS1	$\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}}$	2	$u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$ $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$	$\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}}$	-1	$u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$ $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$
	$\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_i}}$	1,5		$\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_j}}$	3	
	$kpi_i^{CS2\_i\_n}$	6		$kpi_i^{CS2\_j\_n}$	4	
	$kpi_j^{CS2\_i\_n}$	13,5		$kpi_j^{CS2\_j\_n}$	15	
	kpi_{net}^{NCS}	17		kpi_{net}^{NCS}	17	
	$kpi_{net}^{CS2\_i\_n}$	19,5		$kpi_{net}^{CS2\_j\_n}$	19	

In the example, the main idea to be taken into account is that even sometimes the results are not as the expected ones and the CC is not met (either when $\alpha^{CS2\_j\_n} = 0$ or $\beta^{CS2\_i\_n} = 0$), the $kpi_{net}^{CS2\_n}$ is fulfilled considering that:

$$kpi_{net}^{CS2\_n} \geq kpi_{net}^{NCS}$$

STEP 7. Agreement on the definition of the stopping rule of the Iterative Process. Examples of rules to stop the iterative process are defined hereafter:

- After a certain number of iterations agreed by all the parties, defined by m_max
- When $kpi_{net}^{CS2\_n}$ is higher than the kpi_{net}^{NCS}
- When a certain value of $kpi_{net}^{CS2\_n}$ is achieved
- When $\alpha^{CS2\_i\_n} = 1$ and $\beta^{CS2\_i\_n} = 1$ the selected alternative will be the one proposed by *Enterprise i*
- When $\alpha^{CS2\_j\_n} = 1$ and $\beta^{CS2\_j\_n} = 1$ the selected alternative will be the one proposed by *Enterprise j*
- Defining a significant difference between the alternatives. Determine if an alternative of solution is significantly higher.
  - When $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}}$ is between an upper and lower bound defined by the enterprises
- The 90% of enterprises decide that $\alpha^{CS2\_j\_n} = 1$ or $\beta^{CS2\_i\_n} = 1$
- *Etc.*

STEP 8. Select an alternative of solution n (a solution of the SAM^{CS2_i} *and* SAM^{CS2_j}): From the solution generated with the results of the SAM in the CS2: (i) *Enterprise i* selects an alternative: $u\_str_{is}^{CS2\_i\_n}$

$ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$, and (ii) *Enterprise j* selects an alternative: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$. n is the number assigned to the alternative selected, this number is assigned consecutively to the selected alternatives $n= [1, 2, ..., n]$. The first alternative to select will normally be that one that provides the optimum value of the KPI at network level, max. $kpi_{net}^{CS2\_n}$. The first alternative selected will coincide with the first iteration of the negotiation process, therefore $n = m$.

STEP 9. Simulate the SAM^{CS2} using the values of the alternative selected (n)

After selecting an alternative of solution n, each Enterprise simulates the simulates the SAM^{CS2}:

- *Enterprise i* simulates the $SAM^{CS2\_i\_n}$
  - Considering the values of the decision variables corresponding to the alternative n: $u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$
  - Obtaining the values: $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}}$, $\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_i}}$, $kpi_i^{CS2\_i\_n}$, $kpi_j^{CS2\_i\_n}$, $kpi_{net}^{CS2\_i\_n}$
- *Enterprise j* simulates the $SAM^{CS2\_j\_n}$
  - Considering the values of the decision variables corresponding to the alternative n: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$
  - Obtaining the values: $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}}$, $\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_j}}$, $kpi_i^{CS2\_j\_n}$, $kpi_j^{CS2\_j\_n}$, $kpi_{net}^{CS2\_j\_n}$

STEP 10. Exchange the values of the decision variables of the alternatives selected:

- *Enterprise i* exchanges with *Enterprise j* the values of the decision variables corresponding to the alternative n selected: $u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$
- *Enterprise j* exchanges with *Enterprise i* the values of the decision variables corresponding to the alternative n selected: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$

STEP 11. Simulate the SAM^{CS2} using the values of the decision variables selected in other enterprises of the network

Each Enterprise simulates the SAM^{CS2} considering the values of the decision variables exchanged in STEP 10.

- *Enterprise i* simulates the SAM^{CS}
  - Considering the values of the decision variables corresponding to the alternative n selected by *Enterprise j*: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$
  - Obtaining the values: $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_j}}$, $\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_j}}$, $kpi_i^{CS2\_j\_n}$, $kpi_j^{CS2\_j\_n}$, $kpi_{net}^{CS2\_j\_n}$
- *Enterprise j* simulates the SAM^{CS2}
  - Considering the values of the decision variables corresponding to the alternative n selected by *Enterprise i*: $u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$
  - Obtaining the values: $\Delta kpi_i^{CS2\_j\_n\_SAM^{CS2\_i}}$, $\Delta kpi_j^{CS2\_j\_n\_SAM^{CS2\_i}}$, $kpi_i^{CS2\_i\_n}$, $kpi_j^{CS2\_i\_n}$, $kpi_{net}^{CS2\_i\_n}$

In the alternative of solution n (which corresponds to the iteration m), depending on alternative selected by each enterprise, the values corresponding to the KPIs at Enterprise level kpi_i^{CS2}, kpi_j^{CS2} and the KPIs corresponding to the network level kpi_{net}^{CS2} will be decreased or increased.

STEP 12. Analysis of Alternative of solution n selected by $Enterprise\ i$ and $Enterprise\ j$

Step 12.1. Analysis of the Alternative of solution n selected by $Enterprise\ i$
If $Enterprise\ i$: $\alpha^{CS2\_i\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 1$ and
If $Enterprise\ i$ and $Enterprise\ j$ do not want to continue analysing the Alternative of solution n selected by $Enterprise\ j$ →Negotiation Finished
Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by $Enterprise\ i$: $u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$

Step 12.2. If $Enterprise\ i$: $\alpha^{CS2\_i\_n} = 0$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 0$ or
$Enterprise\ i$: $\alpha^{CS2\_i\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 0$ or
$Enterprise\ i$: $\alpha^{CS2\_i\_n} = 0$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 1$
$Enterprise\ i$ and $Enterprise\ j$ continue analysing the Alternative of solution n selected by $Enterprise\ j$

Step 12.3. In the analysis of the Alternative of solution n selected by $Enterprise\ j$
If $Enterprise\ i$: $\alpha^{CS2\_j\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_j\_n} = 1$ and
In the analysis of the Alternative of solution n selected by $Enterprise\ i$
If $Enterprise\ i$: $\alpha^{CS2\_i\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 1$ and → Identify which alternative, the selected by the $Enterprise\ i$ or the selected by $Enterprise\ j$, provides higher network performance ($kpi_{net}^{CS2\_i\_n} \geq kpi_{net}^{CS2\_j\_n}$)
If $kpi_{net}^{CS2\_i\_n} \geq kpi_{net}^{CS2\_j\_n}$ Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by $Enterprise\ i$: $u\_str_{is}^{CS2\_i\_n}$ $ti\_str_{is}^{CS2\_i\_n}$, $u\_str_{js}^{CS2\_i\_n}$ $ti\_str_{js}^{CS2\_i\_n}$
If $kpi_{net}^{CS2\_i\_n} \leq kpi_{net}^{CS2\_j\_n}$ Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by $Enterprise\ j$: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$

Analysis of the Alternative of solution n selected by $Enterprise\ j$
If $Enterprise\ i$: $\alpha^{CS2\_j\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_i\_n} = 1$
Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by $Enterprise\ j$: $u\_str_{is}^{CS2\_j\_n}$ $ti\_str_{is}^{CS2\_j\_n}$, $u\_str_{js}^{CS2\_j\_n}$ $ti\_str_{js}^{CS2\_j\_n}$

Step 12.4. If $Enterprise\ i$: $\alpha^{CS2\_j\_n} = 0$ and $Enterprise\ j$: $\beta^{CS2\_j\_n} = 0$ or
$Enterprise\ i$: $\alpha^{CS2\_j\_n} = 1$ and $Enterprise\ j$: $\beta^{CS2\_j\_n} = 0$ or
$Enterprise\ i$: $\alpha^{CS2\_j\_n} = 0$ and $Enterprise\ j$: $\beta^{CS2\_j\_\_n} = 1$
The stopping rule of the Iterative Process is not met → Repeat from STEP 8 to STEP 12
The stopping rule of the Iterative Process is not met → Negotiation Finished and Non Collaborative Solution achieved

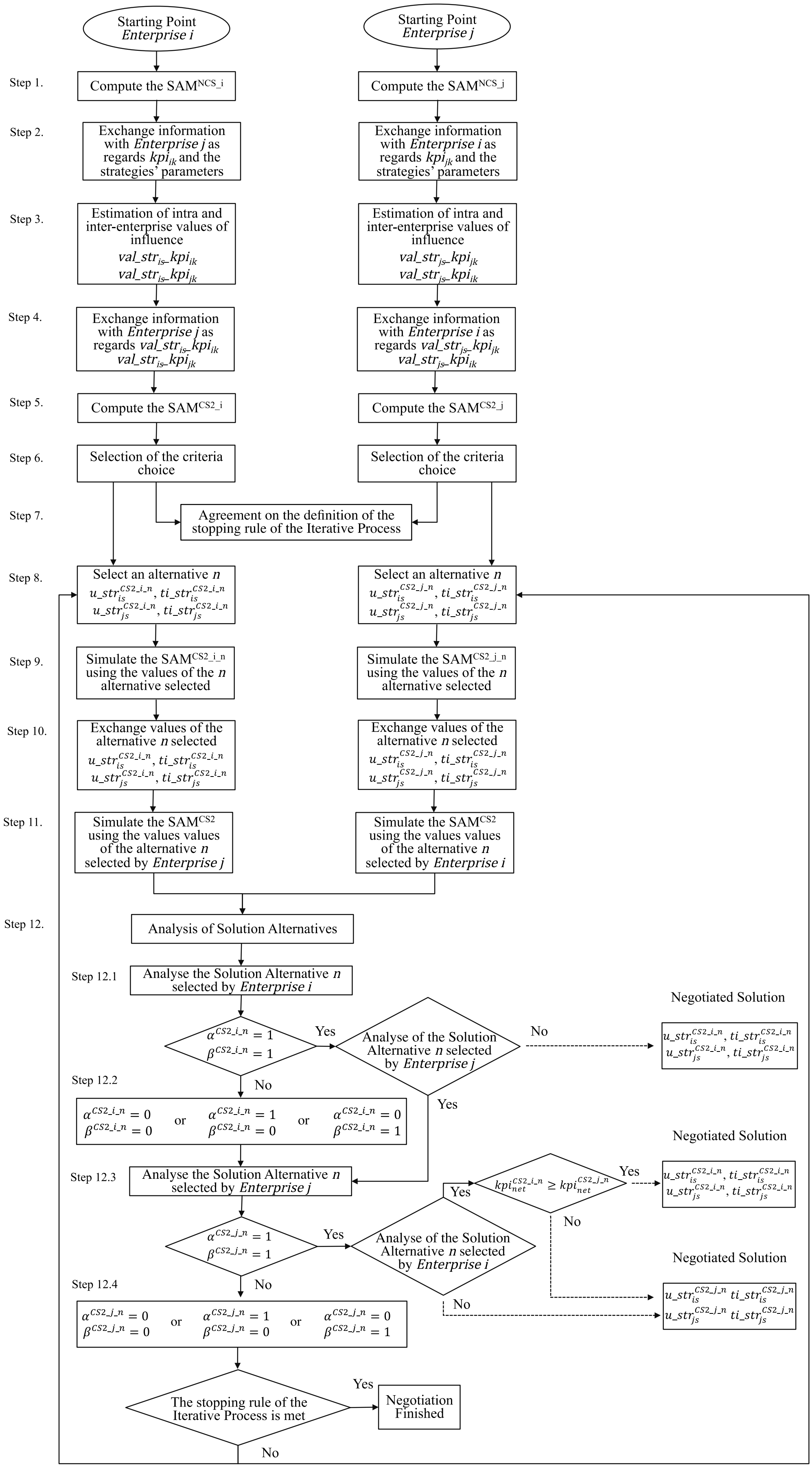


Figure 8.17. Negotiation Process CS2

Negotiation Process CS3 (NP_CS3)

Hereafter, the negotiation process carried out by the enterprises that decide to establish the CS3 (NP_CS3) is described. In Figure 8.18 an scheme of the negotiation process carried out by the enterprises that decide to establish the CS2 (NP_CS2) is shown. The NP_CS3 supports enterprises on the negotiation process to:

- Jointly estimate the values of influence. This is possible due to the enterprises exchange information as regards the strategies formulated, referring not only to the parameters associated but also to the description of the formulated strategies.
- Negotiate the solutions (values of the decision variables: u_str_{is} , ti_str_{is}) obtained in the resolution of the SAM when establishing the CS3.

Before describing the steps of negotiation, the parameters used in the NP_CS3 are presented Table 8.9. A description of these parameters is also given.

Table 8.9. Parameters used in NP_CS3

Notation	Definition
kpi_{ik}	Key performance indicator defined in *Enterprise i*
$val\_str_{is}\_kpi_{ik}$	Estimated Intra-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{ik} defined by *Enterprise i*
$val\_str_{is}\_kpi_{jk}$	Estimated Inter-enterprise value of influence that the strategy str_{is} formulated by *Enterprise i* has on kpi_{jk} defined by *Enterprise j*
q	Maximum number of iterations, agreed by the enterprises, carried out in the negotiation as regards the values estimated for the inter-enterprise values of influence ($val\_str_{is}\_kpi_{jk}$)
$val\_str_{is}\_kpi_{jk}{}^{CS3\_i\_q}$	Value of influence estimated by *Enterprise i* considering how its own strategy formulated str_{is} influences the kpi_{jk} defined by the *Enterprise j*, corresponding to the iteration q. The negotiation scenario considered is the CS3
$val\_str_{is}\_kpi_{jk}{}^{CS3\_j\_q}$	Value of influence estimated by *Enterprise j* considering how the strategy formulated by *Enterprise i* str_{is} influences the kpi_{jk} defined in its own *Enterprise j*, corresponding to the iteration q. The negotiation scenario considered is the CS3
n	Number assigned to the alternative selected for the solution of SAM considering the results of CS3 (SAM^{CS3_i}), this number is assigned consecutively to the selected alternatives $n= [1, 2, \ldots, n]$
m	Number assigned to the iteration process carried out in the negotiation of solutions. This number will coincide with the number assigned to the alternative selected $n=m$
m_max	Maximum number of iterations agreed by the partners to negotiate alternatives of solution
SAM^{NCS_i}	Strategies Alignment Model computed in *Enterprise i* considering the NCS
SAM^{CS3_i}	Strategies Alignment Model computed in *Enterprise i* considering the CS3
$SAM^{CS3\_i\_n}$	Simulation of the Strategies Alignment Model computed in *Enterprise i* considering the CS3 using the values selected in the alternative n: $u\_str_{is}^{CS3\_n}$, $ti\_str_{is}^{CS3\_n}$, $u\_str_{js}^{CS3\_n}$, $ti\_str_{js}^{CS3\_n}$
kpi_{net}^{NCS}	Value of the Key performance indicator at network level kpi_{net} considering the results of NCS
kpi_i^{NCS}	Value of the kpi_i (defined at the enterprise level) computing the influences of the strategies activated in *Enterprise i*, considering the results of NCS
$u\_str_{is}^{NCS}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) obtained in the NCS
$ti\_str_{is}^{NCS}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) obtained in the NCS
$kpi_i^{CS3\_i\_n}$	Value of the kpi_i (defined at the enterprise level) computing the influences of the strategies activated in all the network enterprises (*Enterprise i* and *Enterprise j*) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$kpi_j^{CS3\_i\_n}$	Value of the kpi_j (defined at the enterprise level) computing the influences of the strategies activated in all the network enterprises (*Enterprise i* and *Enterprise j*) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$u\_str_{is}^{CS3}$	Set of solutions for the value of the units of strategy str_{is} to be activated (u_str_{is}) in *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i})
$ti\_str_{is}^{CS3}$	Set of solutions for the value of the initial time of activation of strategy str_{is} (ti_str_{is}) formulated in *Enterprise i* when computing the Strategies Alignment Model

Notation	Definition
	considering the CS3 (SAM^{CS3_i})
$u\_str_{is}^{CS3\_i\_n}$	Value of the units of strategy str_{is} to be activated (u_str_{is}) in *Enterprise i* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$ti\_str_{is}^{CS3\_i\_n}$	Value of the initial time of activation of strategy str_{is} (ti_str_{is}) formulated in *Enterprise i* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$u\_str_{js}^{CS3\_i\_n}$	Value of the units of strategy str_{js} to be activated (u_str_{js}) in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$ti\_str_{js}^{CS3\_i\_n}$	Value of the initial time of activation of strategy str_{js} (ti_str_{js}) formulated in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$kpi_{net}^{CS3\_i\_n}$	Value of the kpi_{net} (defined at the network level) obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}), corresponding to the alternative n
$\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_i}}$	Increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j* obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 ($u\_str_{js}^{CS3\_i\_n}$, $ti\_str_{js}^{CS3\_i\_n}$) corresponding to the alternative n
$\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_j}}$	Increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j* obtained by *Enterprise j* when computing the Strategies Alignment Model considering the CS3 ($u\_str_{js}^{CS3\_j\_n}$, $ti\_str_{js}^{CS3\_j\_n}$) corresponding to the alternative n
CCx^i	Criterion Choice x of *Enterprise i*
$\Delta^{min} kpi_i^{CS3\_j}$	Minimum increase of the kpi_i derived from the influences of the strategies activated in *Enterprise j*, considering the results of CS3, defined by *Enterprise i*
$\alpha^{CS3\_i\_n}$	1 if the negotiation rule defined by *Enterprise i* is fulfilled, considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS3_i} 0 if the negotiation rule defined by *Enterprise i not* is fulfilled considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS3_i}
$\alpha^{CS3\_j\_n}$	1 if the negotiation rule defined by *Enterprise i* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS3_j} 0 if the negotiation rule defined by *Enterprise i not* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS3_j}
$\beta^{CS3\_i\_n}$	1 if the negotiation rule defined by *Enterprise j* is fulfilled, considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS3_i} 0 if the negotiation rule defined by *Enterprise j not* is fulfilled considering results of the alternative n selected by *Enterprise i* obtained in application of the SAM^{CS3_i}
$\beta^{CS3\_j\_n}$	1 if the negotiation rule defined by *Enterprise j* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS3_j} 0 if the negotiation rule defined by *Enterprise j not* is fulfilled considering results of the alternative n selected by *Enterprise j* obtained in application of the SAM^{CS3_j}

Next, the steps required for the NP_CS3 are listed and described:

STEP 1. Calculation of the SAM in the NCS (SAM^{NCS_i}). Application of the SAM considering the NCS. Calculation of the KPIs at enterprise level considering that each enterprise of the network individually applies the SAM in the NCS by only taking into account the information about their own objectives and strategies, and computes:

- The values of the KPI at enterprise level
    - *Enterprise i*: kpi_i^{NCS}
    - *Enterprise j*: kpi_j^{NCS}
- The solution as regards the strategies to be activated and the time of activation
    - *Enterprise i*: $u\_str_{is}^{NCS}$, $ti\_str_{is}^{NCS}$
    - *Enterprise j*: $u\_str_{js}^{NCS}$, $ti\_str_{js}^{NCS}$

The KPI at network level is computed from the sum of the KPIs obtained at the enterprise level, kpi_{net}^{NCS}=

$kpi_i^{NCS} + kpi_j^{NCS}$.

STEP 2. Exchange the information as regards the parameters to feed the model.

As regards the KPIs, all the measures defined by the performance indicators are also exchanged and explained (kpi_{ik}):

- *Enterprise i*: exchanges information as regards its defined KPIs with the *Enterprise j* → kpi_{ik}, w_{ik}, $Threshold\_kpi_{ik}$, kpi_{ik}_min.
- *Enterprise j*: exchanges information as regards its defined KPIs with the *Enterprise i* → kpi_{jk}, w_{jk}, $Threshold\_kpi_{jk}$, kpi_{jk}_min.

The codification of the strategies formulated and its definition is the information to be exchanged in CS3. Each enterprise provides a simplified definition, for each strategy, of what a unit strategy means and implies (u_str_{is}). The parameters that characterise these strategies are exchanged, allowing each enterprise to compute the SAM^{CS3}

- *Enterprise i*: exchanges information with the *Enterprise j* as regards (i) the code of each strategy formulated (u_str_{i1}, u_str_{i2}, … , u_str_{is}) and the definition associated to each strategy, and (ii) the parameters associated c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$.
- *Enterprise j*: exchanges information with the *Enterprise i* as regards (i) e code of each strategy formulated (u_str_{j1}, u_str_{j2}, … , u_str_{js}) and the definition associated to each strategy, and (ii) the parameters associated c_str_{js}, $d_1\_str_{js}$, $d_2\_str_{js}$, $d_4\_str_{js}$.

Information as regards the budget is also exchanged

- *Enterprise i*: exchanges information of the b_i with the *Enterprise j*
- *Enterprise j*: exchanges information of the b_j with the *Enterprise i*

All the values will be exchanged given a scale and the cost and budget will be relative/proportional one another. The budget and other costs will be associated to real values, but it will not be the real monetary value itself. This allows enterprises to maintain their confidentiality as regards the values of costs and budget.

STEP 2 could require as many meetings as necessary to share the information.

STEP 3. Estimation of intra-enterprise values of influence ($val\_str_{is}\_kpi_{ik}$).

- *Enterprise i*:
  - *Intra*-enterprise values of influence: $val\_str_{is}\_kpi_{ik}$
- *Enterprise j*:
  - *Intra*-enterprise values of influence: $val\_str_{js}\_kpi_{jk}$

STEP 4. Negotiation as regards the values estimated for the inter-enterprise values of influence ($val\_str_{is}\_kpi_{jk}$).

In this negotiation process we consider that the enterprises are willing to arrive to an agreement as regards the estimation of inter-enterprise values of influence. The enterprises will agree with the number of iterations carried out to estimate the inter-enterprise values of influence $val\_str_{is}\_kpi_{jk}$, determined by the parameter q. In case the value $val\_str_{is}\_kpi_{jk}$ is not agreed, this value will be finally estimated by the enterprise that defines the strategy. In case of $val\_str_{is}\_kpi_{jk}$ *Enterprise i* will estimate the value if no agreement is reached. In case of $val\_str_{js}\_kpi_{ik}$ *Enterprise j* will estimate the value if no agreement is reached. The negotiation process, as regards the values estimated for the inter-enterprise values of influence, will be repeated as many times as number of parameters $val\_str_{is}\_kpi_{jk}$ exist.

Step 4.1 *Enterprise i* estimates how its own strategy formulated str_{is} influences the kpi_{jk} defined by the *Enterprise j*. Proposing a value for $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$, that corresponds to the iteration q.

Step 4.2 *Enterprise j*, taking into account the strategies formulated by *Enterprise i*, analyses the value $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$ proposed by *Enterprise i*.
If *Enterprise j* accepts the value $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$ proposed by *Enterprise i* → Negotiation finished. Jointly estimation of inter-enterprise value of influence $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$
If *Enterprise j* does not accepts the value $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$ proposed by *Enterprise i* → *Enterprise j* estimates a new value for $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$.

Step 4.3 *Enterprise i* analyses the value $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$ proposed by *Enterprise j*, corresponding to the iteration q.
If *Enterprise i* accepts the value $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$ proposed by *Enterprise j* → Negotiation finished. Jointly estimation of inter-enterprise value of influence $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$
If *Enterprise i* does not accepts the value $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$ proposed by *Enterprise j* and the number of iterations does not exceed from maximum number of iterations agreed, defined by the parameter q→ Repeat from the Step 4.1.
If *Enterprise i* does not accepts the value $val\_str_{is}\_kpi_{jk}^{CS3\_j\_q}$ proposed by *Enterprise j* and the number of iterations exceed from maximum number of iterations agreed, defined by the parameter q→ Negotiation Finished. Estimation of inter-enterprise value of influence proposed by *Enterprise i*, which defines the strategy str_{is}: $val\_str_{is}\_kpi_{jk}^{CS3\_i\_q}$

STEP 5. Calculation of the SAM in the CS3 (SAM^{CS3_i}). Application of the SAM considering the CS3. Each enterprise calculates its own SAM^{CS3_i} using the information agreed (as regards the values of inter-influence, $val\_str_{is}\_kpi_{jk}$, $val\_str_{js}\_kpi_{ik}$) and exchanged (the values of intra-enterprise influence and the parameters associated with the KPIs and the strategies). As all the enterprises have the same input values, the set of results obtained will be also the same in each enterprise ($u\_str_{is}^{CS3}$, $ti\_str_{is}^{CS3}$, $u\_str_{js}^{CS3}$, $ti\_str_{js}^{CS3}$). Calculation of the KPIs at enterprise and network level considering the solution of the SAM^{CS3}. Obtaining,

- The value of the KPI at network level
  - *Enterprise i* and *Enterprise j*: kpi_{net}^{CS3}
- The values of the KPIs at enterprise level
  - *Enterprise i* and *Enterprise j*: kpi_i^{CS3} and kpi_j^{CS3}
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i* and *Enterprise j*: $u\_str_{is}^{CS3}$, $ti\_str_{is}^{CS3}$, $u\_str_{js}^{CS3}$, $ti\_str_{js}^{CS3}$

The resolution of the Strategies Alignment Model in each of the enterprises, SAM^{CS3_i} and SAM^{CS3_j}, provides a set of solutions. One or more solutions will be optimal, while others are close to the optimal (considering them suboptimal solutions). Each solution provided by SAM^{CS3} will be considered as an alternative, there will be as much alternatives as solutions. n is the maximum number of solution alternatives. The alternative of solutions are obtained, from the computation of SAM^{CS3} in each enterprise, are:

- The value of the KPI at network level:
  - *Enterprise i*: $kpi_{net}^{CS3\_i\_n}$
  - *Enterprise j*: $kpi_{net}^{CS3\_j\_n}$
- The values of the KPIs at enterprise level
  - *Enterprise i*: $kpi_i^{CS3\_i\_n}$ and $kpi_j^{CS3\_i\_n}$
  - *Enterprise j*: $kpi_i^{CS3\_j\_n}$ and $kpi_j^{CS3\_j\_n}$
- The solution as regards the strategies to be activated and the time of activation
  - *Enterprise i*: $u\_str_{is}^{CS3\_i\_n}$, $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$, $ti\_str_{js}^{CS3\_i\_n}$
  - *Enterprise j*: $u\_str_{is}^{CS3\_j\_n}$, $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$, $ti\_str_{js}^{CS3\_j\_n}$

STEP 6. Selection of the Criteria Choice (CCx^i). Relate the output of the SAM with the objectives. Definition of the negotiation the rules.

CC1. Minimum increase accepted for the KPI at Enterprise level (kpi_i) derived from the influence of the strategies activated in other enterprises ($\Delta^{min} kpi_i^{CS3\_j}$). Thus,

$$\alpha^{CS3\_i\_n} = \begin{cases} 1 \leftrightarrow \sum_j \Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_i}} \geq \Delta^{min} kpi_i^{CS3\_j} \\ 0 \end{cases}$$

$$\alpha^{CS3\_j\_n} = \begin{cases} 1 \leftrightarrow \sum_j \Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_j}} \geq \Delta^{min} kpi_i^{CS3\_j} \\ 0 \end{cases}$$

CC2.The value of the KPI at enterprise level defined by *Enterprise i*, $kpi_i^{CS3\_i\_n}$ and obtained by *Enterprise i* when computing the Strategies Alignment Model considering the CS3 (SAM^{CS3_i}) corresponding to the alternative n must be higher than the value of the KPI at enterprise level defined by *Enterprise i*, $kpi_i^{CS3\_j\_n}$ and obtained by *Enterprise j* corresponding to the alternative n. Thus,

$$\alpha^{CS3\_j\_n} = \begin{cases} 1 \leftrightarrow kpi_i^{CS3\_i\_n} \geq kpi_i^{CS3\_j\_n} \\ 0 \end{cases}$$

CC3. The KPI at network level obtained in the alternative n proposed by *Enterprise i* must by higher than the value of the KPI at network level obtained in the alternative n proposed by *Enterprise j*.

$$\alpha^{CS3\_j\_n} = \begin{cases} 1 \leftrightarrow kpi_{net}^{CS3\_i\_n} \geq kpi_{net}^{CS3\_j\_n} \\ 0 \end{cases}$$

An illustrative example of the criteria choice selected and defined in each enterprise, CCx^i, can be seen in Table 8.8. The main idea to be taken into account is that even sometimes the results are not as the expected ones and the CC is not met (either when $\alpha^{CS3\_j\_n} = 0$ or $\beta^{CS3\_i\_n} = 0$), the $kpi_{net}^{CS3\_n}$ is fulfilled considering that:

$$kpi_{net}^{CS3\_n} \geq kpi_{net}^{NCS}$$

STEP 7. Agreement on the definition of the stopping rule of the Iterative Process. Examples of rules to stop the iterative process are defined hereafter:

- After a certain number of iterations agreed by all the parties, defined by m_max
- When $kpi_{net}^{CS3\_n}$ is higher than the kpi_{net}^{NCS}
- When a certain value of $kpi_{net}^{CS3\_n}$ is achieved
- When $\alpha^{CS3\_j\_n} = 1$ and $\beta^{CS2\_i\_n} = 1$
- Defining a significant difference between the alternatives. Determine if an alternative of solution is significantly higher.
    - When $\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_i}}$ is between an upper and lower bound defined by the enterprises

  The 90% of enterprises decide that $\alpha^{CS3_{j_n}} = 1$ and $\beta^{CS3_{i_n}} = 1$
- Etc.

STEP 8. Select an alternative of solution n (a solution of the SAM^{CS3_i} *and* SAM^{CS3_j}): From the solution generated with the results of the SAM in the CS3: (i) *Enterprise i* selects an alternative of solution: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$, and (ii) *Enterprise j* selects an alternative of solution: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$. n is the number assigned to the alternative selected, this number is assigned consecutively to the selected alternatives *n= [1, 2, ..., n]*. The first alternative to select will normally be that one that provides the optimum value of the KPI at network level, max. $kpi_{net}^{CS3\_n}$. The first alternative selected will coincide with the first iteration of the negotiation process, therefore $n = m$.

STEP 9. Simulate the SAM^{CS3} using the values of the alternative selected (n)

After selecting an alternative of solution n, each Enterprise simulates the simulates the SAM^{CS3}:

- $Enterprise\ i$ simulates the $SAM^{CS3\_i\_n}$
    - Considering the values of the decision variables corresponding to the alternative n: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$
    - Obtaining the values: $\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_i}}$, $\Delta kpi_j^{CS3\_j\_n\_SAM^{CS3\_i}}$, $kpi_i^{CS3\_i\_n}$, $kpi_j^{CS3\_i\_n}$, $kpi_{net}^{CS3\_i\_n}$
- $Enterprise\ j$ simulates the $SAM^{CS3\_j\_n}$
    - Considering the values of the decision variables corresponding to the alternative n: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$
    - Obtaining the values: $\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_j}}$, $\Delta kpi_j^{CS3\_j\_n\_SAM^{CS3\_j}}$, $kpi_i^{CS3\_j\_n}$, $kpi_j^{CS3\_j\_n}$, $kpi_{net}^{CS3\_j\_n}$

STEP 10. Exchange the values of the decision variables of the alternatives selected:

- $Enterprise\ i$ exchanges with $Enterprise\ j$ the values of the decision variables corresponding to the alternative n selected: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$
- $Enterprise\ j$ exchanges with $Enterprise\ i$ the values of the decision variables corresponding to the alternative n selected: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$

STEP 11. Simulate the SAM^{CS3} using the values of the decision variables selected in other enterprises of the network

Each Enterprise simulates the SAM^{CS3} considering the values of the decision variables exchanged in STEP 10.

- $Enterprise\ i$ simulates the SAM^{CS3}
    - Considering the values of the decision variables corresponding to the alternative n selected by $Enterprise\ j$: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$
    - Obtaining the values: $\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_j}}$, $\Delta kpi_j^{CS3\_j\_n\_SAM^{CS3\_j}}$, $kpi_i^{CS3\_j\_n}$, $kpi_j^{CS3\_j\_n}$, $kpi_{net}^{CS3\_j\_n}$
- $Enterprise\ j$ simulates the SAM^{CS3}
    - Considering the values of the decision variables corresponding to the alternative n selected by $Enterprise\ i$: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$
    - Obtaining the values: $\Delta kpi_i^{CS3\_j\_n\_SAM^{CS3\_i}}$, $\Delta kpi_j^{CS3\_j\_n\_SAM^{CS3\_i}}$, $kpi_i^{CS3\_i\_n}$, $kpi_j^{CS3\_i\_n}$, $kpi_{net}^{CS3\_i\_n}$

In the alternative of solution n (which corresponds to the iteration m), depending on alternative selected by each enterprise, the values corresponding to the KPIs at Enterprise level kpi_i^{CS3}, kpi_j^{CS3} and the KPIs corresponding to the network level kpi_{net}^{CS3} will be decreased or increased.

STEP 12. Analysis of Alternative of solution n selected by *Enterprise i* and *Enterprise j*

Step 12.1. Analysis of the Alternative of solution n selected by *Enterprise i*
If *Enterprise i*: $\alpha^{CS3\_i\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_i\_n} = 1$ and
If *Enterprise i* and *Enterprise j* do not want to continue analysing the Alternative of solution n selected by *Enterprise j* → Negotiation Finished
Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by *Enterprise i*: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$

Step 12.2. If *Enterprise i*: $\alpha^{CS3\_i\_n} = 0$ and *Enterprise j*: $\beta^{CS3\_i\_n} = 0$ or
Enterprise i: $\alpha^{CS3\_i\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_i\_n} = 0$ or
Enterprise i: $\alpha^{CS3\_i\_n} = 0$ and *Enterprise j*: $\beta^{CS3\_i\_n} = 1$

Enterprise i and *Enterprise j* continue analysing the Alternative of solution n selected by *Enterprise j*

Step 12.3. Analysis of the Alternative of solution n selected by *Enterprise j*
If *Enterprise i*: $\alpha^{CS3\_i\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_i\_n} = 1$ and
Analysis of the Alternative of solution n selected by *Enterprise i*
If *Enterprise i*: $\alpha^{CS3\_j\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_j\_n} = 1$ → Identify which alternative, the selected by the *Enterprise i* or the selected by *Enterprise j*, provides higher network performance ($kpi_{net}^{CS3\_i\_n} \geq kpi_{net}^{CS3\_j\_n}$)
If $kpi_{net}^{CS3\_i\_n} \geq kpi_{net}^{CS3\_j\_n}$ Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by *Enterprise i*: $u\_str_{is}^{CS3\_i\_n}$ $ti\_str_{is}^{CS3\_i\_n}$, $u\_str_{js}^{CS3\_i\_n}$ $ti\_str_{js}^{CS3\_i\_n}$
If $kpi_{net}^{CS3\_i\_n} \leq kpi_{net}^{CS3\_j\_n}$ Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by *Enterprise j*: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$

Analysis of the Alternative of solution n selected by *Enterprise j*
If *Enterprise i*: $\alpha^{CS3\_j\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_j\_n} = 1$
Collaborative and Negotiated Solution in iteration $m=n$ of the solution proposed by *Enterprise j*: $u\_str_{is}^{CS3\_j\_n}$ $ti\_str_{is}^{CS3\_j\_n}$, $u\_str_{js}^{CS3\_j\_n}$ $ti\_str_{js}^{CS3\_j\_n}$

Step 12.4. If *Enterprise i*: $\alpha^{CS3\_j\_n} = 0$ and *Enterprise j*: $\beta^{CS3\_j\_n} = 0$ or
Enterprise i: $\alpha^{CS3\_j\_n} = 1$ and *Enterprise j*: $\beta^{CS3\_j\_n} = 0$ or
Enterprise i: $\alpha^{CS3\_j\_n} = 0$ and *Enterprise j*: $\beta^{CS3\_j\_n} = 1$
The stopping rule of the Iterative Process is not met → Repeat from STEP 8 to STEP 12
The stopping rule of the Iterative Process is not met → Negotiation Finished and Non Collaborative Solution achieved

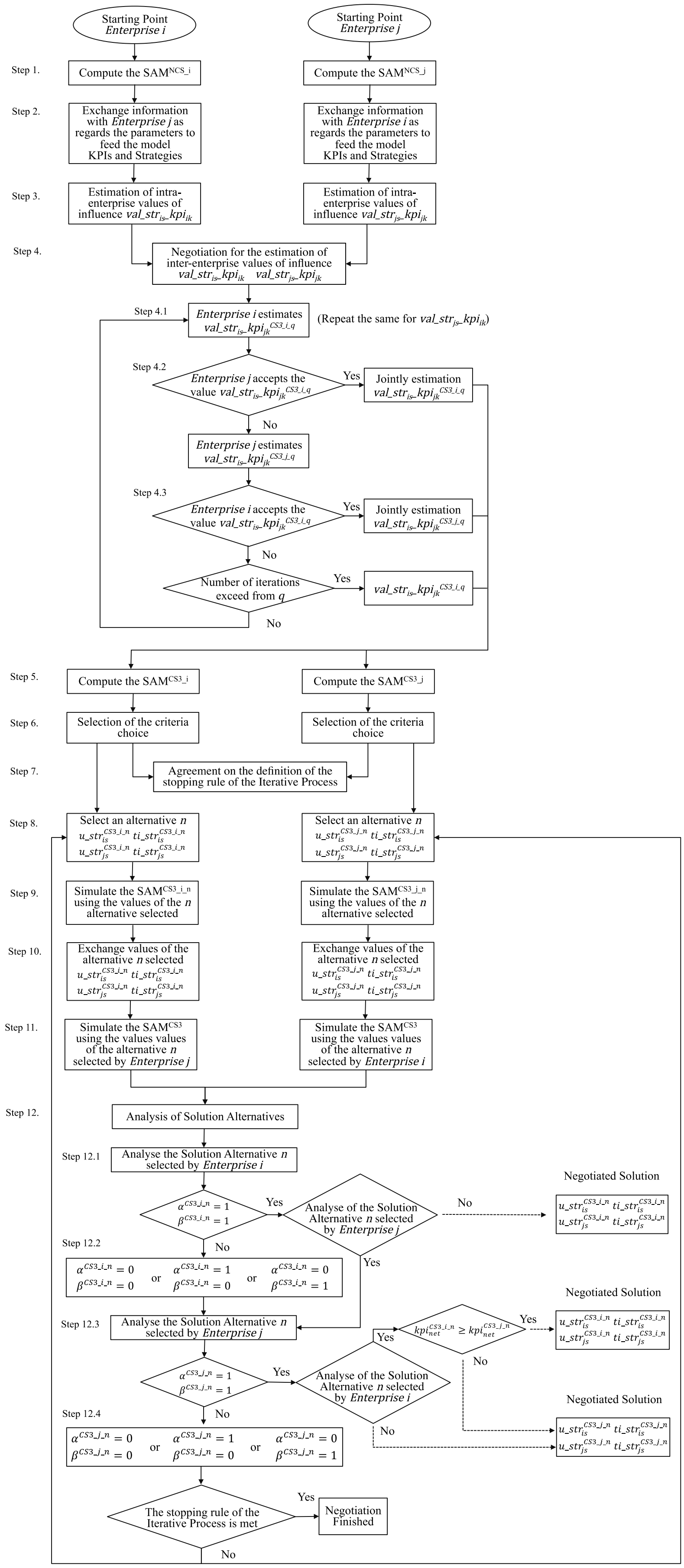


Figure 8.18. Negotiation Process CS3

8.3.12 Phase 12. Solutions Assessment

The main aim of this phase is to identify potential appearing conflicts when activating certain strategies. Possible misalignments and negative-influences appearing in the generated solution are to be identified and analysed. Focusing on the enterprises that generate misalignments in the activation of their strategies, which generate negative influences in the defined KPIs, reducing the performance levels.

Moreover, the aligned strategies will be identified, promoting positive influences to the KPIs defined in the network.

This phase also considers the comparison of the performance levels obtained in different scenarios, i.e. non-collaborative scenarios vs. collaborative scenarios, or between the different levels of collaboration defined. This comparisons will allow the network manager to show the enterprises the importance of activating aligned strategies and performing the decision making of which strategies activate from a collaborative perspective, in order to increase the performance levels at both network and enterprises levels.

In an attempt to help decision-makers when there is uncertainty about the accuracy or the information estimated to feed the SAM, a sensitivity analysis is to be performed. This phase is also in charge of carrying out this analysis.

Sensitivity Analysis

In the sensitivity analysis, the information to be analysed is altered to identify what is the effect, if exist, that would occur in the optimised solution obtained in the SAM. The purpose of sensitivity analysis is to determine the effects undergone in the dependent variables when the values assigned to the independent variables change. Some questions that can be raised include:

- What is the magnitude of change in the optimised solution proposed, resulting from the implementation of the SAM in the simulation software AnyLogic, when a change in an independent variable occurs?
- What independent variables are most sensitive? That is, what would be the independent variables that, if slightly change, produce significant changes in the dependent variables? What independent variables are non-sensitive?
- Does the proposed solution is highly sensitive? So that the solution includes sensitive variables. When independent variables are slightly changed, the solution could be altered so that it is not optimal.

The value associated with the parameter $val\_str_{is}\_kpi_{ik}$ could be often estimated, by the enterprises, in an imprecise way. Since generally decision makers (enterprise managers) might not be able to correctly determine the exact value of the parameter $val\_str_{is}\_kpi_{ik}$, it is important to analyse how the value of the parameter $val\_str_{is}\_kpi_{ik}$ influences on the optimised solution, resulting from the implementation of the SAM in the simulation software AnyLogic. That is, to examine into which extent a small change in the value defined for $val\_str_{is}\_kpi_{ik}$ provokes a change in the final solution obtained in the optimisation experiment.

The sensitivity analysis will allow determining how robust the optimisation solution is against variations on the value that define the parameter $val\_str_{is}\_kpi_{ik}$. Therefore, the sensitivity analysis is a posterior analysis to be performed once the optimisation solution has been obtained.

Lets suppose that one enterprise is not completely sure about the value estimated for the parameter $val\_str_{is}\_kpi_{ik}$. Considering this, instead of asking the enterprise for a specific value, the enterprise can give a range of values between which the company assumes that the value $val\_str_{is}\_kpi_{ik}$ is. The enterprise could opt for saying for example that $val\_str_{is}\_kpi_{ik}$ is between -1 and 1.

From the network manager viewpoint, it is needed to check if the optimisation results are the same regardless the values that $val\_str_{is}\_kpi_{ik}$ can acquire, upper and lower bounds (from -1 to 1). If the solution, regardless the values that $val\_str_{is}\_kpi_{ik}$ acquires, remains the same it will be stated that the optimised solution is robust. However, if the solution changes for some of the estimated values (between -1 and 1), then it must be stated that the solution is sensitive to changes of $val\_str_{is}\_kpi_{ik}$ and it is less robust.

With the sensitivity analysis it can be also determined upper and lower bound values among which the solution begins to change (or not to change, if the solution is robust). This will allow the network manager to (i) determine the values among which the solution is not sensitive to changes, (ii) identify the values from which the solution changes, and (iii) identify what is the new optimised solution and how it affects the company.

Considering the characteristics of the simulation software used to automatically compute the SAM, it must be stated that AnyLogic is not able to perform the sensitivity analysis upon the optimisation experiment from an automated way. The sensitive analysis is limited to the simulation experiments. Therefore, the sensitivity analysis must be carried out manually. The optimisation experiment will be run each time the value $val\_str_{is}\_kpi_{ik}$ changes, considering all the values of the estimated range. According to this, the range of values, which make the solution robust, can be determined. Two steps are applied in order to manually carry out the sensitivity analysis:

Step 1. Consider for the optimisation experiment a determined value of $val\_str_{is}\_kpi_{ik}$ extracted from the range estimated by the company, and run the optimisation experiment. This first run will give a optimised solution. This initial solution will be used to compare the optimised solutions obtained when the parameter $val\_str_{is}\_kpi_{ik}$ acquires different the values included between the upper and lower range defined by the enterprise.

Step 2. Select one by one all the values within the range estimated for the parameter $val\_str_{is}\_kpi_{ik}$ and manually run the optimisation experiments, for each of the values of the estimated range. The solutions obtained for each new value of $val\_str_{is}\_kpi_{ik}$ introduced will be compared with the solution obtained in Step 1.

8.4 Conclusions

This section introduces the Strategies Alignment Guideline (SAG) consisting on 12 phases, with the main aim of giving support to the enterprises on dealing with the strategies alignment process in the context of a CN. The proposed guideline distinguishes three different collaborative scenarios, depending on the information exchanged to establish the strategies alignment process from a collaborative perspective. A negotiation process is designed for each collaborative scenario, in order to agree the solutions as regards which strategies to activate and when. In the negotiation process the enterprises will propose alternative solutions that best fit their requirements.

The SAG gives companies a complete vision of how to perform the strategies alignment process, supporting them from the starting-up phase to the solutions assessment. Besides, a complementary sensitivity analysis is proposed in order to identify the robustness of the optimised solution obtained, resulting from the implementation of the SAM in the simulation software AnyLogic.

The guideline has been designed in a general way to be applied by all the enterprises of the collaborative network, willing to collaboratively perform the strategies alignment process. Its application will be always supported by the network manager.

8.5 References

Alfaro, Juan José, Raúl Rodríguez Rodriguez, Angel Ortiz, and Maria Jose Verdecho. 2010. "An Information Architecture for a Performance Management Framework by Collaborating SMEs." *Computers in Industry* 61(7):676–85. Retrieved January 30, 2015 (http://linkinghub.elsevier.com/retrieve/pii/S0166361510000291).

Da Piedade Francisco, Roberto, Américo Azevedo, and António Almeida. 2012. "Alignment Prediction in Collaborative Networks" edited by Rob Dekkers. *Journal of Manufacturing Technology Management* 23(8):1038–56. Retrieved February 6, 2015 (http://www.emeraldinsight.com/doi/abs/10.1108/17410381211276862).

PART IV. VALIDATION

Chapter 9

Experiments

In this chapter the model (SAM), method (SD), tool (SAGEN) and guideline (SAG), proposed in chapters 5, 6, 7 and 8, are integrated to solve the strategies alignment problem, in the context of a CN, this chapter aims to show the application of the proposed contributions taking into account different scenarios, characterised by different restrictions. The experiments presented are part of the validation process of this dissertation research.

9.1 Introduction

The thesis verification and validation aims to assess, give credibility and accredit the developed original work (Kleijnen 1995).

On the one hand, the verification process consists on confirming that the developed model, method, tool and guideline meets the requirements defined by the modeller. Verification deals with checking if the proposed model is what the designer thinks it is. The verification process is especially relevant in the development of formal models, using formal languages. This verification is performed in the illustrative *Example 7.5* (Chapter 7) in which a CN with a high number of enterprises (concretely 10) was modelled.

On the other hand, the validation process corresponds to the scientific proof of the real system being modelled in order to assess its utility within the context of application, according to the criteria for which the model was designed; that is to identify if the model works as expected (Kleijnen 1995) (Izquierdo et al. 2008) (Campuzano and Mula 2011). The validity of a model is determined by the degree in which the proposed model captures the essence of the real reference system. The validation guarantees that the proposed model solves the problem for which it was created. Amongst other mechanisms, the validity of the model can be determined studying the extent that the results obtained with the model correspond to the data observed in the real modelled system (Moss 2008). Other mechanisms of validation can be found in (Kleijnen 1995), listed as: (i) obtain real-world data, (ii) compare simulated and real data, (iii) test the correlation and mean of simulated and real responses through regression analysis, (iv) perform a sensitivity analysis based on design of experiments, and (v) compare white versus black box simulation models.

As the proposed model to deal with the strategies alignment problem is based on the system dynamics method, some validation tests dealing with dynamic models are collected from (Barlas 1996) and (Sterman 2000), and to be considered: (i) Test of adequacy of the model as regards the parameters used in the model, (ii) Test of dimensional congruence and appropriateness of the units used, (iii) Test to assess the parameters and variables used compared with the reality, (iv) Test of structural consistency with respect the knowledge about real systems, (v) Test of analogy with models representing similar systems, (vi) Test of replication of known real systems (vii) Test for analysing the behaviour of the model considering extreme scenarios, (viii) Test of sensibility as regards how the model changes when some parameters are modified (time, flows, etc.), (ix) Test of anomalous behaviours to evaluate the causal relationships among the variables, (x) Test of improvement of the modelled system.

In this chapter, empirical realistic examples have been built in order to show the usefulness of the model, method and tool presented. The proposed examples will show the validity of the proposed model, method and tool to solve and assess the strategies alignment process in each of the proposed scenarios.

Concerning CNs, the process of validation becomes challenging due to there are characterised by being dynamic and complex systems. Proving improvements in CN has a difficulty associated with the performance measurement (Camarinha-Matos and Afsarmanesh 2006).

Regarding the experiments performed in the validation, both the experiments (Chapter 9) and the real application (Chapter 10), a PC with the next characteristics has been employed: System Version: OS X 10.9.5 (13F34), Kernel version: 13.4.0 Darwin, Boot volume: Macintosh HD, Processor Name: Intel Core i5, Processor speed: 2.7 GHz, Number of processors: 1, Total number of cores: 4, Level 2 cache (per core): 256 KB, Level 3 cache: 4 MB.

9.2. Validation Elements

In order to show the relevance of the model, method, tool and guideline proposed to deal with the strategies alignment problem a set of validation elements are considered:

- Validation of the research by peer reviewed publications (Chapter 9, section 9.2.1)
- Empirical Experiments (Chapter 9, section 9.2.2)
  - Illustrative Example modelling a reduced CN (Mix of Strategies)
  - Illustrative Example modelling an extended CN (Mix Strategies)
- Case study (Chapter 10)
  - CN of the Food Sector
  - CN of the Automotive Sector

9.2.1 Validation of the research by peer reviewed publications

Part of the validation is determined by the peer review publications that resulted from the work developed in this dissertation research. This research received relevant feedback from the reviewers of the journals, books and conferences, in which the developed work was published.

The research papers published in peer-reviewed journals, books and conference proceedings are presented in (Figure 9.1). These publications are organised on the basis of the contributions made along the thesis.

Andres, B. and Poler, R. (2015) Dealing with the Alignment of Strategies Within the Collaborative Networked Partners. In: Technological Innovation for Cloud-Based Engineering Systems Camarinha-Matos . L.M. et al. (Eds.). DoCEIS 2015, IFIP AICT 450, pp. 13–21, 2015. DOI: 10.1007/978-3-319-16766-4_2

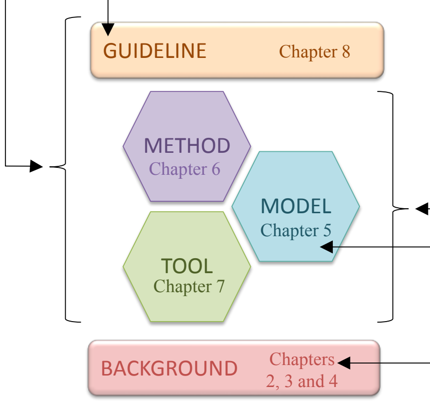
Andres, B. and Poler, R. (2016) Towards a Methodology to support the Strategies Alignment Process in Collaborative Networks. 8th International Conference Interoperability for Enterprise Systems and Aplications. I-ESA 2016.

Andres, B. and Poler, R. (2015) Modelling the Strategies Alignment process in the Collaborative Network context. In: 9th International Conference on Industrial Engineering and Industrial Management. XXI International Conference on Industrial Engineering and Operations Management. International IIE Conference 2015 Aveiro, Portugal. July 6-8, 2015

Andres, B., Macedo, P. Camarinha-Matos, L.M. and Poler R. (2014) Achieving coherence between Strategies and Value Systems in collaborative networks In Camarinha-Matos and Afsarmanesh (eds.) Collaborative Systems for Smart Networked Environments. 15th IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2014. IFIP AICT. Springer Heidelberg Dordrecht London NewYork, pp. 251 -262. Doi: 10.1007/978-3-662-44745-1_26

Andres, B., Poler, R., Sanchis, R. (2015) Collaborative Strategies Alignment to Enhance the Collaborative Network Agility and Resilience. In Camarinha-Matos and Afsarmanesh (eds.) IFIP WG 5.5 Working Conference on Virtual Enterprises, PRO-VE 2015. IFIP AICT. Springer Heidelberg Dordrecht London NewYork, vol 463, pp. 88–99, 2015. DOI: 10.1007/978-3-319-24141-8_8

Andres, B. , Poler, R., Rosas, J. And Camarinha-Matos, L.M. (2016) A Decision-Support Tool to Deal with the Strategies Alignment process in Collaborative Networks. 7th Advanced Doctoral Conference on Computing, Electrical and Industrial Systems. DoCEIS 2016.



Andres, B. and Poler, R. (2014). Computing the strategies alignment in Collaborative Networks In: K. Mertins et al. (eds.), Enterprise Interoperability VI, Proceedings of the I-ESA Conferences 7, doi: 10.1007/978-3-319-04948-9_3, Ó Springer International Publishing Switzerland 2014

Andres, B. and Poler, R. (2013). Relevant problems in collaborative processes of non-hierarchical manufacturing networks. Journal of Industrial Engineering and Management, 6 (3): 723-73.

Andres, B. and Poler, R. (2014). Research on Collaborative Processes in Non-Hierarchical Manufacturing Networks. In: L.M. Camarinha-Matos et al. (Eds.): DoCEIS 2014, IFIP AICT 423, pp. 21–28, 2014 © IFIP.

Andres, B. and Poler, R. (2015): Models, guidelines and tools for the integration of collaborative processes in non-hierarchical manufacturing networks: a review, International Journal of Computer Integrated Manufacturing.

Andres, B. and Poler, R. (2015) Approaches for Collaborative Networks Simulation: A review. In: 9th International Conference on Industrial Engineering and Industrial Management. Aveiro, Portugal. July 6-8, 2015

Figure 9.1. Publications derived from the thesis (Andres and Poler 2013) (Andres et al. 2014) (Andres and Poler 2014a) (Andres and Poler 2014b) (Andres and Poler 2015a)(Andres and Poler 2015b) (Andres, Poler, and Sanchis 2015)(Andres and Poler, 2016) (Andres et al., 2016)

9.2.2 Empirical Experiments

Two examples are presented in this section to validate the SAM:

- one considering a CN with a reduced number of enterprises, strategies and performance indicators. The strategies modelled correspond to the three defined types, binary, discrete and continuous, and
- the other considering a higher number of enterprises, strategies and performance indicators. As considering more enterprises only binary strategies are considered, as being the most common type of strategies that would be modelled in a real situation.

Within each validation example two scenarios are considered and compared the non-collaborative and the collaborative one. In the non-collaborative scenario, the enterprises implement the SAM from an isolated perspective by only considering the KPIs and strategies defined by themselves. In the collaborative scenario, the enterprises implement the SAM from a common perspective, considering not only the influence of the strategies defined by themselves, but also taking into account the influence of the strategies formulated by the rest of network enterprises. Concerning the level of collaboration, as being a illustrative example, the level of collaboration modelled corresponds to the third level of collaboration (CS3). Recalling, the Collaborative Scenario 3 (CS3), corresponding to the Level 3 of Collaboration, is characterised by the exchange of both the defined KPIs and the formulated strategies. The information regarding the KPIs defined in each enterprise is exchanged, including Δkpi_{ik}^{max}, $Threshold\_kpi_{ik}$, $\Delta kpi_{ik\_}min$, w_{ik} and kpi_{ik}. The values of the parameters that characterise the strategies is also exchanged: c_str_{is}, $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$, b_i and u_str_{is}. Besides the network enterprises jointly estimate the inter-enterprise values of influence ($val\_str_{is}\_kpi_{jxk}$ and $val\_str_{js}\_kpi_{ixk}$). Each enterprise estimates the intra-enterprise values of influence of its own strategies in its own KPIs (Enterprise i estimates $val\_str_{is}\_kpi_{ixk}$ and Enterprise j estimates $val\_str_{js}\_kpi_{jxk}$). The intra-enterprise values of influence are exchanged. The procedure followed to obtain the solutions in each of the modelled scenarios is shown in (Figure 9.2).

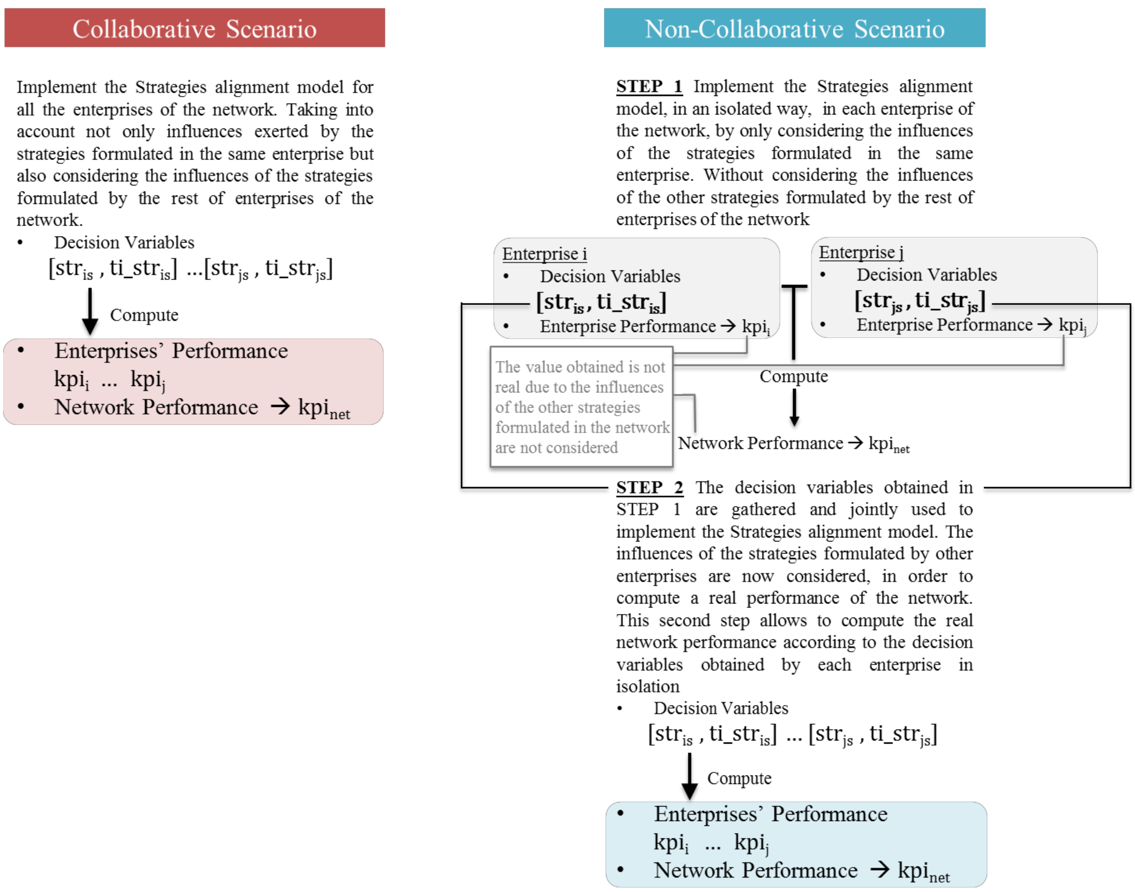


Figure 9.2. Procedure followed to obtain optimised solutions in the Collaborative and Non-Collaborative Scenarios

9.2.2.1 Example 9.1. Network of 2 enterprises (Mix of Strategies)

The example proposed considers a CN with two enterprises (distributor and manufacturer), each one defining two objectives. The achievement of the objectives is measured through the KPIs (kpi_{ixk}) each one with its corresponding weights (w_{ixk}):

- Distributor (e_1)
  - o_{11}: Increase the product sales by a 10%
    $$\Delta kpi_{111} = \Delta sales = \frac{sales_{\,t} - sales_{t-1}}{sales_{\,t}} \times 100$$
  - o_{12}: Reduce the product costs by a 30%
    $$\Delta kpi_{121} = \Delta costs = \frac{costs_{\,t-1} - costs_{t}}{costs_{\,t-1}} \times 100$$
- Manufacturer (e_2)
  - o_{21}: Increase the profit by a 15%
    $$\Delta kpi_{211} = \Delta netProfit = \frac{netProfit_{\,t} - netProfit_{t-1}}{netProfit_{\,t}} \times 100$$
  - o_{22}: Reduce the quantity of product that cannot be sold by 100 %
    $$\Delta kpi_{221} = \Delta prodNOdistributed = \frac{prodNOdistributed_{t-1} - prodNOdistributed_{t}}{prodNOdistributed_{t-1}} \times 100$$

In order to achieve the objectives defined, each enterprise formulates two strategies (e_1: str_{11} and str_{12}, e_2: str_{21} and str_{22}) and defines its related data as regards the durations and costs. Different types of strategies are defined. Depending on the strategy defined the value of each u_str_{is} will be characterised by being binary, discrete or continuous. The enterprises have a certain budget to carry on these strategies.

- Distributor (e_1)
  - str_{11}: Invest 0,5 m.u on marketing activities. This strategy acquires continuous values, due to this strategy is formulated in monetary units invested to carry out marketing activities. In this case, c_str_{11} = 0,5 m.u and the maximum investment is constrained by a quantity of m.u. defined in the enterprise corresponding to $str_{11}\_mu = 2{,}25 m.u.$ (out of the budget that is 4 m.u.). Therefore, the maximum number of units of strategy is defined by $u\_str_{11} = 4{,}5$ *(units of strategy)* that corresponds to the maximum amount of m.u. the enterprise is willing to invest on marketing activities.
  - str_{12}: Conduct negotiations with other manufacturers to reduce the purchasing costs. This strategy can only adopt binary values 0 if not activated and or 1 if activated
- Manufacturer (e_2)
  - str_{21}: Use different distribution channels to sell the product in other markets. Opening up of new markets. This strategy can only adopt binary values 0 if not activated and or 1 if activated
  - str_{22}: Buy one machine to make derivative products, reprocessing the product that cannot be sold (i.e. low cost product) . This strategy acquires discrete value, due this strategy is defined by the number of machines to buy. In this case, c_str_{22} = 3 m.u.. This example considers a maximum amount of machines of 2 ($u\_str_{is} = 2$) (involving a cost of 6 m.u. out of the budget that is 9 m.u.).

All the data as regards the objectives and strategies defined in the example is shown in Table 9.1. The values of influence that each strategy has on the defined KPIs are given. The data depicted on the cells in dark grey correspond to the values of influence that the strategies defined in one enterprise have on the KPIs defined in the same enterprise (intra-enterprise values of influence). While the white coloured cells represent the values related to the inter-enterprise influences, that is, the values of influence that the strategies defined in one enterprise have on the KPIs defined in the other enterprise of the CN. In the non-collaborative scenario only the inter-enterprise values of influence will be used. Whilst in the collaborative scenario will take into consideration both intra and inter-enterprise values of influence.

Table 9.1. Example 9.1:Data (Mix of Strategies)

Distributor (e_1) b_1 = 4																
													kpi'_{111}		kpi'_{121}	
													w_{111}	0,5	w_{121}	0,5
													$Threshold\_kpi'_{111}$	0,05	$Threshold\_kpi'_{121}$	0,01
str_{11}	u_str_{11}	?	ti_str_{11}	?	c_str_{11}	0,5	$d'_1\_str_{11}$	0,05	$d'_2\_str_{11}$	0,01	$d'_4\_str_{21}$	0,3	$val\_str_{11}\_kpi'_{111}$	0,4	$val\_str_{11}\_kpi'_{121}$	0
str_{12}	u_str_{12}	?	ti_str_{12}	?	c_str_{12}	4	$d'_1\_str_{12}$	0,2	$d'_2\_str_{12}$	0,03	$d'_4\_str_{21}$	0,7	$val\_str_{12}\_kpi'_{111}$	0,2	$val\_str_{12}\_kpi'_{121}$	0,9
													$val\_str_{21}\_kpi'_{111}$	-0,6	$val\_str_{21}\_kpi'_{121}$	-0,6
													$val\_str_{22}\_kpi'_{111}$	0,3	$val\_str_{22}\_kpi'_{121}$	0,4
Manufacturer (e_2) b2 = 9																
													kpi'_{211}		kpi'_{221}	
													w_{211}	0,5	w_{221}	0,5
													$Threshold\_kpi'_{211}$	0,2	$Threshold\_kpi'_{221}$	0,1
str_{21}	u_str_{21}	?	ti_str_{21}	?	c_str_{21}	7	$d'_1\_str_{21}$	0,1	$d'_2\_str_{21}$	0,02	$d'_4\_str_{21}$	0,75	$val\_str_{21}\_kpi'_{211}$	1	$val\_str_{21}\_kpi'_{221}$	0,7
str_{22}	u_str_{22}	?	ti_str_{22}	?	c_str_{22}	3	$d'_1\_str_{21}$	0,05	$d'_2\_str_{21}$	0,01	$d'_4\_str_{21}$	0,5	$val\_str_{22}\_kpi'_{211}$	0,2	$val\_str_{22}\_kpi'_{221}$	0,8
													$val\_str_{11}\_kpi'_{211}$	0,8	$val\_str_{11}\_kpi'_{221}$	0,6
													$val\_str_{12}\_kpi'_{211}$	-0,5	$val\_str_{12}\_kpi'_{221}$	-0,5

9.2.2.1.1 Collaborative Scenario

In the collaborative scenario the enterprises participating take into account the influences of all the strategies formulated by the enterprises.

In the optimisation experiment carried out in the simulation software used (AnyLogic) (Figure 9.3):

- Strategies $str_{12}$and str_{21} acquire binary values are defined as *discrete parameters*, being 0 the lower bound and 1 the upper bound.
- Strategy str_{11} and the decision variable ti_str_{is} (generally for all the strategies) acquire continuous values. The minimum number of units of strategies to activate in str_{11} will be 0 and the maximum is defined by the distributor as the maximum number of monetary units to invest in marketing activities, limited to 4,5. With respect to variable initial time of activation $ti_str_{is}$the minimum is defined by 0 and the maximum value that can acquire is 1, considering the horizon of simulation.
- Strategy str_{22}acquires discrete values. The minimum number of units of strategies to activate in str_{22} will be 0 and the maximum is defined by the manufacturer as the maximum number of machines to buy, limited to 2.

The solution derived from the optimisation experiment is shown in Figure 9.4. It could happen that the different solutions for the decision variables lead to the same optimised result. In the above figure appears the best ultimate simulated solution. In Annex 9.1 the list of possible solutions leading to the optimised solutions is shown. Considering, from the set of solutions, that the enterprises decide to activate the strategies as soon as possible, the final solution will be the proposed in Table 9.2. If the distributor decides to activate its strategy str_{11} as late as possible, the final solution will be the proposed Table 9.3.

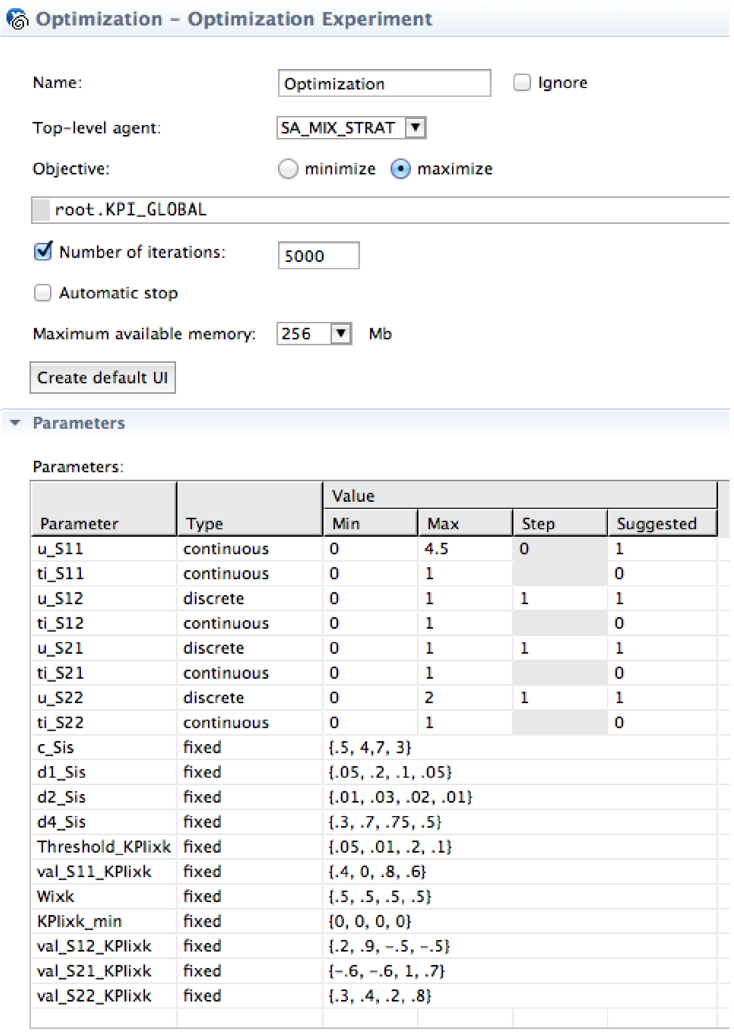
Table 9.2. Optimisation results considering the activation of strategies as soon as possible

Number of Iteration	Current Objective	Feasible	u_S11	ti_S11	u_S12	ti_S12	u_S21	ti_S21	u_S22	ti_S22
2905	0,81979	1	4,5	0,004602122	0	0	0	0	2	0

Table 9.3. Optimisation results considering the activation of strategies as late as possible

Number of Iteration	Current Objective	Feasible	u_S11	ti_S11	u_S12	ti_S12	u_S21	ti_S21	u_S22	ti_S22
1077	0,81979	1	4,5	0,130772577	0	0	0	0	2	0

Considering the results derived from the optimisation experiment (Figure 9.4), the simulation experiment is run (Figure 9.5). The values concerning the enterprise performance indicators (kpi'_i) and the network performance indicator (kpi'_{net}) are computed in the simulation experiment.



Parameter	Type	Value			
		Min	Max	Step	Suggested
u_S11	continuous	0	4.5	0	1
ti_S11	continuous	0	1		0
u_S12	discrete	0	1	1	1
ti_S12	continuous	0	1		0
u_S21	discrete	0	1	1	1
ti_S21	continuous	0	1		0
u_S22	discrete	0	2	1	1
ti_S22	continuous	0	1		0
c_Sis	fixed	{.5, 4,7, 3}			
d1_Sis	fixed	{.05, .2, .1, .05}			
d2_Sis	fixed	{.01, .03, .02, .01}			
d4_Sis	fixed	{.3, .7, .75, .5}			
Threshold_KPlixk	fixed	{.05, .01, .2, .1}			
val_S11_KPlixk	fixed	{.4, 0, .8, .6}			
Wixk	fixed	{.5, .5, .5, .5}			
KPlixk_min	fixed	{0, 0, 0, 0}			
val_S12_KPlixk	fixed	{.2, .9, -.5, -.5}			
val_S21_KPlixk	fixed	{-.6, -.6, 1, .7}			
val_S22_KPlixk	fixed	{.3, .4, .2, .8}			

Figure 9.3. Example 9.1: Optimisation Experiment for the Collaborative Scenario

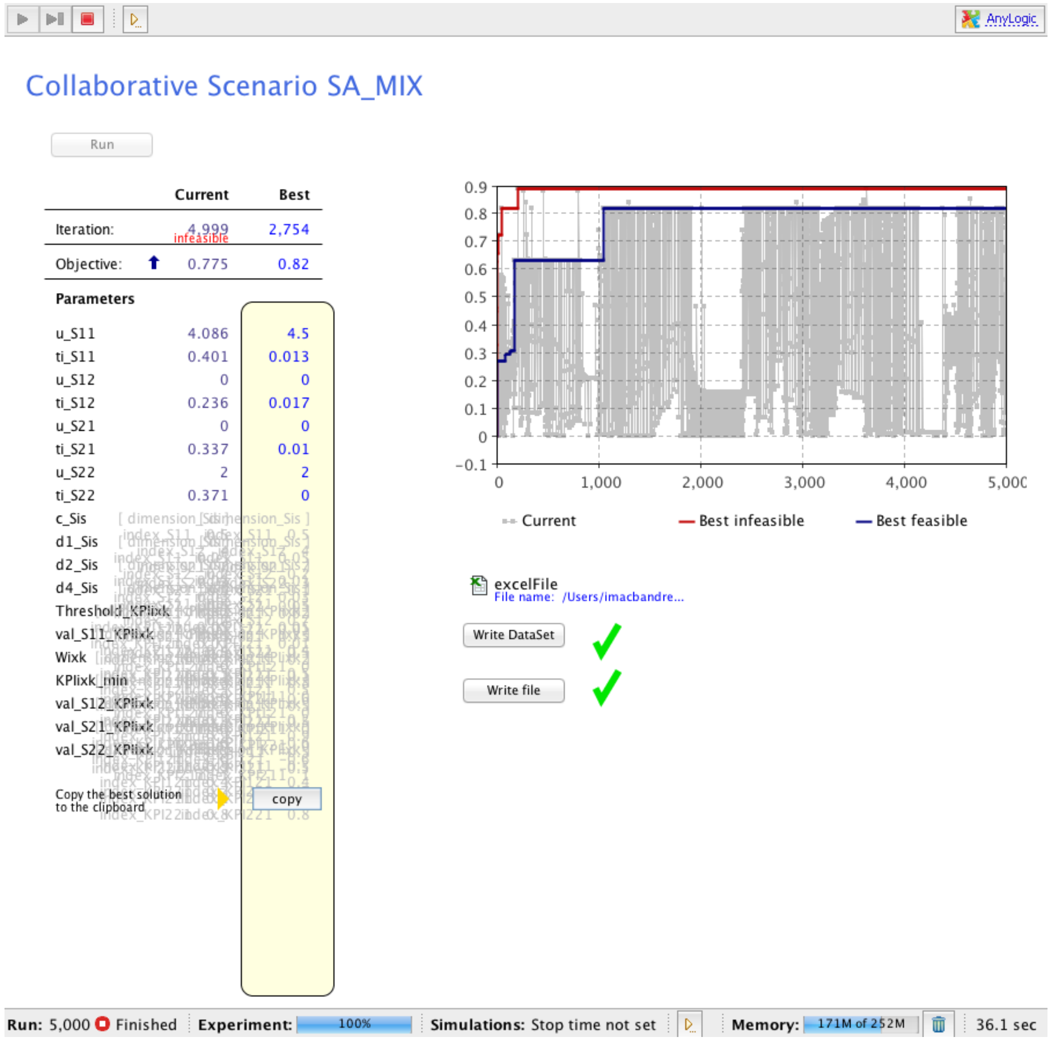


Figure 9.4. Example 9.1: Optimisation Experiment results for the Collaborative Scenario

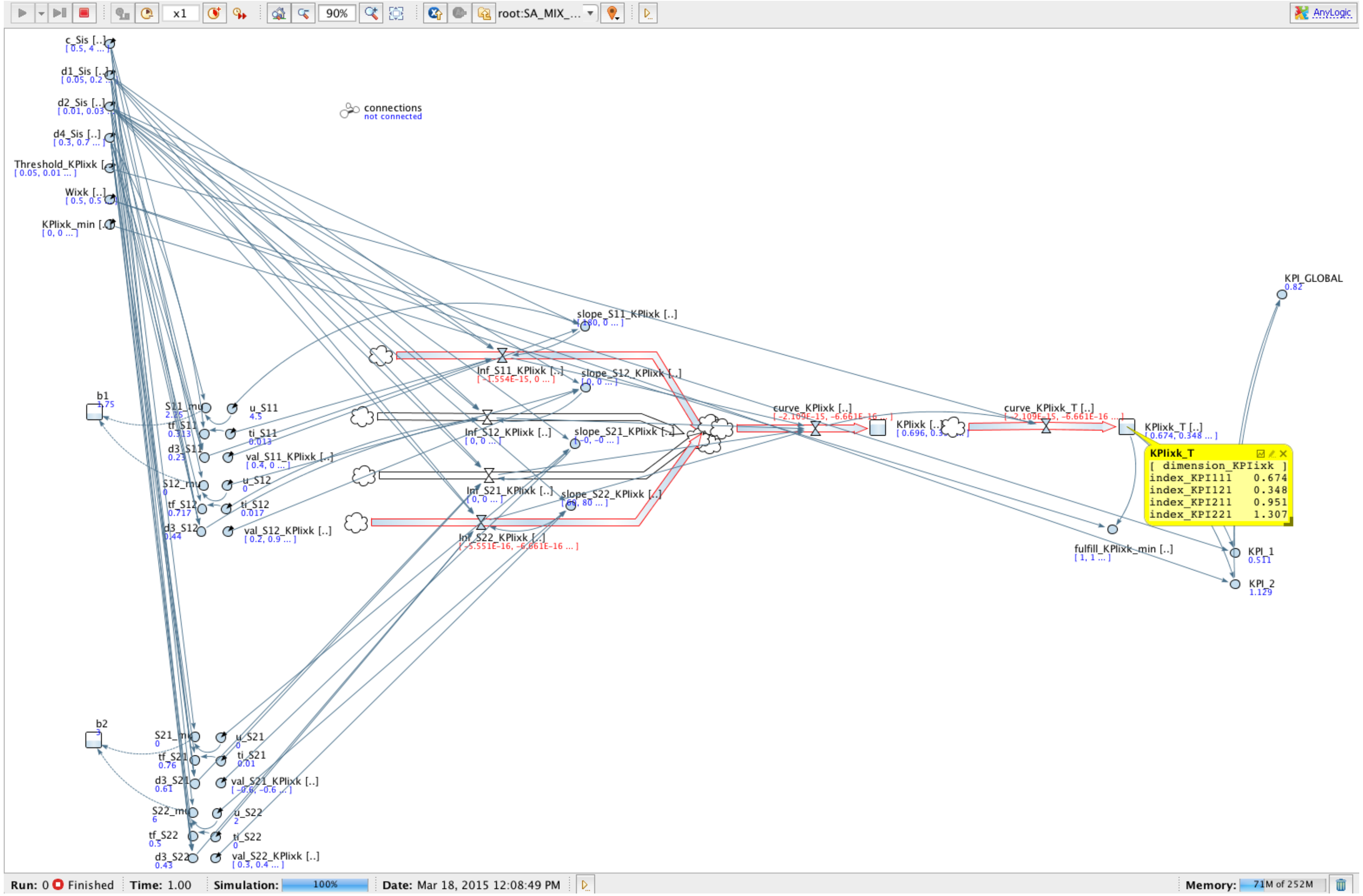


Figure 9.5. Example 9.1: Simulation Experiment Results. Flow diagram for the Collaborative Scenario

9.2.2.1.2 Non-Collaborative Scenario

STEP 1. Obtaining Optimisation results by considering each enterprise in isolation

When simulating each enterprise in isolation, the enterprises only take into account the influences that its formulated strategies exert on the own performance indicators. The decision-making is made from an isolate perspective without considering how the strategies formulated by other network enterprises affect the achievement of its objectives (performance). The optimisation experiment results can be seen in Figure 9.6 for the distributor and in Figure 9.7 for the Manufacturer. The simulation experiments can be seen in Figure 9.8 for the distributor and in Figure 9.9 for the Manufacturer.

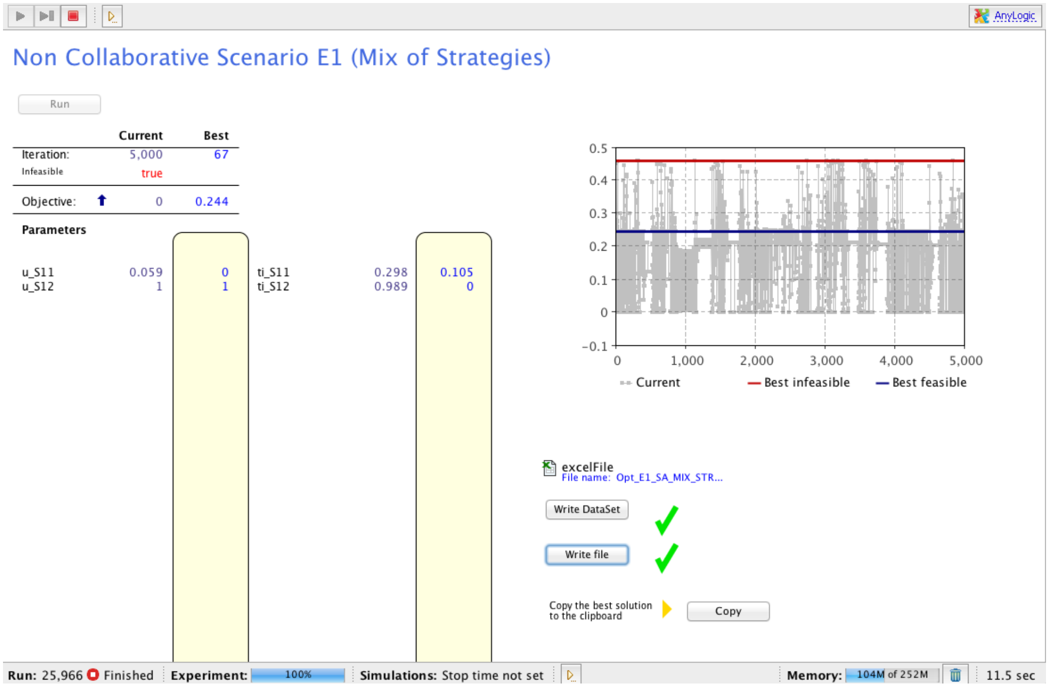


Figure 9.6. Example 9.1: Optimisation experiment results for the Distributor in the Non-Collaborative Scenario

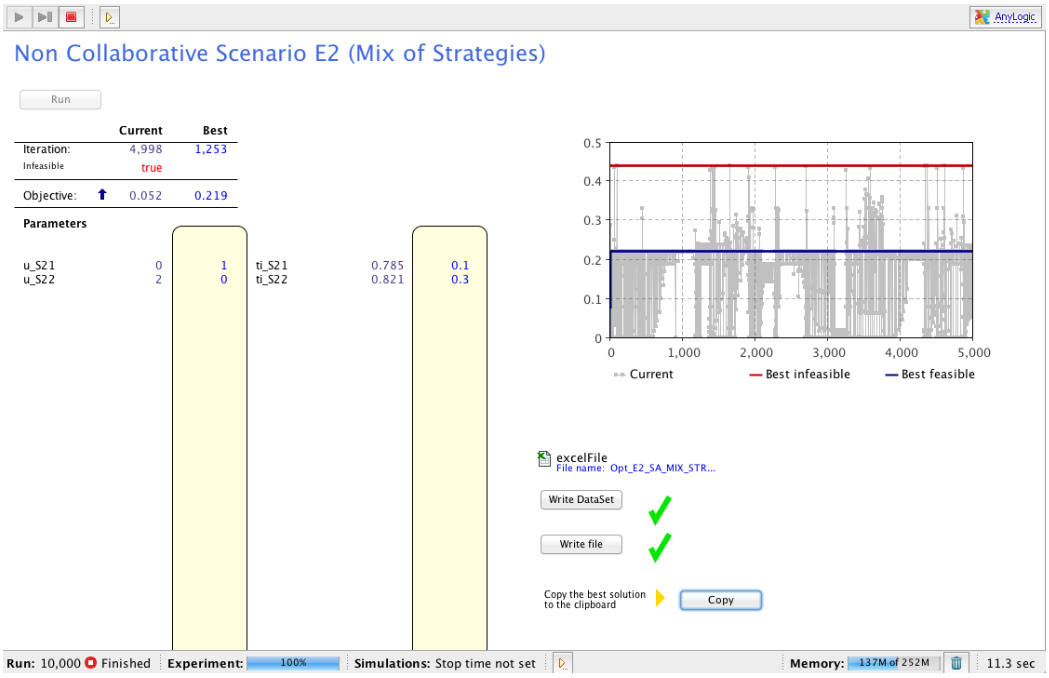


Figure 9.7. Example 9.1:Optimisation experiment results for the Manufacturer in the Non-Collaborative Scenario

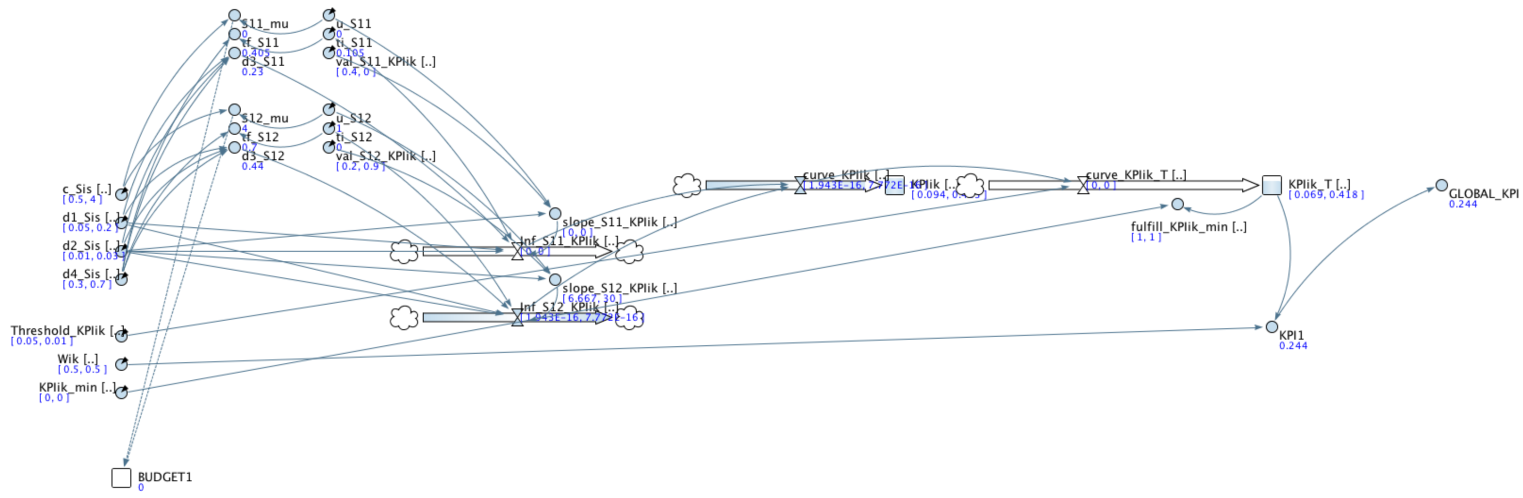


Figure 9.8. Example 9.1: Simulation Experiment Results. Flow diagram for the Distributor in the Non-Collaborative Scenario

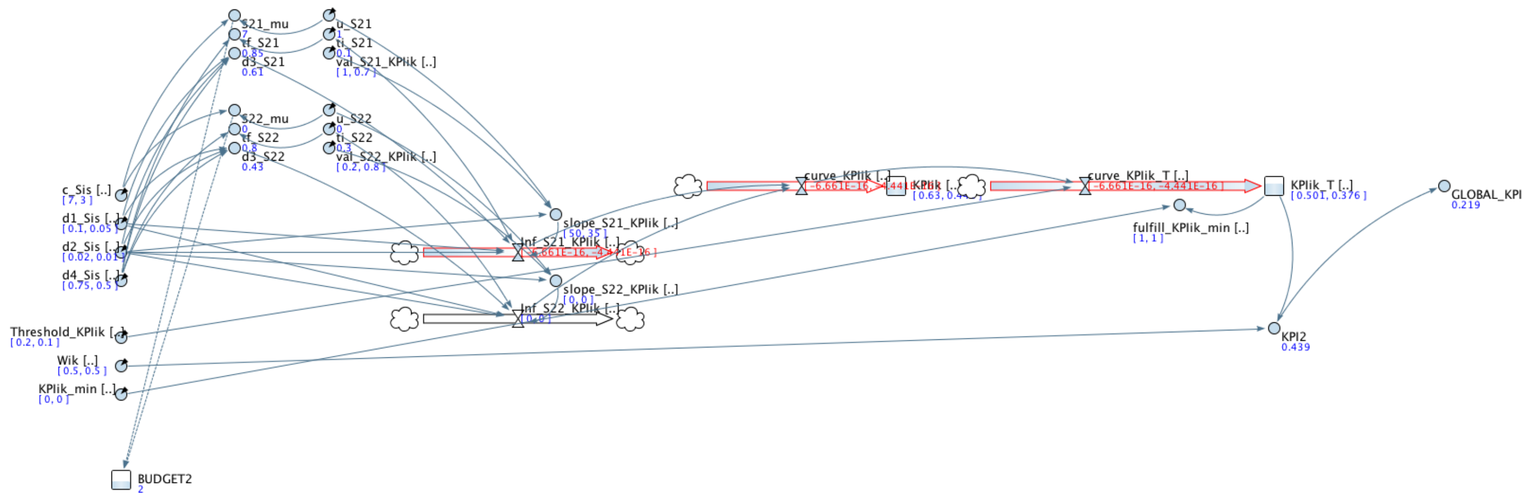


Figure 9.9. Example 9.1: Simulation Experiment Results. Flow diagram for the Manufacturer in the Non-Collaborative Scenario

STEP 2. Obtaining Simulation results by considering the optimisation results obtained in STEP 1

In STEP 1 the solutions were obtained for each enterprise by only considering intra-enterprise influences (influences exerted by the strategies formulated in the same enterprise). These solutions do not considered the inter-enterprise influences exerted by the strategies formulated by the other partner of the network. Not considering the inter-enterprise influences does not mean that these influences do not exist. Therefore, in order not to have a distorted solution of the enterprise and network performances the values obtained in STEP 1, for each decision variable in each enterprise, are gathered and introduced in the simulation experiment that represents the whole network (Figure 9.10). Then, the simulation experiment is carried out in order to obtain the real performance measures for both, the enterprise performance indicators (kpi'_i) and the network performance indicator (kpi'_{net}) (Figure 9.11).

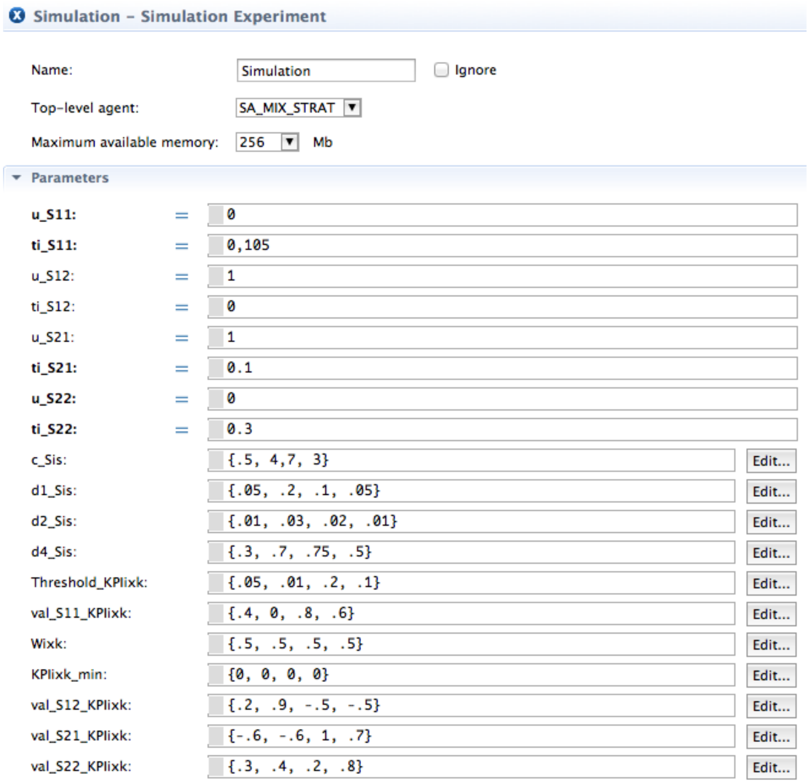


Figure 9.10. Example 9.1: Simulation Experiment Input.

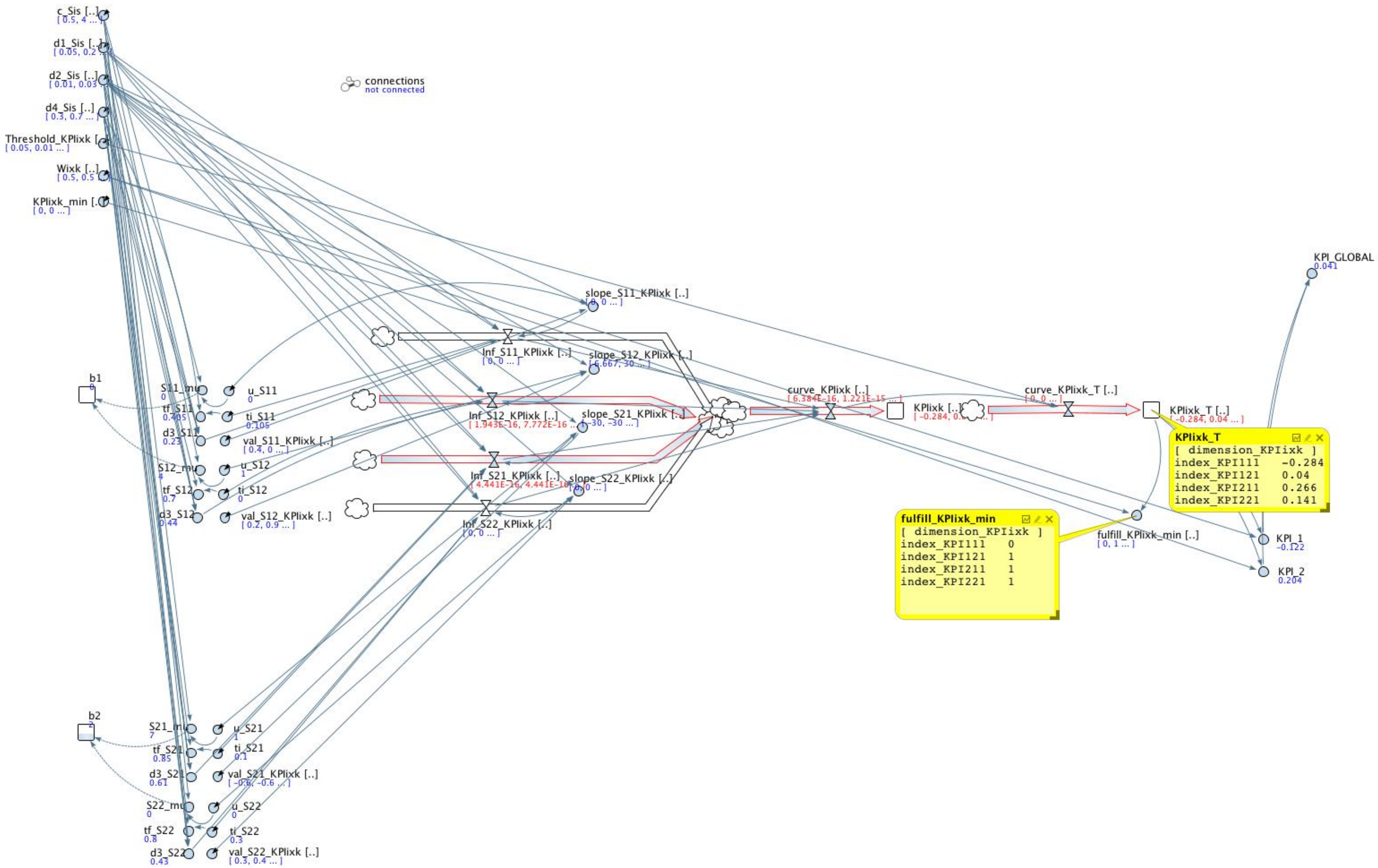


Figure 9.11. Example 9.1: Simulation Experiment. Performance Results at enterprise and network levels considering the inter-enterprise influences

9.2.2.1.2 Scenarios comparison

In Example 9.1, the optimised solution of the collaborative scenario (using the SAM) generates a level of network performance significantly higher than the performance resulting from the solution obtained in the non-collaborative scenario. Moreover, the solution obtained in the non-collaborative scenario breaches the restriction of non-negativity of all the KPIs of the network ($fulfilment\ kpi'_{ixk} > 0$). Whereas that the solution of the collaborative scenario complies with the restriction of non-negativity being the fulfilment of all the KPIs 1.

Table 9.4. Example 9.1: Comparison of the collaborative and non-collaborative scenario

	Isolated Enterprises (STEP 1: intra-enterprise)	Non-collaborative Scenario (STEP 2: inter-enterprise)	Collaborative Scenario	Performance Improvement
u_str11	0	0	4,5	
ti_str11	0,105	0,105	0,013	
u_str12	1	1	0	
ti_str12	0	0	0,017	
u_str21	1	1	0	
ti_str21	0,1	0,1	0,01	
u_str22	0	0	2	
ti_str22	0,3	0,3	0	
$\nabla kpi'11$	0,069	-0,288	0,674	334,03%
fulfilment kpi'11	1	0	1	
$\nabla kpi'12$	0,418	0,04	0,348	770,00%
fulfilment kpi'12	1	1	1	
$\nabla kpi'21$	0,501	0,226	0,951	320,80%
fulfilment kpi'21	1	1	1	
$\nabla kpi'22$	0,376	0,141	1,307	826,95%
fulfilment kpi'22	1	1	1	
kpi'_1 (Distributor)	0,224	-0,122	0,511	518,85%
kpi'_2 (Manufacturer)	0,439	0,204	1,129	453,43%
$\boldsymbol{kpi'_{net}}$	**0,3315**	**0,041**	**0,82**	1900,00%

9.2.2.1.3 Sensitivity Analysis

When the decision maker of one enterprise is not sure about the values of influence $val\_str_{is}\_kpi_{ik}$ an estimation of an exact value for each parameter is not possible. Unlike, the decision maker defines a range of values among which he/she thinks it may be the values for $val\_str_{is}\_kpi_{ik}$; as a result $val\_str_{is}\_kpi_{ik} = [\alpha, ..., \beta]$.

In order to determine if the optimal solution changes when some of the influence values are considered, a sensitivity analysis is performed. With this sensitivity analysis, the enterprise will be able to identify the range of influence values from which the optimised solution changes. In the light of this, it will be determined if the optimal solution is sensitive to changes in the parameters $val\_str_{is}\_kpi_{ik}$. That is, if the optimal solution changes when the parameters $val\_str_{is}\_kpi_{ik}$ change.

The degree of robustness of the solution can also be identified by considering the amplitude of the range. If the solution changes for small ranges of $val\_str_{is}\_kpi_{ik}$ it will be stated that the solution is slightly robust; whilst the solution does not change for broad ranges of $val\_str_{is}\_kpi_{ik}$, it will be stated that the solution is robust enough.

Sensitivity analysis of the solution considering the parameters $val\_str_{11}\_kpi_{11}$ and $val\_str_{11}\_kpi_{12}$

Lets suppose that the distributor is not sure about the values of influence of $val\_str_{11}\_kpi_{11}$ and $val\_str_{11}\_kpi_{12}$. Is in this case when the enterprise defines a range of values among which thinks it may be the values of influence for both parameters, defining that $val\_str_{11}\_kpi_{11} = [0'2, ..., 0'6]$ and $val\_str_{11}\_kpi_{12} = [-0'35, ..., 0'35]$.

In this example, the solution of the collaborative scenario (Table 9.4) is considered as a base to compare with the solutions obtained from the sensitivity analysis. The optimal solution ($u\_str_{11} = 4{,}5$, $u\_str_{12} = 0$, $u\_str_{21} = 0$, $u\_str_{22} = 2$, $ti\_str_{11} = 0{,}013$, $ti\_str_{12} = 0{,}017$, $ti\_str_{21} = 0{,}01$, $ti\_str_{22} = 0$) is obtained considering the following values $val\_str_{11}\_kpi_{11} = 0.4$ and $val\_str_{11}\_kpi_{12} = 0$.

Next step is to determine if the optimal solution is sensitive to changes in the parameters $val\_str_{11}\_kpi_{11}$ or $val\_str_{11}\_kpi_{12}$, and to which extent.

To do that, the optimisation experiment is repeated the necessary times in order to determine if changes on the values imply changes on the optimisation results. For changes in the parameter $val\_str_{11}\_kpi_{11}$ the solution does not change therefore the optimal solution is rather robust (Table 9.5). For changes in the parameter $val\_str_{11}\_kpi_{12}$ the solution changes from the value -0,35, positive values of the parameter does not influence on the optimal solution, therefore it can be stated that the solution is less robust against changes on the parameter $val\_str_{11}\_kpi_{12}$ (Table 9.6). In both examples, it can be observed that, logically, the kpi_{net} changes when the values of influence change but the interesting change is that given in the decision variables.

Table 9.5. Example 9.1: Sensitivity Analysis ($val\_str_{11}\_kpi_{11}$)

kpi_{net}	0,766	0,779	0,793	0,806	**0,82**	0,833	0,847	0,86	0,874
u_str11	4,5	4,5	4,5	4,5	**4,5**	4,5	4,5	4,5	4,5
ti_str11	0	0	0	0	**0**	0	0	0	0
u_str12	0	0	0	0	**0**	0	0	0	0
ti_str12	0	0	0	0	**0**	0	0	0	0
u_str21	0	0	0	0	**0**	0	0	0	0
ti_str21	0	0	0	0	**0**	0	0	0	0
u_str22	2	2	2	2	**2**	2	2	2	2
ti_str22	0	0	0	0	**0**	0	0	0	0
$val\_str_{11}\_kpi_{11}$	0,2	0,25	0,30	0,35	**0,4**	0,45	0,50	0,55	0,60

Table 9.6. Example 9.1: Sensitivity Analysis ($val\_str_{11}\_kpi_{12}$)

kpi_{net}	**0,697**	0,739	0,753	0,766	0,779	0,793	**0,82**	0,847	0,86	0,874	0,887	0,901	0,914
u_str11	**4,166**	4,5	4,5	4,5	4,5	4,5	**4,5**	4,5	4,5	4,5	4,5	4,5	4,5
ti_str11	**0,405**	0	0	0	0	0	**0**	0	0	0	0	0	0
u_str12	**0**	0	0	0	0	0	**0**	0	0	0	0	0	0
ti_str12	**0,116**	0	0	0	0	0	**0**	0	0	0	0	0	0
u_str21	**0**	0	0	0	0	0	**0**	0	0	0	0	0	0
ti_str21	**0**	0	0	0	0	0	**0**	0	0	0	0	0	0
u_str22	**2**	2	2	2	2	2	**2**	2	2	2	2	2	2
ti_str22	**0,398**	0	0	0	0	0	**0**	0	0	0	0	0	0
$val\_str_{11}\_kpi_{11}$	**-0,35**	-0,3	-0,25	-0,2	-0,15	-0,10	**0**	0,10	0,15	0,2	0,25	0,3	0,35

9.2.2.2 Example 9.2. Network of 4 enterprises

The example proposed considers a CN with four enterprises, three performance indicators and four strategies. The main aim of carrying out this example is to model a larger CN, drawing a closer situation that could occur in a real case. As it has been stated, each enterprise defines three objectives, the achievement of the objectives is measured through three KPIs (kpi_{ixk}) each one with its corresponding weights (w_{ixk}). In order to achieve the objectives defined, each enterprise formulates four strategies and defines its related data as regards the durations and costs. The enterprises have a certain budget to carry on these strategies. All the data as regards the objectives and strategies defined in the example is shown in Annex 9.2, in which the values of influence that each strategy exerts on the defined KPIs are given. These values of influence were randomly created. Considering this, the scale of the problem has quadrupled, the decision variables has increased up to 32.

9.2.2.2.1 Collaborative Scenario

In the collaborative scenario the enterprises participating take into account the influences of all the strategies formulated by the enterprises. The optimisation experiment considering the mix of strategies is formulated as shown in Figure 9.12 The results derived from the optimisation are presented in Figure 9.13

and the results of the simulation experiment considering the input of the optimal solution are presented in Figure 9.14.

Optimization – Optimization Experiment

Parameter	Type	Value			
		Min	Max	Step	Suggested
u_S11	discrete	0	3.3	0.1	0.1
u_S12	discrete	0	2	1	1
u_S13	discrete	0	5	1	1
u_S14	discrete	0	2.50	0.1	0.1
u_S21	discrete	0	1.7	0.1	0.1
u_S22	discrete	0	2	1	1
u_S23	discrete	0	5	1	1
u_S24	discrete	0	3.3	0.1	0.1
u_S31	discrete	0	2.5	0.1	0.1
u_S32	discrete	0	2	1	1
u_S33	discrete	0	3.3	0.1	0.1
u_S34	discrete	0	3.3	0.1	0.1
u_S41	discrete	0	1.7	0.1	0.1
u_S42	discrete	0	2	1	1
u_S43	discrete	0	5	1	1
u_S44	discrete	0	3.3	0.1	0.1
c_Sis	fixed	{3, 5, 2, 4, 6, 5, 2, 3, 4, 5, 3, 3, 6, 5, 2, 3}			
ti_S11	continuous	0	1	0	0.1
ti_S12	continuous	0	1	0	0.1
ti_S13	continuous	0	1	0	0.1
ti_S14	continuous	0	1	0	0.1
ti_S21	continuous	0	1	0	0.1
ti_S22	continuous	0	1	0	0.1
ti_S23	continuous	0	1	0	0.1
ti_S24	continuous	0	1	0	0.1
ti_S31	continuous	0	1	0	0.1
ti_S32	continuous	0	1	0	0.1
ti_S33	continuous	0	1	0	0.1
ti_S34	continuous	0	1	0	0.1
ti_S41	continuous	0	1	0	0.1
ti_S42	continuous	0	1	0	0.1
ti_S43	continuous	0	1	0	0.1
ti_S44	continuous	0	1	0	0.1

Figure 9.12. Example 9.2: Optimisation Experiment for the Collaborative Scenario

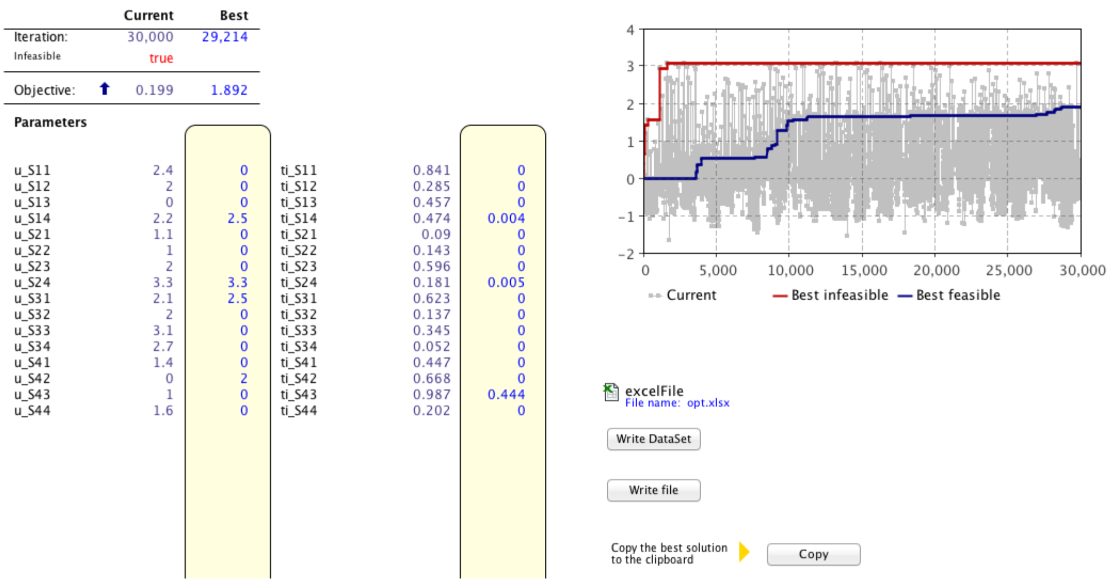


Figure 9.13. Example 9.2: Optimisation Experiment results for the Collaborative Scenario

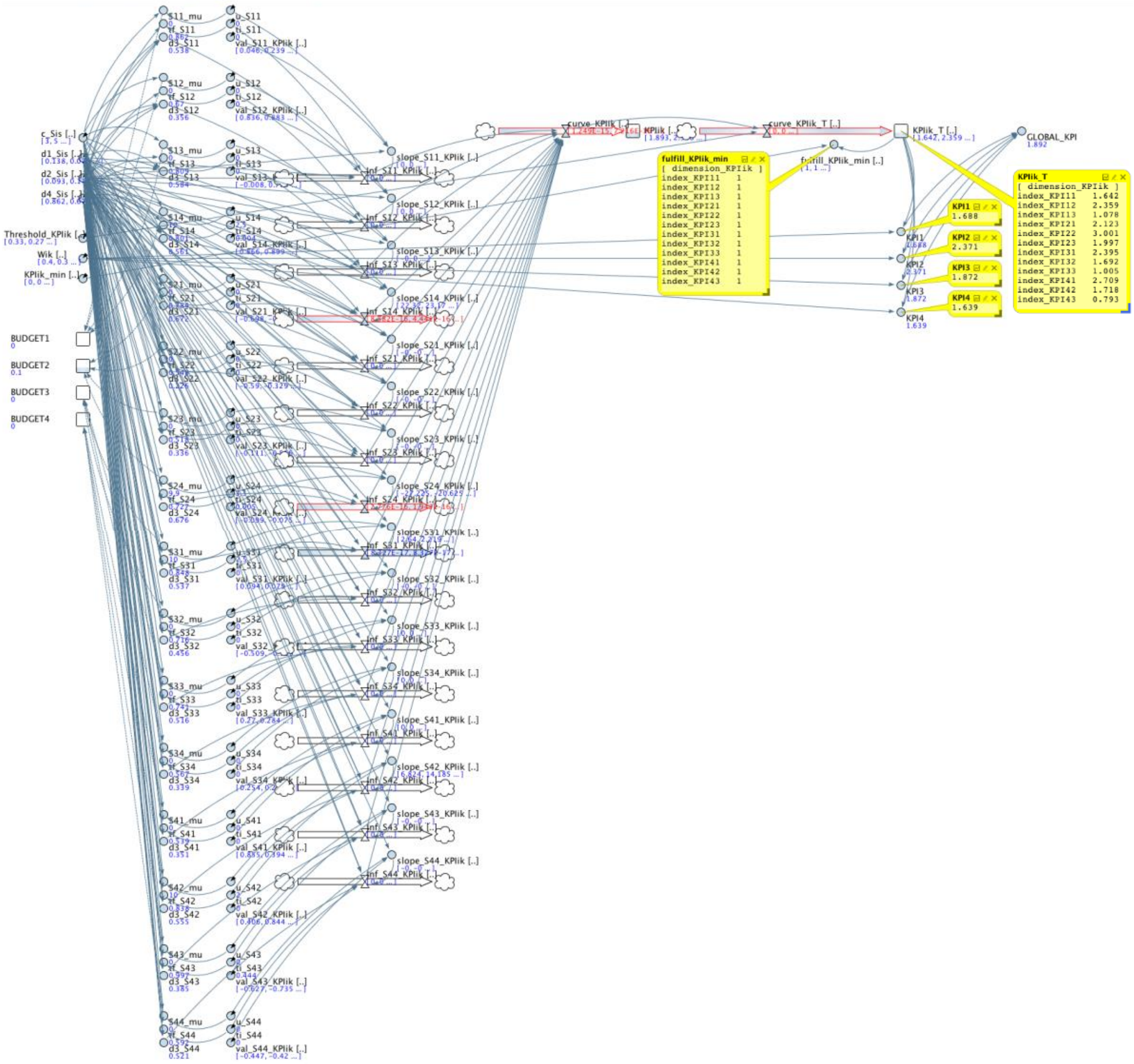


Figure 9.14. Example 9.2: Simulation Experiment Results. Flow diagram for the Collaborative Scenario

9.2.2.2.2 Non-Collaborative Scenario

For computing the non-collaborative scenario the procedure defined in Figure 9.2 has been applied. The optimisation results can be seen in the second column of the comparison presented in the next sub-section (Table 9.7). The flow diagram of the non-collaborative scenario (Figure 9.15) is obtained through the simulation experiment, which has been run considering the results obtained from the developed individual optimisation experiments (obtained in STEP 1).

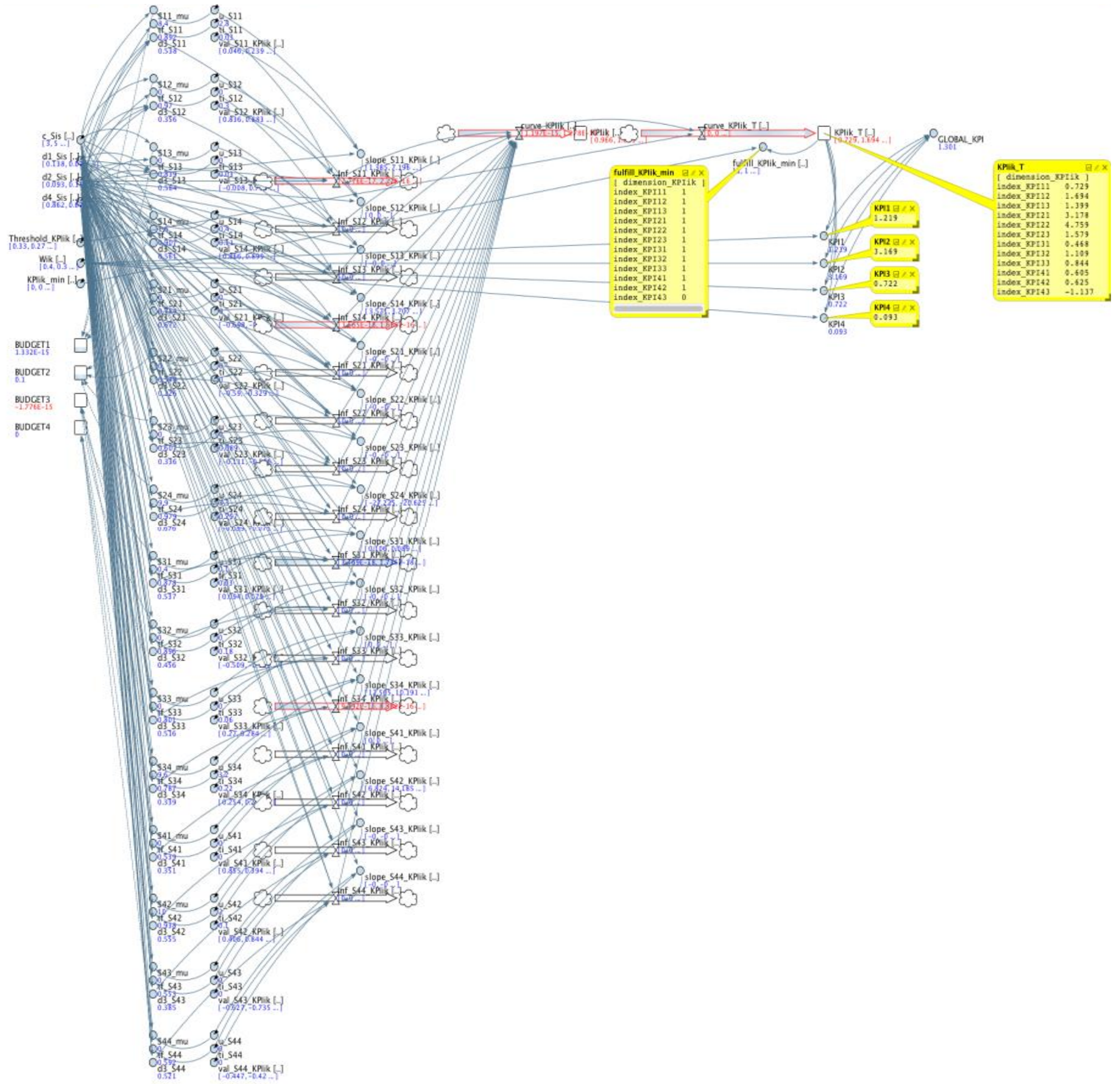


Figure 9.15. Example 9.2: Simulation Experiment Results. Flow diagram for the Non-Collaborative Scenario

9.2.2.2.3 Scenarios Comparison

As occurred in Example 9.1, in the Example 9.2, the optimised solution of the collaborative scenario (using the SAM) generates a level of network performance significantly higher than the performance resulting from the solution obtained in the non-collaborative scenario. Moreover, the solution obtained in the non-collaborative scenario breach the restriction of non-negativity of all the KPIs of the network. Whereas that the solution of the collaborative scenario complies with the restriction of non-negativity being the fulfilment of the KPIs higher than 0.

It can be observed that the performance at network level is higher in the collaborative scenario, but this, does not necessarily means that the performance indicators computed at the enterprise level improve in the collaborative scenario. It can be observed that the enterprise 2 achieves higher performance levels (kpi'_2) in the non-collaborative scenario. To this extent the network manager has to negotiate with the networked partners in order to adopt the solution that increases the performance level from a global perspective and not from an individual point of view.

Table 9.7. Example 9.2: Comparison of the collaborative and non-collaborative scenario

	Isolated Enterprises (STEP 1: intra-enterprise)	**Non-collaborative Scenario (STEP 2: inter-enterprise)**	**Collaborative Scenario**	**Percentage Improvement**
Perstr11	2,8	2,8	0	
ti_str11	0,03	0,03	0	
str12	0	0	0	
ti_str12	0,3	0,3	0	
str13	0	0	0	
ti_str13	0,03	0,03	0	
str14	0,4	0,4	2,5	
ti_str14	0,11	0,11	0,004	
str21	0	0	0	
ti_str21	0	0	0	
str22	0	0	0	
ti_str22	0	0	0	
str23	0	0	0	
ti_str23	0,089	0,089	0	
str24	3,3	3,3	3,3	
ti_str24	0,257	0,257	0,005	
str31	0,1	0,1	2,5	
ti_str31	0,03	0,03	0	
str32	0	0	0	
ti_str32	0,18	0,18	0	
str33	0	0	0	
ti_str33	0,06	0,06	0	
str34	3,2	3,2	0	
ti_str34	0,22	0,22	0	
str41	0	0	0	
ti_str41	0	0	0	
str42	2	2	2	
ti_str42	0,1	0,1	0	
str43	0	0	0	
ti_str43	0	0	0,444	
str44	0	0	0	
ti_str44	0	0	0	
∇*kpi'111*	1,561	**0,729**	1,642	125,24%
fulfilment kpi'111	1	1	1	
∇*kpi'121*	0,702	**1,694**	2,359	39,26%
fulfilment kpi'121	1	1	1	
∇*kpi'131*	1,712	**1,399**	**1,078**	-22,94%
fulfilment kpi'131	1	1	1	
∇*kpi'211*	1,662	**3,178**	**2,123**	-33,20%
fulfilment kpi'211	1	1	1	
∇*kpi'221*	1,998	**4,759**	**3,001**	-36,94%
fulfilment kpi'221	1	1	1	
∇*kpi'231*	2,101	**1,579**	1,997	26,47%
fulfilment kpi'231	1	1	1	
∇*kpi'311*	1,059	**0,468**	2,395	411,75%
fulfilment kpi'311	1	1	1	
∇*kpi'321*	1,233	**1,109**	1,692	52,57%
fulfilment kpi'321	1	1	1	
∇*kpi'331*	1,292	**0,844**	1,005	19,08%
fulfilment kpi'331	1	1	1	
∇*kpi'411*	1,094	**0,605**	2,709	347,77%
fulfilment kpi'411	1	1	1	
∇*kpi'421*	0,883	**0,625**	1,718	174,88%
fulfilment kpi'421	1	1	1	
∇*kpi'431*	0,503	**-1,137**	0,793	169,74%
fulfilment kpi'431	1	**0**	1	
kpi'_1	1,349	**1,219**	1,688	38,47%
kpi'_2	0,959	**3,169**	**2,371**	-25,18%
kpi'_3	0,387	**0,722**	1,872	159,28%
kpi'_4	0,203	**0,093**	1,639	1662,37%
$\boldsymbol{kpi'_{net}}$	**0,7245**	**1,301**	**1,892**	45,43%

9.3. Chapter discussion and conclusions

In this chapter two illustrative examples are proposed in detail in order to validate the model, method and tools proposed to solve the strategies alignment process in a CN. Two scenarios are considered in each example, the collaborative and the non-collaborative scenario. Concluding that, collaborative scenarios result on decisions that generate higher levels of performance. Nevertheless, not all the performance indicators at enterprise levels will be increased in the collaborative scenarios. The usefulness of these experiments is to show the different values obtained when different conditions are considered.

Scenarios considering a set of macro strategies defined at network level could be also considered for its modelling with the main aim of aligning these macro strategies with the strategies defined at enterprise level and compute the decision variables that generate maximum levels of performance at network level.

In order to perform a complete assessment, a sensitivity analysis is performed, allowing determining which of the modelled parameters $val\_str_{is}\_kpi_{ik}$ influence on the optimal solution, as regards the decision variables, when aligning strategies.

The empirical experiments (*Examples 9.1 - 9.2*) proposed in this chapter allowed to validate the model, method and tools proposed to deal with the strategies alignment problem. The main contributions of each of the examples proposed are described in Table 9.8.

Table 9.8. Contribution of the provided numerical examples

Purpose	**Ex. 9.1**	**Ex. 9.2**
To model a CN with a reduced number of enterprises, strategies and KPIs	✓	
To model a CN with a considerable number of enterprises, strategies and KPIs (closer to a real CN magnitude)		✓
To show examples of the defined objectives and formulated strategies	✓	
To model a CN in which different type of strategies are formulated (strategies acquiring binary, discrete and continuous values)	✓	✓
To show optimisation and simulation results	✓	✓
To show how to select the most appropriate solution through defining selection rules, when the optimisation experiment brings more than one optimal solution.	✓	
To show how to model and solve the strategies alignment process in a collaborative scenario	✓	✓
To show how to model and solve the strategies alignment process in a non-collaborative scenario	✓	✓
To show a comparison between the solutions obtained in the two scenarios modelled (collaborative and non-collaborative)	✓	✓
To show how to perform the sensitivity analysis	✓	

While carrying out the Example 9.2, some limitations were observed:

- The optimisation experiment, in the simulation software used, is based on a combinatory resolution method. The number of iterations required to solve the modelled problem depends on the number of enterprises, the performance indicators defined and the strategies formulated. Moreover, the definition of continuous parameters or discrete parameters with small step values exponentially increase the resolution complexity, disproportionally increasing the number of combinations of the solutions. Therefore, the definition of the number of iterations must be decided for each problem according to its size. Considering this, the appropriate number of iterations used in small problems (Example 9.1) is 5000 and in higher problems (Example 9.2) is 100000.
- The Example 9.2 was extended to five enterprises, each one defining 3 KPIs and formulating 4 strategies. The number of the strategies increased on 20, having a total of 40 decision variables (u_str_{is}, ti_str_{is}). The number of restrictions also increased to 40 (5 capacity constraint + 20 time constraint + 15 KPIs fulfilment). When carrying out the optimisation experiment the decision variables remained in 0 and no solution was obtained, considering

100000 iterations. Requiring longer periods of time (more than 1440 minutes), which at the end are time consuming. It is because of the size of the SAM that the simulation software does not provides any solution due to there are too much variables and, therefore, to much combinations and restrictions to accomplish. At this point, it can be stated that the optimisation experiment, carried out in the simulation software used to solve the SAM, is not valid for big problems, with more than 40 decision variables and more than 40 restrictions. The time consuming of the optimisation experiment is more than one 24 hours when the number of variables increase.

- Another limitation related with the combinatory resolution method is that when running the optimisation experiment in the same problem (with the same number of iterations) it could happen that different optimisation results are obtained. It is again when the proper definition of the number of iterations is crucial in order to always obtain the same optimal solution.
- The simulation software does not accept more than 265 characters due to Java restrictions, when defining the names of the parameters and the decision variables modelled. Therefore the number of decision variables, strategies and KPIs, modelled in AnyLogic is restricted to 80. For example, in a network of 10 enterprises, the maximum number of strategies to model for each enterprise is restricted to 4 and the maximum number of KPIs is limited to 4.
- The number of iterations in the optimisation experiment is defined by user. Depending on the number of variables the user has to estimate the number of iterations. Some times the definition of the number of iterations is uncertain, so that it depends on the experience of the modeller, when solving this specific problem of strategies alignment.
- The gap of the optimiser used by the simulation software is not know due to limitations of the commercial solver used by AnyLogic to solve the optimisation experiment
- Better and quicker solutions are obtained with AnyLogic University version in Macintosh Operating System (Mac OS). The same problem modelled and solved with AnyLogic Professional in Windows Operating System provide worse results and the optimisation experiment lasts more time to be performed. According to AnyLogic support service, AnyLogic is the same for Windows and Mac OS. Both installation packages include the same modules. Therefore, no explanation was found for this limitation observed in AnyLogic Professional in Windows Operating System. Motivated by this situation, the optimisation experiments performed in this thesis were run using AnyLogic University version in Macintosh Operating System (Mac OS).

9.4 References

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Annex 9.1. Example 9.1: Solutions for the Collaborative Scenario

Accessible in: https://goo.gl/KrSdvh

Annex 9.2. Example 9.2: Data

Accessible in: https://goo.gl/cEHEXe

Chapter 10

Real Application

In this chapter, two real cases of application are considered to validate the proposed contribution in industrial scenarios. The strategies alignment model is applied in pilots of two different industries, food and automotive. The validation through real networks has served to show the implementation usefulness of the model, method, tool and guideline proposed, in Chapters 5, 6, 7, and 8, to deal with the problem addressed in this thesis, the strategies alignment process within the context of a CN.

10.1 Introduction

Throughout this chapter, an application of the contribution proposed in this thesis, consisting of a model, a method, a tool and a guideline (respectively presented in of Chapters 5, 6, 7 and 8), is carried out in two pilots belonging to the food and automotive industries. This is the first experience, offered by the author, in which the proposed contribution is applied in a real case, to address the strategies alignment process, within a CN context.

Two are the pilots considered for the application of the strategies alignment model (SAM):

- Pilot 1. Food Industry: Collaborative network consisting of two enterprises: the manufacturer and the distributor. The exchange of information is characterised by following a complete collaborative scenario (recall CS3 characterised in Chapter 8). Complete exchange information, regarding the strategies and the objectives, is established among all the network partners.
- Pilot 2. Automotive Industry: Collaborative network consisting of two enterprises: the first and second tiers. The exchange of information is characterised by following a partial collaborative scenario (recall CS1 characterised in Chapter 8). A minimum exchange of information, as regards the KPIs, is established among the network partners. The information as regards the strategies formulated in each enterprise remains private.

The initial goal of this real application is to support, to all the enterprises belonging to the Pilots, on the collaborative decision-making of identifying which strategies activate in each enterprise, amongst all those initially formulated. The main aim of applying the strategies alignment complete approach leads to identify and select the set of strategies to activate in each enterprise that positively influence the majority of the objectives defined by each enterprise of the network, so that if there are negative influences there are kept to the minimum. The obtained set of aligned strategies will result from the application of the artefacts proposed in this thesis. The proposed strategies alignment guideline (SAG) is used in order to support the participating enterprises in the process of estimation of all the parameters required to feed the SAM, as well as in the process of information exchange.

In the following sections, the process of application of the Strategies Alignment Approach is described, and the results derived from its implementation in two real industrial Pilots are presented and analysed. The two pilots considered for the establishment of the strategies alignment process, in a collaborative way, are described in Section 10.2. Within the Pilots the implementation of (i) the mathematical model: SAM, (ii) the method: System Dynamics, (iii) the tools: AnyLogic simulation software, Microsoft DMS and SAGEN application, and (iv) the guideline: SAG, is carried out. The needs identified in the Pilots under study, in terms of strategies alignment, are identified in Section 10.3. After that, a kick off meeting is carried out in each of the enterprises, participating in the Pilots, in which the strategies alignment process is introduced (Section 10.4). A detailed guide for data collection is introduced in Section 10.5, in order to support enterprises with the data gathered in order to feed the SAM. The results obtained through the implementation of the proposed contribution, to collaboratively deal with the strategies alignment process, is shown in Section 10.6 (for Pilot 1), and Section 10.7 (for Pilot 2). After the implementation, a survey was conducted to all the enterprises participating in both Pilots; the results are reported in Section 10.8. Finally, a discussion of the work carried out in the validation process in the real industrial Pilots is given in Section 10.9.

10.2. Pilots Description

10.2.1. Pilot 1: Food Industry Network

The network under study, in Pilot 1, is located in Spain, in the province of Valencia, and operates within the food industry. Two are the companies that take part in the network studied in Pilot 1, acquiring the role of manufacturer and distributor. For confidentiality reasons, the names that are used throughout this chapter to allude companies are fictitious.

The two partners of the food industry network establish a collaborative relationship when carrying out their business. The distributor is interested in developing a total quality model (TQM) in its business and in this TQM model the manufacturer develops a fundamental role. Thus, the two enterprises determine that their relation is based on the trustiness, stability, constant work and jointly commitment in order to achieve a common goal that leads to satisfy the needs of the final customer providing greatest value on the market. These two enterprises work with a clear logic: running sum games, in which both the manufacturer and the distributor win. Besides, these two network partners jointly work to improve the execution of the shared processes.

The partners of the food industry network, conforming the Pilot 1, apply the collaborative scenario CS3. As a reminder, the CS3 is characterised by the complete exchange of information exchange about the (i) definition of KPIs and the parameters associated, (ii) definition of the units of strategies, and the parameters associated, such as the costs of the strategies, and (iii) the budget. All the enterprises of the network (i and j) are involved in the jointly estimation of all the values of influence ($val\_str_{is}\_kpi_{ik}$, $val\_str_{is}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{jk}$, $val\_str_{js}\_kpi_{ik}$)

In respect of the enterprises participating in the Pilot 1, two are the agents participating in the data collection process required to feed the strategies alignment model: (i) on behalf the manufacturer the Business Analyst of the Commercial Department has participated, (ii) on behalf the distributor the responsible of the Area of Strategy and Business Development has been involved.

10.2.2. Pilot 2: Automotive Industry Network

The network under study, in Pilot 2, is also located in Spain, in the province of Valencia, and operates within the automotive industry. Two are the companies that take part in the studied network, acquiring the role of first and second tiers. For confidentiality reasons, the names that are used throughout this chapter to allude companies are fictitious.

The two partners of the automotive industry network establish a minimum collaborative relationship when carrying out their business. Accordingly, the collaborative scenario applied in this Pilot 2 is the CS1. As a reminder, the CS1 is characterised by the minimum exchange of information. Only the information regarding the KPIs defined is exchanged. The values of influence ($val\_str_{is}\_kpi_{ik}$ and $val\_str_{is}\_kpi_{jxk}$) are estimated by each enterprise considering its own information and the information exchanged about the KPIs. Enterprise i estimates the impact that its strategies would have in its own objectives and the objectives defined by Enterprise j, and vice versa. In this case, the network manager (if required), according to the expertise and the knowledge acquired, could assess the Enterprise i on estimating $val\_str_{is}\_kpi_{ik}$ and $val\_str_{is}\_kpi_{jx}$, and the Enterprise j on estimating $val\_str_{js}\_kpi_{jk}$ and $val\_str_{js}\_kpi_{jx}$.

In respect of the enterprises participating in the Pilot 2, two are the agents participating in the data collection process required to feed the strategies alignment model: (i) on behalf the second tier the Production/Planner Manager has participated, (ii) on behalf the first tier the logistic manager and the plant manager have been involved.

10.3. Identification of the Pilots needs

During the decision-making of what strategies activate, each enterprise of the network formulates its own strategies and carries out the ones that are considered appropriate. Therefore, each enterprise activates the strategies that generate good performance and that allow reaching each enterprise objectives. So far, the enterprises make this decision without considering how the activated strategies affect the other network partners. Thus, a gap in the enterprises decision-making is identified; considering that, if the activated strategies were aligned, the benefits could probably increase, enhancing the individual and network profits, and improving the collaborative relationship established among the network partners.

Thus, in the enterprises belonging to *Pilot 1* and *Pilot 2* a gap is identified when deciding which strategies activate in order to generate positive improvements in all the objectives defined by all the network partners. Motivated by this situation, the proposed strategies alignment model, method, tools and guideline were implemented in order to deal with the decision-making of which strategies to activate, considering the collaborative perspective, with the main aim of identifying the aligned ones.

The main problems to solve in the strategies alignment process and the expected results are listed next:

<u>Problems to solve</u>

The decision-making process referred to the strategies activation is currently performed from a non-collaborative perspective. To that effect, the enterprises decide from an isolate way which strategies to activate without considering how these strategies will influence the other network partners. The activation of strategies is done by considering a very simple process based on the increase of profits for the enterprises. Nevertheless, the enterprises must be aware of taking into account other performance indicators. Thus, all the KPIs defined to measure the enterprises objectives have to be considered, as all these KPIs will be influenced by the activation of strategies, in both the same enterprise and other network enterprises. The observed problems, when performing the strategies alignment process from an isolated perspective, are:

- Lack of consideration of all the strategies from an holistic perspective, that is taking into account the strategies defined in the same enterprise and in the other network partners
- Lack of consideration of all the KPIs, and the influences that the strategies have on their attainment
- Misalignment on the strategies activated. The strategies activated do not favour the objectives of all the enterprises participating in the network.
- Partnerships failure when establishing collaborative relationships
- Selfish behaviours
- Reduction of the performance at the network level

<u>Expected Results</u>

Currently, the enterprises activate those strategies that provide benefits for themselves so that a non-collaborative relationship is established. The implementation of the strategies alignment model will support enterprises on the decision of which strategies to activate from a collaborative context, achieving:

- Increase of the network performance level
- In most of the cases the increase of the individual enterprises performance. It would happen that the increase in one KPI will be generated at the expense of anther KPI (the reduction of performance level of another KPI)
- Improvement of the collaborative relationships due to the decision of strategies selection, of what are the strategies to activate, will be objectively made, by equally considering all the enterprises' objectives and strategies.

Definitely, collaboratively performing the strategies alignment process will allow to (i) show SMEs how they are currently making decisions when selecting the strategies to activate, (ii) to show SMEs how to collaboratively make decisions with the main aim of selecting aligned strategies and (iii) to train companies in the decision-making process so that they collaboratively perform the selection of aligned strategies. The strategies alignment approach offers decision makers a new vision of the problem of selecting strategies, from a global perspective within the CN context. Hence, decision-makers not only consider the achievement of the objectives of their company, but also take into account the influences that strategies have on the objectives of other network partners

The contribution developed in this thesis is implemented in two industrial Pilots, considering a reduced amount of enterprises. Nevertheless, the implementation of the complete approach to deal with the strategies alignment process could be extended in the future for modelling the strategies and KPIs of other network partners belonging to the network of the validated Pilots.

10.4. Kick of meeting

The way in which the strategies alignment model is applied in Pilot 1 and Pilot 2 and the results obtained from the application of the SAM is shown in sections 10.6 and 10.7, respectively. Before that, the kick of meeting carried out, separately, in each of the enterprises participating in both pilots, is presented.

First of all, the participants, in the study of the strategies alignment process, are identified:

- The interviewed people belonging to the enterprises, in charge of providing the required data. It will normally acquire the role of the enterprise manager
- The expert in the strategies alignment process, also in charge of analysing the model results. It will normally acquire the role of the network manager.

A first meeting was arranged with each of the enterprises participating in Pilot 1 and Pilot 2. The main aim of the meeting was to explain how the strategies alignment process works. In the light of this, and in order to show the interest of aligning strategies, a presentation was performed explaining the effectiveness and increase on network performance, as well as the improvement of relationships generated from the activation of aligned strategies. Next points were treated in the introductory meeting:

- The need from the enterprises of the Pilots to define a set of objectives. The defined objectives are reached from the activation of the formulated strategies. The objectives have the characteristic of being measurable; therefore, all the objectives have associated, for its measurement, at least one key performance indicator (KPI).
- The formulation of a set of strategies to reach the defined objectives. Each strategy has an associated cost when activated.
- The definition of a budget that will be devoted to the activation of the strategies previously formulated.
- The consideration that amongst all the formulated strategies, the enterprises have to activate some of them in order to accomplish and attain the defined objectives, at the minimum cost. The main aim is to maximise the performance at both enterprise and network level.
- The importance of identifying the influences that each of the formulated strategies have in the objective attainment.
- The use of KPIs to measure the objectives' attainment. Therefore, the activation of a particular strategy will influence on the KPIs level, defined to measure the objectives.
- The strategies alignment process is modelled by considering the KPIs increase/decrease to identify how the strategies activated influence on the objectives achievement.
- The consideration of that the strategies alignment model takes into account, at the same time, the strategies formulated in all the enterprises of the network and its influence in all the objectives defined (by each of the enterprises of the CN). Therefore, in order to compute the KPIs increase there are considered not only the strategies activated in one enterprise, but also the strategies activated by other network partners.
- The definition of two types of scenarios when modelling the strategies alignment process. The collaborative scenario, in which the enterprises consider common perspective in the decision-making

of which strategies activate, so that all the strategies and all the KPIs (and therefore objectives) are taken into account. And the non-collaborative scenario in which the decision is made from an isolated perspective, so that each enterprise only considers the its strategies and KPIs. In the non-collaborative scenario the strategies formulated in other enterprises and the influences they have in the objectives defined by other enterprise are not considered in the decision-making of which strategies to activate. The results obtained in the collaborative scenario are compared with the ones obtained in the non-collaborative scenario.

An illustrative example modelling a network of two enterprises in both scenarios, non-collaborative (Figure 10.1) and collaborative scenario (Figure 10.2) is presented to the enterprises of the Pilots in order to show the improvements obtained when aligning the strategies; showing the increase of KPI, in the collaborative perspective.

In Figure 10.1 the non-collaborative scenario is represented. The enterprise A and the enterprise B only consider how their own strategies affect in the achievement of their own objectives. This is not a real situation, as the strategies formulated by one partner influence on the achievement of other partners' objectives. The enterprise A and the enterprise B select, on an individual basis, the strategies to activate taking into account the importance of reaching one objective or another. Considering the strategies formulated and the objectives defined (see Figure 10.1), the decisions reached in the non-collaborative scenario are described below:

- Enterprise A → Decides to activate Strategy 1 (Str_{1A}) that favours the achievement of its Objective 1, (Obj_{1A}), considered very relevant for the enterprise A. The decision of enterprise A of activating the Str_{1A} negatively influences the achievement of the Objective 1 of the enterprise B (Obj_{1B}) due to the increase of the net demand on an exclusive market segment will be fostered by the good quality of the products. Str_{1A} goes completely in opposite direction, reducing quality package in supplied products.
- Enterprise B → Decides to activate Strategy 1 (Str_{1B}) that favours the achievement of its Objective 1 (Obj_{1B}), considered very relevant for the enterprise B. The decision of enterprise B of activating the Str_{1B} negatively influences the achievement of the Objective 1 of the enterprise A (Obj_{1A}). The strategy Str_{1B} for promoting exclusive products is not aligned with Obj_{1B} that measures the reduction of costs, due to the exclusivity is related with the increase of costs.

Each enterprise of the network selects the strategies according to the objectives defined by each one. In the non-collaborative scenario, the increase of the performance level of each objective (Obj_{1A} / Obj_{1B}) is not real, due to the enterprises do not have the negative and positive influences of the strategies activated by other partners. That is, the enterprise A does not consider the negative influences on its KPIs of the strategies activated by the enterprise B, the same happens with the enterprise B when deciding what are strategies to activate.

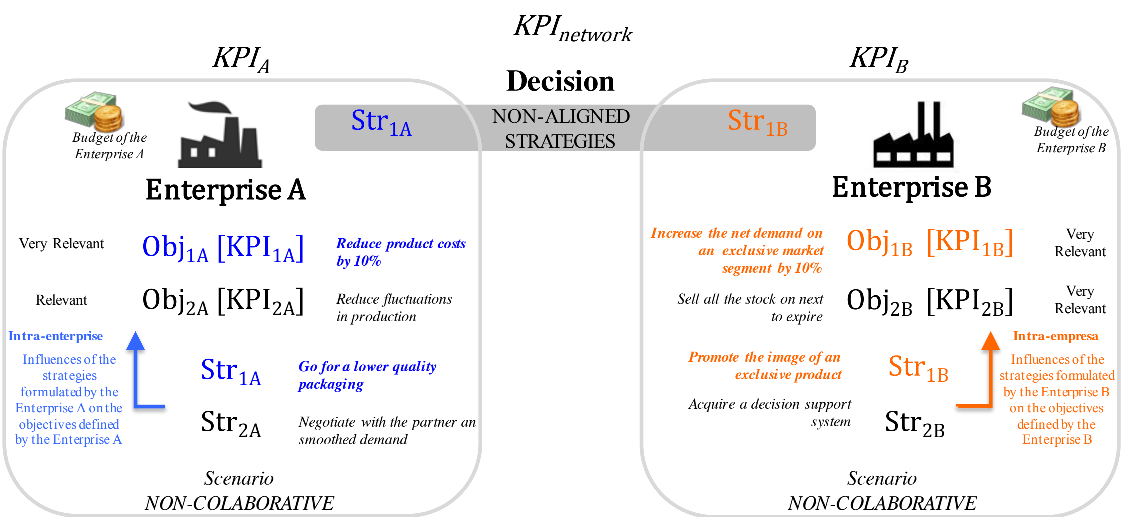

Figure 10.1. First Meeting: Non-Collaborative Scenario Illustrative Example

In Figure 10.2 the collaborative scenario is illustrated. The enterprise A considers how their own strategies and the strategies formulated by enterprise B affect on the achievement of all the objectives defined by both enterprises. The enterprise B proceeds in the same way. The collaborative scenario models a realistic situation due to all the strategies are taken into account to compute the performance level of all the objectives. Looking at Figure 10.2, in the collaborative scenario the enterprise A and the enterprise B take into account (i) the positive influence that the strategy 2, formulated by enterprise B, has on the objectives of the Enterprise A ■ and (ii) the negative influence that the strategy 1, formulated by the enterprise A, has on the objective 1 of the enterprise B ■.

Considering all the strategies formulated and the objectives defined, the decisions reached in the collaborative scenario are described below:

- Enterprise A → Decides to activate Strategy 2 (Str_{2A}) that favours the achievement of its Objective 2, (Obj_{2A}). In enterprise A, the decision of activating the Str_{2A} positively influences the achievement of the Objective 2 of the enterprise B (Obj_{2B})
- Enterprise B → Decides to activate Strategy 2 (Str_{2B}) that favours the achievement of its Objective 1 (Obj_{2B}). In enterprise B, the decision of activating the Str_{2B} positively influences the achievement of the Objective 2 of the enterprise A (Obj_{2A})

When considering the collaborative scenario, the increase of the performance level of each objective (Obj_A / Obj_B) is real, due to the enterprises take into account the negative and positive influences of the strategies activated by other partners. That is, the enterprise A considers the negative/positive influences exerted by the strategies of enterprise B in its own KPIs. The same occurs in the enterprise B when deciding which strategies to activate.

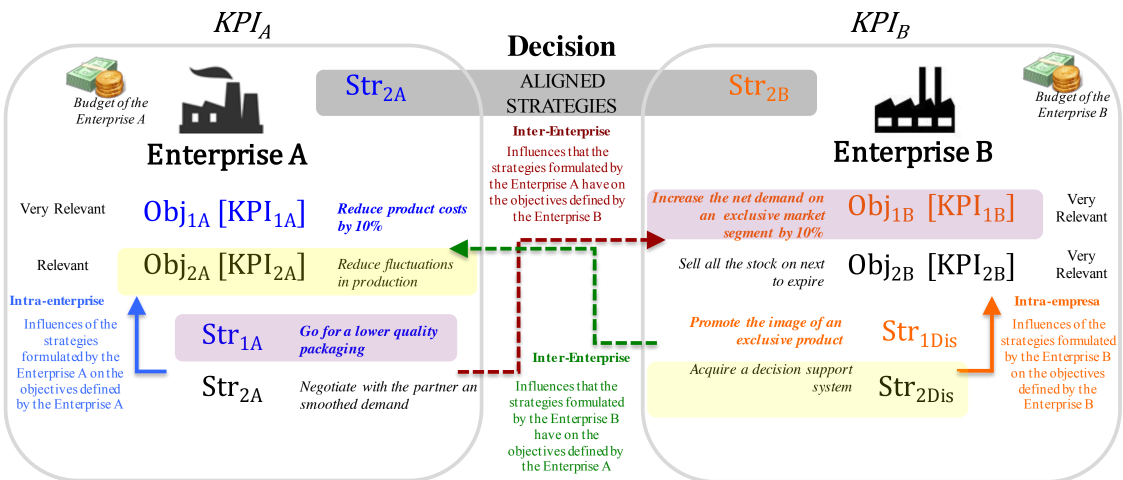

Figure 10.2. First Meeting: Collaborative Scenario Illustrative Example

Before finalising the kick of meeting, and once introduced the strategies alignment process and presented the illustrative example, the enterprises were asked to think on a set of objectives interesting to measure and a set of strategies to carry out. In the following meeting these objectives and strategies will be used for identifying the influences and applying the strategies alignment model (SAM), method, tools and guideline (SAG).

10.5. Detailed Guide for Data Collection

When collecting data from the enterprises, in the data collection stage (*Chapter 8*. *Guideline*: *Phase 3 KPIs definition* and *Phase 4 Strategies formulation*), an extended explanation was needed. In the meetings carried out with each of the enterprises of Pilot 1 and 2 a comprehensive explanation of the meaning of the parameters defined in the mathematical formulation of the SAM is required. A Detailed Guide for Data Collection is proposed at this stage of validation. Eleven steps are described in this detailed guide in order to obtain all the required data. The way the steps are described, enable asking the enterprises about the parameters required to feed the SAM, in an understandable way; facilitating the process of collecting data. Specifically, the values related with parameters characterising the strategies, $d_{1}\_str_{is}$, $d_{2}\_str_{is}$ and the KPIs, $Threshold\_kpi_{ik}$, kpi_{ik}_min are not trivial when giving an estimation. The steps followed to collect all the parameters included in the SAM are described next (see Figure 10.3):

Step 1. The Enterprise defines a set of objectives (for example, increase sales, reduce stock, reduce costs, etc.). The Enterprise defines a set of key performance indicators (kpi_{ik}) that quantify aspects that could serve to determine the objectives attainment. For example "Reduce the stock level", referred to the percentage of the reduction in stocks in comparison with the previous year. The enterprises also define the maximum level of KPI to achieve. For example, reduce by a 100% the stocks in the enterprise (this would be an ideal situation).

Step 2. The Enterprise elaborates a list of strategies (u_str_{is}) that could serve to achieve the defined objectives. An example is proposed to the enterprises in order to have a better insight. For example, "Acquire a new tool to support the Production Planning process". A brief description of the formulated strategies is also required.

Step 3. Assign a cost to the formulated strategy (c_str_{is}). Each strategy has an associated cost. To assign the costs, it is enough to define a fictitious value, which does not have to mean the real monetary units required to implement a strategy. The strategies costs are proportional one another. That is, if the Strategy 1 has a cost that is half the cost of Strategy 2, the enterprise will consider that: Cost of Strategy 1 = 5 and Cost of Strategy 2 = 10

Step 4. Estimate the Budget (b_i). Monetary units that the company owns to carry out the strategies. The budget will be defined in proportion to the cost determined by each strategy.

Step 5. Determine the total length of the formulated strategy ($d_{4}\_str_{is}$). Each strategy has a duration in time. The duration may be permanent or it may be a defined by a number. For example, lets suppose that the strategy "Acquire a new tool to support the Production Planning process" lasts 8 months.

Step 6. Estimate the Strategy Delay ($d_{1}\_str_{is}$). Estimate the time elapsed since the strategy is activated until the strategy starts to influence the performance level of the KPI. As example, the strategy "Acquire a new tool to support the Production Planning process" is activated in the 1st February. But since the strategy is activated until the strategy begins to take effect in the KPI (Reduce the Stock level) passes a time period, which is defined by the delay of the strategy ($d_{1}\_str_{is}$). This delay may be caused by the previous analysis of needs, previous meetings to know the AS IS scenario in which the production planning is performed, the time required to program the tool, the time required to build the optimisation algorithms embedded in the tool, etc. In the illustrated example $d_{1}\_str_{is}$ =1 month, see Figure 10.3.

Step 7. Estimate the length of time that the strategy needs for generating the maximum influence (or increase) in the KPI ($d_{2}\_str_{is}$). The influence that the strategy formulated "Acquiring a new tool to support the Production Planning process" has on the defined KPI "Reducing the stock level" is not immediate, but is considered progressive. There is a period of time since the tool starts to work in the enterprise until the tool runs itself and automatically calculates the optimised Production Plan. The duration $d_{2}\_str_{is}$ is associated with the learning curve, in which the tool may have to undergo improvement processes, while it is used. In the illustrated example $d_{2}\_str_{is}$ = 1'5 months, see Figure 10.3.

Step 8. The enterprise estimates how the defined KPIs would vary if each of the strategies were activated. This estimated value is gathered in the parameter $val\_str_{is}\_kpi_{ik}$. Some strategies will positively affect the KPIs, while others will negatively affect. Lets suppose that the strategy "Acquiring a new tool to support the Production Planning process" is activated: determine the value in which the KPI is positively influenced (percentage of the reduction in stocks). For example $val\_str_{is}\_kpi_{ik}$ = 10 (positively influencing). The values of influence are also proportionally estimated one another, the same as done when estimating the strategies costs. Phase 6 of the Strategies Alignment Guideline (SAG) has to be followed in order to obtain these values. The parameters $val\_str_{is}\_kpi_{ik}$ and $val\_str_{is}\_kpi_{jk}$ are estimated in a different way depending on the Collaborative Scenario selected (EVI_CS1, EVI_CS2, EVI_CS3).

Step 9. Value of the kpi_{ik} below of which it is considered that the influence is null ($Threshold\_kpi_{ik}$). In the example (see Figure 10.3) is noted that, during the period in which the KPI begins to increase, on 1st March the strategy works at 0%, the 1st April the strategy is working at 70%. On 15th April the strategy is working at 100%. The question to answer in this step, to determine the parameter related with the $Threshold\_kpi_{ik}$, is: *From what percentage of the learning curve (defined in the step 6) the strategy str_{is} is starting to provide a positive value to the kpi_{ik}?* In the illustrated example, until the strategy does not generate an increase of 10% in the learning curve, it is considered that the strategy is not influencing the kpi_{ik}. The $Threshold\_kpi_{ik}$ will be estimated from the percentage here estimated.

Step 10. Minimum increase desired for the KPI (kpi_{ik}_min). The effort to activate the strategies is offset by the minimum achievement of the performance levels in the KPIs defined. The enterprise has to estimate what is the minimum increase/decrease to be observed in the KPIs. If the maximum increase/reduction is defined by the 100% (recall that in the step 2 the reduction of the stock could be minimised to 0 units), the enterprise defines the minimum percentage that at least the KPI should reach, considering the maximum value defined. In the example, it could be stated that the enterprise estimates that the KPI "Reducing the stock level" should arrive at the 5% of reduction, to compensate the effort of activating the strategies.

Step 11. Importance of the kpi_{ik} (w_{ik}). The KPIs defined in each enterprise are characterised by having different levels of importance/relevance for the enterprise. The enterprises will define by a percentage the importance of each kpi_{ik} defined, considering that $\sum_k w_{ik} = 100\%$.

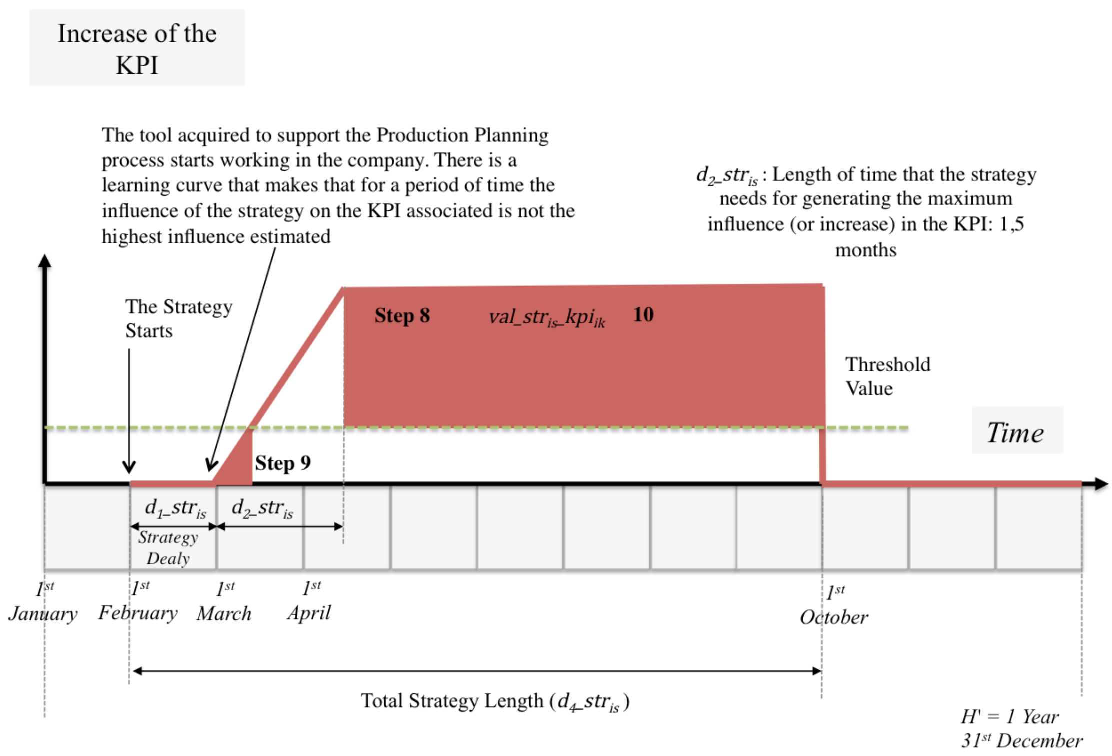

Figure 10.3. Illustrative Example: Graphical representation of SAM parameters

The list parameters obtained from the enterprises that can be directly used as an input in the SAM are: u_str_{is}, c_str_{is}, b_i, kpi_{ik}, $val\_str_{is}\_kpi_{ik}$, $val\_str_{is}\_kpi_{jk}$, w_{ik}.

The rest of parameters have to be treated in order to make them suitable for input to the model (see sub-sections 10.5.1, 10.5.2 and 10.5.3).

10.5.1. Treatment of the parameters characterising the strategies: $d_1\_str_{is}$, $d_2\_str_{is}$, $d_4\_str_{is}$

Usually, the enterprises estimate the value of duration parameters in months. Regardless of the time units used by enterprises to estimate, the parameters of duration and time should be introduced in the model considering as a base the unit. Recall that the horizon simulated in the SAM is *H'=1*. Therefore, if $d_1\_str_{is} = 1\ month$, being the horizon of simulation $H = 1 year$, the normalised value for $d'_1\_str_{is} = d_1\_str_{is}/H$. In this particular case $d'_1\_str_{is} = 0{,}083$.

According to equations 5.1 to 5.3 in *Chapter 5. Model to represent the Strategies Alignment Process in a CN*: $d_1'\_str_{is} = \frac{d_1\_str_{is}}{H}$, $d_2'\_str_{is} = \frac{d_2\_str}{H}$ and $d_4'\_str_{is} = \frac{d_4\_str}{H}$.

10.5.2. Treatment of the parameters characterising the KPIs: $Threshold\_kpi_{ik}$

The value of the parameter $Threshold\_kpi_{ik}$ is calculated from the percentage data given by the enterprises in step 9. The value associated for the parameter $Threshold\_kpi_{ik}$ is subtracted once the functions that models the behaviour of the kpi_{ixk} when str_{is} is activated ($f\_inf\_str_{is}\_kpi'_{ixk}\ (t), f\_inf\_str_{js}\_kpi'_{ixk}\ (t)$), are added, as it is done in (5.26). The curve $f\_kpi'_{ixk}(t)$ is obtained, representing the function that models the overall behaviour of the kpi_{ixk} considering all the activated strategies.
The sum of the curves of influence attained in $f\_kpi'_{ixk}(t)$ can acquire different shapes. For example, a lineal function wether all the strategies defined by the enterprise have the same delay time ($d1\_s_{is}$) and need the same time to generate the maximum increase in the KPI ($d2\_s_{is}$). Nevertheless, this situation will not be always like this. Unlike, each strategy can acquire different durations for the delay time ($d1\_s_{is}$) and require different times to generate the maximum increase in the KPI ($d2\_s_{is}$). This will result on a curve of $f\_kpi'_{ixk}(t)$ represented by a polynomial function. Accordingly, the threshold value is computed considering the following steps:

1. Compute the area under the curve $f\_kpi'_{ixk}(t)$ from the initial time value until the first unit of time in which the curve $f\_kpi'_{ixk}(t)$ reaches the maximum value (see Figure 10.4). The striped area corresponds to the area limited by the first unit of time in which the curve $f\_kpi'_{ixk}(t)$ reaches the maximum value $\int_{t=0}^{t=\max f\_kpi'_{ixk}(t)} f\_kpi'_{ixk}(t)$. The light orange shaded area corresponds to the total area of the curve represented by $\int_{t=0}^{tf} f\_kpi'_{ixk}(t)$.
2. The enterprise defines a percentage to compute the threshold value (step 9). This percentage is computed based on the area under the curve limited by the first unit of time in which the curve $f\_kpi'_{ixk}(t)$ reaches the maximum value $\int_{t=0}^{t=\max f\_kpi'_{ixk}(t)} f\_kpi'_{ixk}(t)$. The $Threshold\_kpi_{ik}$ value is extracted from the percentage (step 9)given by de enterprise, multiplied by the area under the limited curve ($\int_{t=0}^{t=\max f\_kpi'_{ixk}(t)} f\_kpi'_{ixk}(t) \cdot Percentage_{step9}$). Through the resulting area the point at which intersects with the vertical axis (ordinate) (see Figure 10.4) is identified and the $Threshold\_kpi_{ik}$ value obtained.

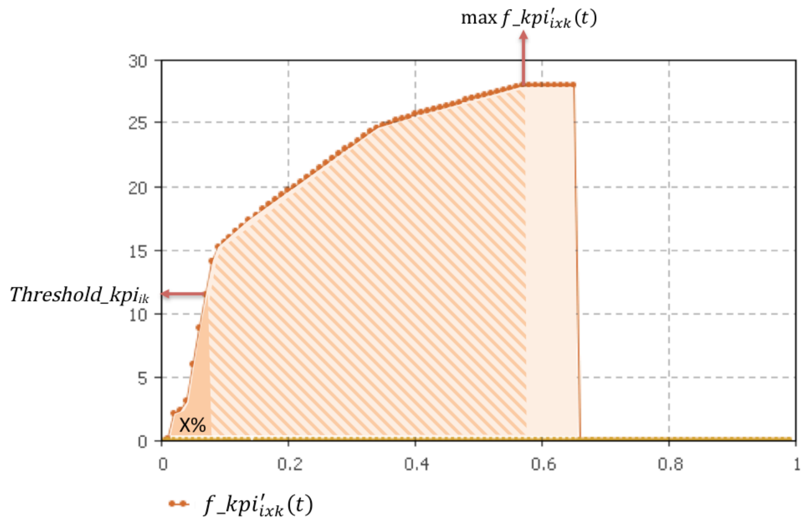

Figure 10.4. Graphical representation of $f\_kpi'_{ik}(t)$ to calculate the *Threshold_kpiik*

Using the SD notation the `Threshold_KPIik` is obtained by computing the ***Percentage**step9* · `KPIik_curve` (limited by max $f\_kpi'_{ixk}(t)$) and identifying the point at which this result intersects with the vertical axis (ordinate) of the `KPIik_curve`.

Note: Simplification of the procedure to obtain the value of the parameter *Threshold_kpiik* when *all the strategies have the same value for $d_1\_str_{is}$, $d_2\_str_{is}$*

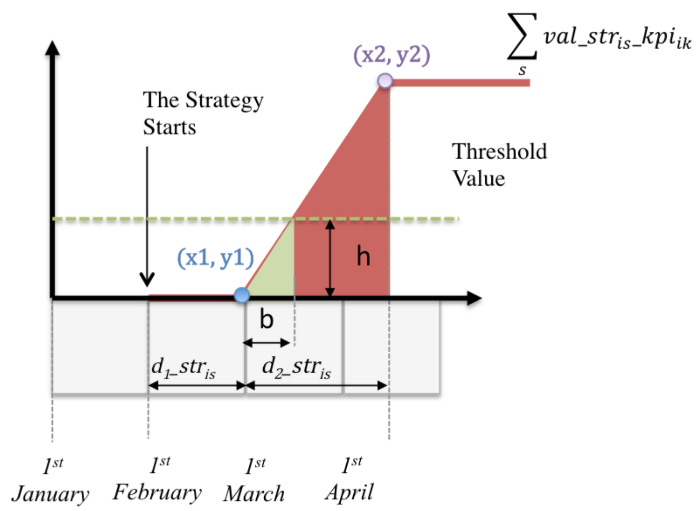

Figure 10.5. Computing the *Threshold_kpiik*

The minimum area ■ (*Area_min*) is the percentage defined by the enterprise over the total area ■ under the line representing the increase Figure 10.5. The line representing the increase is modelled as:

$y = mx + N$, where m is the slope of the line, thus:

$$y = \frac{(y2 - y)}{(x2 - x1)} x + (-\left(\frac{(y2 - y1)}{(x2 - x1)} \cdot x1\right) + y1)$$

$$m = \frac{h}{b} = \frac{(y2 - y1)}{(x2 - x1)}$$

$$Area\_total = \frac{(\sum_s val\_str_{is}\_kpi_{ik}) \cdot d_2\_str_{is}}{2}$$

$$Area\_min = Percentage_{step9} \cdot Area\_total$$

$$Area\_min = \frac{h \cdot b}{2} = \frac{h \cdot \frac{h}{m}}{2}$$ → where h is the $Threshold\_kpi_{ik}$

Accordingly, $Threshold\_kpi_{ik} = \sqrt{Area\_min \cdot 2 \cdot m}$

10.5.3. Treatment of the parameters characterising the KPIs: kpi_{ik}_min

In order to obtain the value kpi_{ik}_min, from the percentage data given by the enterprises in step 10, the next procedure is used:

For each kpi_{ik} simulate the SAM by only considering the strategies that have positive influences in the kpi_{ik} (kpi_{ik}_posInf).

In the example of Enteprise 1 of Pilot 1 the value of:

- kpi_{11}_posInf is obtained when simulating the SAM by only considering str_{11}, str_{12}, str_{13}, str_{14}, str_{15}
- kpi_{12}_posInf is obtained when simulating the SAM by only considering str_{11}, str_{12}, str_{13}, str_{14}, str_{15}
- kpi_{13}_posInf is obtained when simulating the SAM by only considering str_{11}, str_{12}, str_{13}, str_{14}
- kpi_{14}_posInf is obtained when simulating the SAM by only considering str_{11}, str_{12}, str_{13}, str_{14}
- kpi_{15}_posInf is obtained when simulating the SAM by only considering str_{11}, str_{12}, str_{13}, str_{14}, str_{15}

Accordingly, $kpi_{ik}\_min = Percentage_{step10} \cdot kpi_{ik}\_posInf$

Using the SD notation the `KPIik_min` = $Percentage_{step10} \cdot$ `KPIik.` The `KPIik` is calculated based on ideal conditions without subtracting the value identified for `Threshold_KPIik` and activating only strategies (`u_Sis`) that generate positive influences on the calculated `KPIik`.

The kick of meeting and the detailed guide for data collection presented is common for all the enterprises. Next sections focus on the study of each particular Pilot.

10.6 Pilot 1: Food Industry

In this section the application of the strategies alignment model in the food industry consisting of a network of two enterprises (manufacturer and distributor) is presented. The process followed to gather the data required to feed the SAM has been collaboratively done (following the SAG described in Chapter 8 for CS3). In the CS3 the information of the manufacturer and the distributor, regarding the strategies and the objectives, is completely known and the values of influence are jointly estimated. A set of meetings were arranged in order to gather the required information and have the feedback from the enterprises once the strategies alignment process was implemented.

10.6.1. Information gathering

Each enterprise defines the set of objectives to be achieved and formulates the set of strategies that will allow achieving these objectives. Each enterprise of Pilot 1 formulates a total of five strategies, and defines four KPIs. The strategies formulated by the manufacturer are known and shared with the distributor, and vice versa. In order to maintain the confidentiality, the strategies are presented next in coded form. As regards the KPIs defined, the two enterprises participating in Pilot 1 consider the same objectives and the same KPIs. The information as regards the strategies and the objectives is known by all the partners. The information gathered by the enterprises participating in the Pilot 1 is summarised next and shown in Table 10.1, and include the:

- Definition of the key performance indicators (KPIs) (kpi_{ik})

- Importance that each KPI has for each of the participating enterprises (w_{ik}). See that the importance of the key performance indicators defined (w_{ik}) are equally considered in terms of importance
- Formulated strategies (u_str_{is})
- Cost of the formulated strategies (c_str_{is})
- Length of the formulated strategies ($d_4\_str_{is}$)
- Influence that each formulated strategy (u_str_{is}) has on the KPIs (kpi_{ik}), defined by the parameter $val\_str_{is}\_kpi_{ik}$. The influence is estimated through considering the increase that the KPIs suffer when a particular strategy is activated. The participating enterprises have estimated all the influence values so that they keep proportional relation to each other.
- The budget owned to activate the strategies (b_i)

The way to proceed for estimating all the values of influence is the same as that one described in the Chapter 8, considering the CS3. The enterprises meet and exchange information as regards the strategies formulated and KPIs defined. Both the manufacturer and the distributor participate in the jointly estimation of the values of influence and agree the values of influence (see Phase 6, Collaborative Scenario 3 (EVI_CS3)).

The estimation of proportional values of influence ($val\_str_{is}\_kpi_{ik}$) makes the process of gathering the information more comprehensive and easy for the enterprises (see step 8). The data related with the costs is also proportional, for example the cost of the u_S15 defined by the manufacturer is the double than the cost of the u_S11 defined by the same partner (see step 3). Moreover, the values estimated by the manufacturer are proportional to each other and with data estimated by the distributor.

The structure and operation characteristics of Pilot 1 has forced to adapt the phases of the SAG (C*hapter 8*) related with the data collection (*Phase 3. Performance indicators definition* and *Phase 4. Strategies formulation*), and a reduced amount of data has been considered by the enterprises. Normally, it will be always necessary to adapt the phases defined in the SAG in each specific network modelled. The information required by the enterprises was gathered in the simplified template presented in *Chapter 8 Guideline*, so that only part of the data required to feed the SAM was gathered from the enterprises (see Table 8.4 Simplified Template to gather information for the SAM).

Nevertheless, the SAM requires more data from the enterprises than the gathered in Pilot 1. In order to deal with this lack of data, the rest of the data that was not previously gathered from the enterprises is supposed. These data corresponds the following parameters of the SAM: $d_1\_str_{is}$, $d_2\_str_{is}$, $Threshold\_kpi_{ik}$, kpi_{ik}_min. The values of the parameters that have not been previously defined by the enterprises are supposed in a logical way, accepted and agreed by the participating enterprises. All the parameter values required to feed the SAM are presented in Table 10.1. With respect the restrictions defined in the SAM, the restriction of non-negativity of the KPIs was not considered; this supposition was agreed with the enterprises participating in Pilot 1, which considered the option of working with negative values of KPIs.

10.6.2. Implementation of the strategies alignment model

The implementation of the Strategies Alignment Model (SAM) has allowed identifying, out of all the strategies formulated by the partners of Pilot 1, the set of strategies whose activation maximises the performance level of the whole network. The SAM will allow to identify the strategies that maximize the positive impacts and minimize negative ones in the KPIs defined by the both enterprises, manufacturer and distributor. The network manager is in charge of gathering all the results and using the results obtained in the implementation of the SAM. Considering the data gathered and the data supposed (all stored in Table 10.1), two scenarios are modelled, by the network manager, in Pilot 1:

- Non-collaborative Scenario (NCS), in which each enterprise in isolation (the enterprises do not collaborate) makes the decision of which strategies to activate by only considering the data of influence of their own strategies. This scenario only models the intra-enterprise influences, without modelling the external or inter-enterprise influences, that is, considering only the influences that the strategies activated in one network partner have on the objectives of other network partner:

  - Influences that the strategies formulated by the Manufacturer exert on the performance levels of KPIs defined by the Manufacturer (■). Considers the intra-enterprise influences of the manufacturer.
  - Influences that the strategies formulated by the Distributor exert on the performance levels of KPIs defined by the Distributor (■). Considers the intra-enterprise influences of the distributor.

- Collaborative scenario (CS3), in which the decision of identifying which are the aligned strategies to activate, from all the formulated strategies, is made from a collaborative perspective. The data used in the collaborative scenario correspond to all the data gathered by both enterprises, the manufacturer and the distributor (see Table 10.1):
  - Influences that the strategies formulated by the Manufacturer exert on the performance levels of KPIs defined by the Manufacturer (■). Considers the intra-enterprise influences of the manufacturer.
  - Influences that the strategies formulated by the Manufacturer exert on the performance levels of KPIs defined by the Distributor (■). Considers the inter-enterprise influences of the manufacturer.
  - Influences that the strategies formulated by the Distributor exert on the performance levels of KPIs defined by the Distributor (■). Considers the intra-enterprise influences of the distributor.
  - Influences that the strategies formulated by the Distributor exert on the performance levels of KPIs defined by the Manufacturer (■). Considers the inter-enterprise influences of the distributor.

The solutions obtained from the SAM application are shown in the next sub-sections.

Table 10.1. Pilot 1: SAM Data

Manufacturer																			
b1 = 14																			
												KPI11		KPI12		KPI13		KPI14	
												W11	0,25	W12	0,25	W13	0,25	W14	0,25
												Threshold_KPI11	0,5	Threshold_KPI12	0,5	Threshold_KPI13	0,5	Threshold_KPI14	0,5
												KPI11_min	0	KPI12_min	0	KPI13_min	0	KPI14_min	0
u_S11	DIS	c_S11	1	d1_S11	0	d2_S11	0,0001	d4_S11	0,6	ti_S11	CONT	val_S11_KPI11	6	val_S11_KPI12	0	val_S11_KPI13	-2	val_S11_KPI14	-1
u_S12	DIS	c_S12	5	d1_S12	0	d2_S12	0,0001	d4_S12	0,6	ti_S12	CONT	val_S12_KPI11	-5	val_S12_KPI12	0	val_S12_KPI13	0	val_S12_KPI14	0
u_S13	DIS	c_S13	4	d1_S13	0	d2_S13	0,0001	d4_S13	0,6	ti_S13	CONT	val_S13_KPI11	6	val_S13_KPI12	0	val_S13_KPI13	0	val_S13_KPI14	0
u_S14	DIS	c_S14	3	d1_S14	0	d2_S14	0,0001	d4_S14	0,6	ti_S14	CONT	val_S14_KPI11	4	val_S14_KPI12	0	val_S14_KPI13	0	val_S14_KPI14	0
u_S15	DIS	c_S15	2	d1_S15	0	d2_S15	0,0001	d4_S15	0,6	ti_S15	CONT	val_S15_KPI11	3	val_S15_KPI12	0	val_S15_KPI13	0	val_S15_KPI14	0
max_u_S11	1											val_S21_KPI11	-5	val_S21_KPI12	0	val_S21_KPI13	2	val_S21_KPI14	0
max_u_S12	1											val_S22_KPI11	-3	val_S22_KPI12	0	val_S22_KPI13	-3	val_S22_KPI14	6
max_u_S13	1											val_S23_KPI11	2	val_S23_KPI12	0	val_S23_KPI13	-1	val_S23_KPI14	2
max_u_S14	1											val_S24_KPI11	-3	val_S24_KPI12	-4	val_S24_KPI13	8	val_S24_KPI14	10
max_u_S15	1											val_S25_KPI11	1	val_S25_KPI12	0	val_S25_KPI13	0	val_S25_KPI14	1
Distributor																			
b2 = 5																			
												KPI21		KPI22		KPI23		KPI24	
												W21	0,25	W22	0,25	W23	0,25	W24	0,25
												Threshold_KPI21	0,5	Threshold_KPI22	0,5	Threshold_KPI23	0,5	Threshold_KPI24	0,5
												KPI21_min	0	KPI22_min	0	KPI23_min	0	KPI24_min	0
u_S21	DIS	c_S21	1	d1_S21	0	d2_S21	0,0001	d4_S21	0,6	ti_S21	CONT	val_S11_KPI21	6	val_S11_KPI22	0	val_S11_KPI23	-2	val_S11_KPI24	-1
u_S22	DIS	c_S22	1	d1_S22	0	d2_S22	0,0001	d4_S22	0,6	ti_S22	CONT	val_S12_KPI21	10	val_S12_KPI22	0	val_S12_KPI23	0	val_S12_KPI24	0
u_S23	DIS	c_S23	1	d1_S23	0	d2_S23	0,0001	d4_S23	0,6	ti_S23	CONT	val_S13_KPI21	5	val_S13_KPI22	0	val_S13_KPI23	0	val_S13_KPI24	0
u_S24	DIS	c_S24	1	d1_S24	0	d2_S24	0,0001	d4_S24	0,6	ti_S24	CONT	val_S14_KPI21	2	val_S14_KPI22	0	val_S14_KPI23	0	val_S14_KPI24	0
u_S25	DIS	c_S25	2	d1_S25	0	d2_S25	0,0001	d4_S25	0,6	ti_S25	CONT	val_S15_KPI21	0	val_S15_KPI22	0	val_S15_KPI23	0	val_S15_KPI24	0
max_u_S21	1											val_S21_KPI21	0	val_S21_KPI22	8	val_S21_KPI23	0	val_S21_KPI24	0
max_u_S22	1											val_S22_KPI21	0	val_S22_KPI22	0	val_S22_KPI23	-3	val_S22_KPI24	6
max_u_S23	1											val_S23_KPI21	4	val_S23_KPI22	0	val_S23_KPI23	-1	val_S23_KPI24	2
max_u_S24	1											val_S24_KPI21	-2	val_S24_KPI22	-4	val_S24_KPI23	8	val_S24_KPI24	10
max u_S25	1											val_S25_KPI21	0	val_S25_KPI22	0	val_S25_KPI23	0	val_S25_KPI24	1

10.6.3. Results of the Non-Collaborative Scenario

In this sub-section the results obtained from the non-collaborative scenario are presented. As it has been stated the enterprises only consider the intra-enterprise influences without taken into account the inter-enterprise ones. The results for the Manufacturer are presented in Table 10.2, which have been obtained from the optimisation experiment of the simulation software (Figure 10.6). The results obtained for the Distributor are shown in Table 10.3, derived from the optimization experiment carried out (Figure 10.7). In both tables, the first column indicates the strategy code (u_Sis), the second column points out if the formulated strategy is selected for its activation and the third column shows the initial day of activation, considering that the simulation horizon is $H'=1year$. The optimisation experiment (Figure 10.6 and Figure 10.7) gives the values of the initial time of activation of str_{is} (ti_str_{is}) considering that the simulation horizon is $H'=1year$, in Table 10.2 and Table 10.3 the initial day of the Strategy (ti_str_{is}) is provided in days and considering that the $H = 365\ days$. The duration of the optimization experiment for the manufacturer is 51,7 seconds and for the distributor is 51 seconds and 5000 iterations were performed for reaching the optimal solution ($max\ kpi_{net}$).

Table 10.2. Pilot 1: Results of the Manufacturer (non-collaborative scenario)

	Strategy	Result	Initial day of the Strategy
Manufacturer Strategies (Enterprise 1)	*u_S11*	Activate	12,8
	u_S12	Not to Activate	-
	u_S13	Activate	13,1
	u_S14	Activate	14,2
	u_S15	Activate	11,7

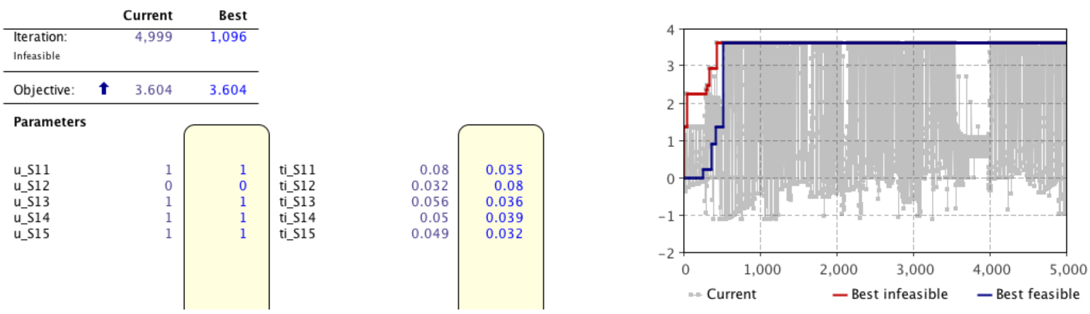

Figure 10.6. Pilot 1: Non-Collaborative Scenario Optimisation Results for the Manufacturer

Table 10.3. Pilot 1: Results of the Distributor (non-collaborative scenario)

	Strategy	Result	Initial day of the Strategy
Distributor Strategies (Enterprise 2)	*u_S21*	Activate	2,2
	u_S22	Activate	2,6
	u_S23	Activate	2,6
	u_S24	Activate	1,8
	u_S25	Not to Activate	-

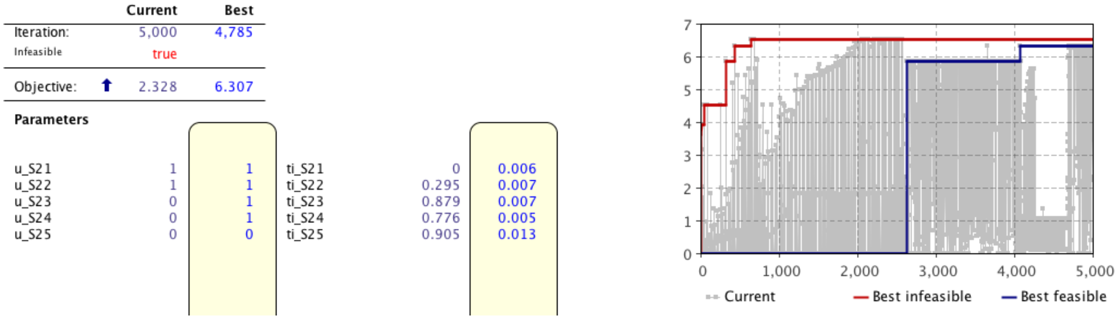

Figure 10.7. Pilot 1: Non-Collaborative Scenario Optimisation Results for the Manufacturer

In order to compare the collaborative and non-collaborative scenario the procedure described in Figure 9.2 (*Chapter 9. Experiments*) has been folloewd. Thus, the simulation experiment, considering both enterprises, has been performed after obtaining the optimisation results (Figure 10.8). Accoridng to Figure 9.2 the input data of the simulation experiment comes from the output data obtained from the optimization experiments of both enterprises.

Using the results obtained in the optimisation experiments carried out in both enterprises the simulation experiment leads the Manufacturer to have a performance of *6,075*; and the Distributor to reach a performance of *8,55*. The network performance results in the average of both enteprises: *7,313*.

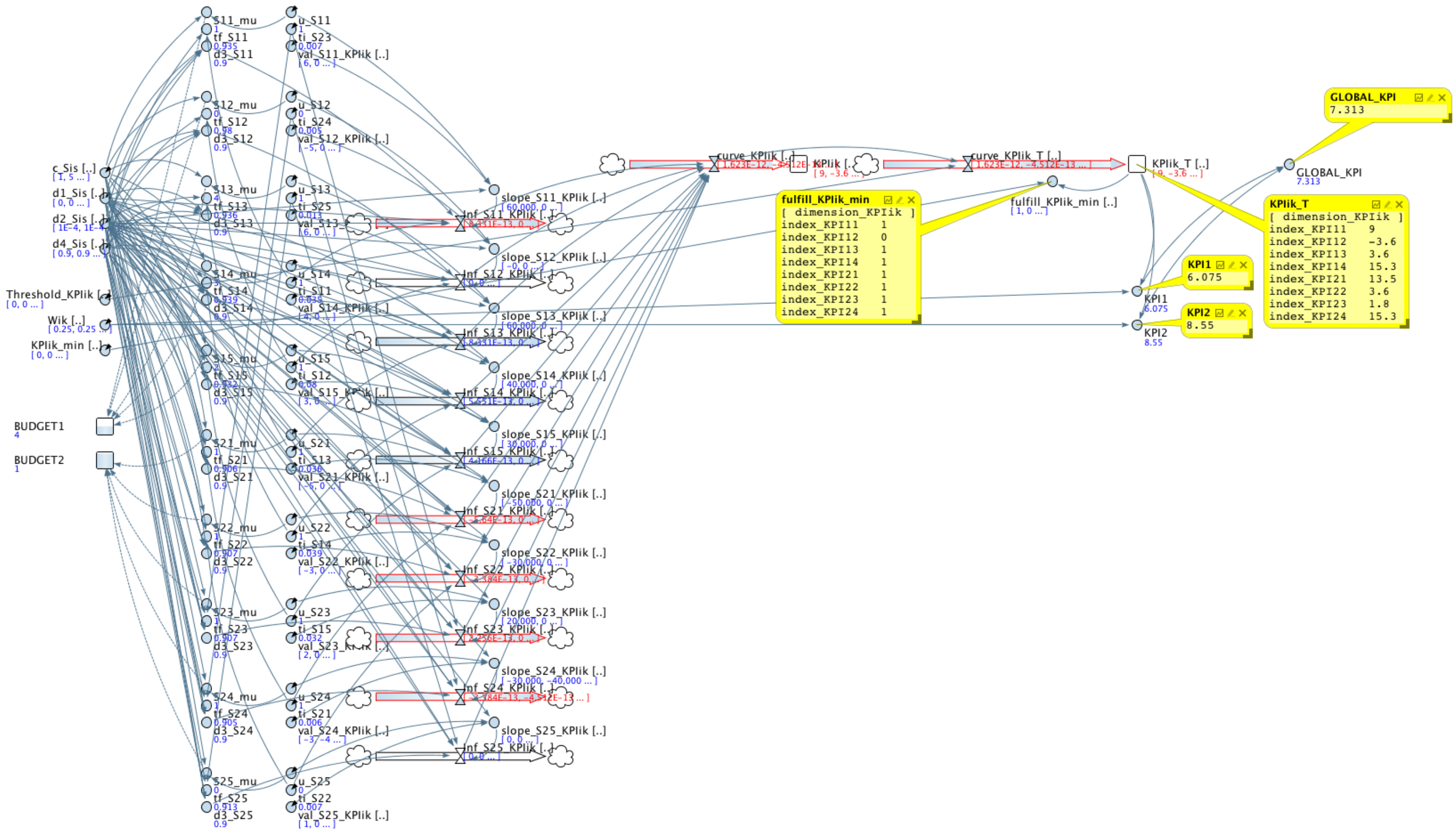

Figure 10.8. Pilot 1: Non-Collaborative Scenario Simulation Results

10.6.4. Results of the Collaborative Scenario

Considering one year of simulation horizon (365 days) the results of the collaborative scenario are presented in Table 10.4. The results are obtained from the optimisation and simulation experiments of the strategies alignment process modelled using SD method in the simulation software AnyLogic (see Figure 10.9 and Figure 10.10). The duration of the optimization experiment for the collaborative scenario is 3,92 minutes. As there are higher number of parameters in the collaborative scenario 10000 iterations were performed for reaching the optimal solution ($max\ kpi_{net}$).

Table 10.4. Pilot 1: Results of the Collaborative scenario

	Strategy	Result	Initial day of the Strategy
Manufacturer Strategies (Enterprise 1)	*u_S11*	Activate	20,8
	u_S12	Activate	20,8
	u_S13	Activate	16,4
	u_S14	Activate	28,8
	u_S15	No to Activate	-
Distributor Strategies (Enterprise 2)	*u_S21*	Activate	12,4
	u_S22	No to Activate	-
	u_S23	Activate	20,8
	u_S24	Activate	21,5
	u_S25	Activate	13,1

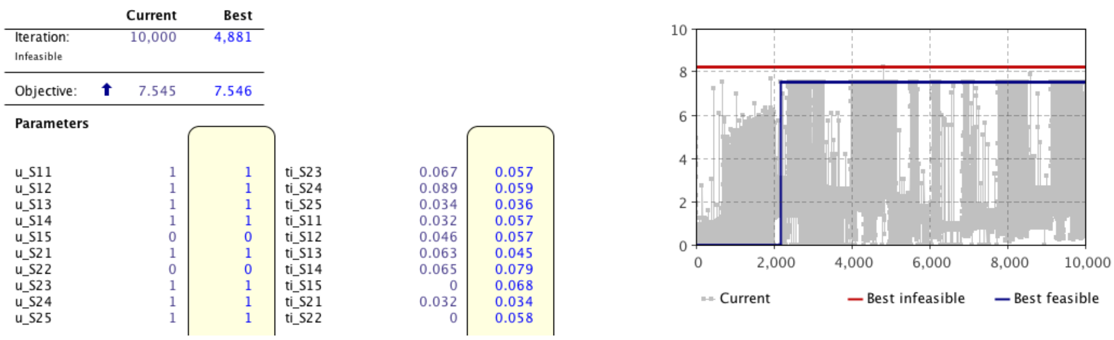

Figure 10.9. Pilot 1: Collaborative Scenario Optimisation Results

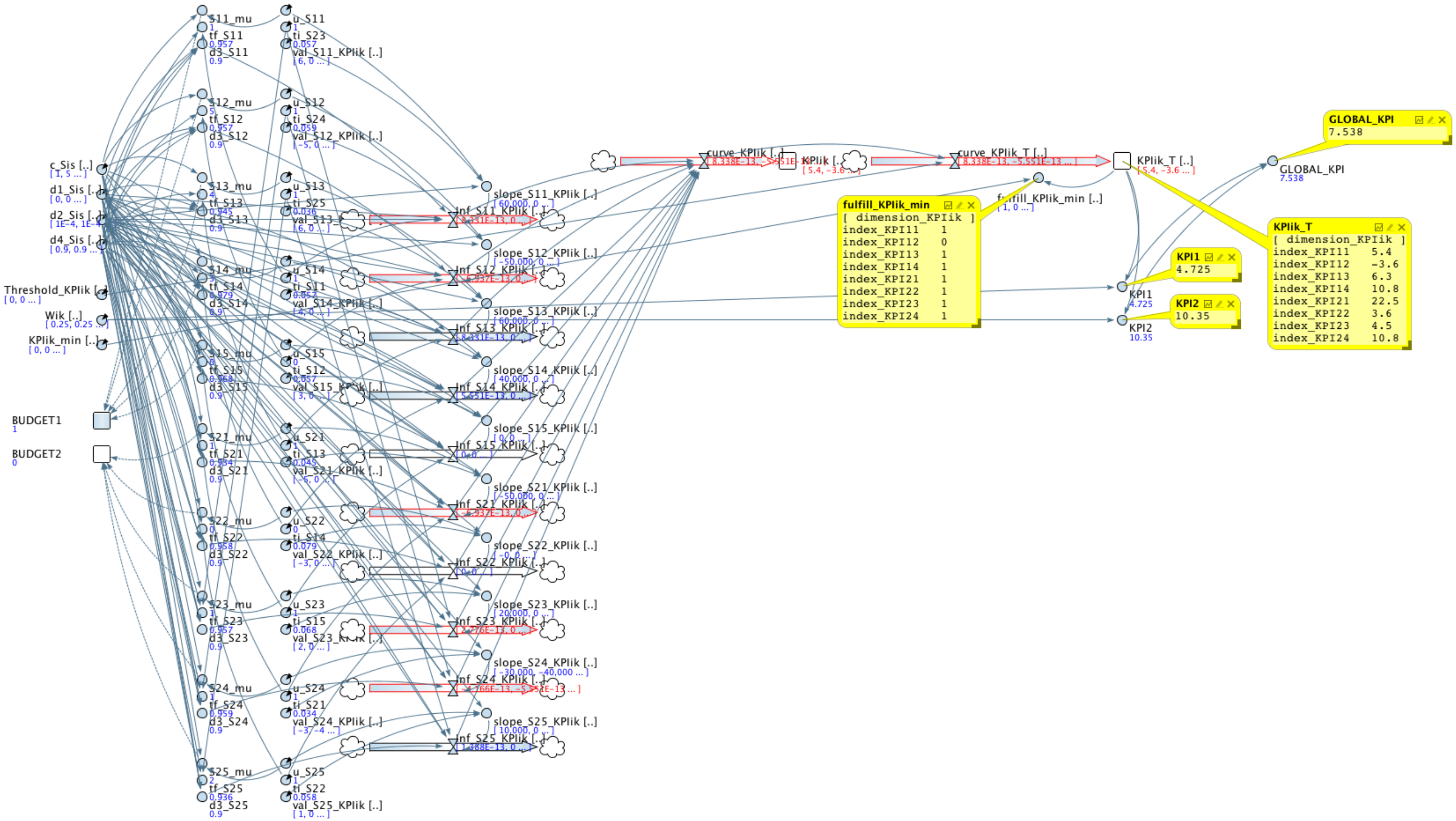

Figure 10.10. Pilot 1: Collaborative Scenario Simulation Results

10.6.5. Performance levels comparison in both scenarios

In this subsection the results of both scenarios modelled in the strategies alignment process, collaborative and non-collaborative, are compared (Table 10.5).

Table 10.5. Pilot 1: Results comparison

		Non-Collaborative Scenario	Collaborative Scenario	Performance Improvement
Manufacturer (Enterprise 1)	u_S11	Activate	Activate	
	u_S12	No to Activate	Activate	
	u_S13	Activate	Activate	
	u_S14	Activate	Activate	
	u_S15	Activate	No to Activate	
	ti_S11	12,8	20,8	
	ti_S12	29,2	20,8	
	ti_S13	13,1	16,4	
	ti_S14	14,2	28,8	
	ti_S15	11,7	-	
	∇kpi_{11}	9	5,4	-40,0%
	∇kpi_{12}	-3,6	-3,6	0,0%
	∇kpi_{13}	3,6	6,3	75,0%
	∇kpi_{14}	15,3	10,8	-29,4%
Distributor (Enterprise 2)	u_S21	Activate	Activate	
	u_S22	Activate	No to Activate	
	u_S23	Activate	Activate	
	u_S24	Activate	Activate	
	u_S25	No to Activate	Activate	
	ti_S21	2,2	12,4	
	ti_S22	2,6	-	
	ti_S23	2,6	20,8	
	ti_S24	1,8	21,5	
	ti_S25	4,7	13,1	
	∇kpi_{21}	13,5	22,5	66,7%
	∇kpi_{22}	3,6	3,6	0,0%
	∇kpi_{23}	1,8	4,5	150,0%
	∇kpi_{24}	15,3	10,8	-29,4%
Manufacturer	Δkpi_1	6,075	4,725	-22,2%
Distributor	Δkpi_2	8,55	10,35	21,1%
Pilot 1	Δkpi_{net}	7,313	7,538	3,1%

Analysing the KPIs defined by the Manufacturer and the Distributor

With regards to the manufacturer, the kpi_{11} is reduced by 40% in the collaborative scenario, with respect the results obtained in the non-collaborative scenario. The kpi_{12} remains the same. The kpi_{13}, has a 75% increase in the collaborative scenario, comparing with the non-collaborative scenario. Finally, in the kpi_{14} a reduction of 29% is observed in the collaborative scenario. In general, the kpi_{13} presents a significant improvement in the collaborative scenario at the expense of reducing the performance levels in kpi_{11} and kpi_{14}.

Considering the results of the Distributor, the kpi_{21} increases the performance level by 66.7% in the collaborative scenario, comparing the results in the non-cooperative scenario. The kpi_{22} remains the same in both scenarios. The kpi_{23}, is increased in the collaborative scenario by 150%, compared with the same KPI in the non-collaborative. Finally, the kpi_{24} presents a worsening of 29.4% in the results of the collaborative scenario with respect to the non-collaborative one. In general, the performance levels of kpi_{21} and kpi_{23} have a significant improvement in the collaborative scenario at the expense of reducing the performance level of the kpi_{24}.

Analysing the KPIs at the enterprises level: KPI_Manufacturer and KPI_Distributor

With regards the manufacturer, the solution obtained for the collaborative scenario makes that the Δkpi_1 is reduced by 22,2% ($\Delta kpi_1^{col} = 4{,}725$ respect the $\Delta kpi_1^{non-col} = 6{,}07$). On the other hand, the distributor increases its performance level by 21,1% in the results obtained from the collaborative scenario (thus, $\Delta kpi_2^{non-col} = 8{,}55$ respect $\Delta kpi_2^{col} = 10{,}35$). In general, the distributor increases its performance level at the expense of reducing the performance level of the manufacturer.

Analysing the network performance

The network performance level, Δkpi_{net}, presents an improvement of 3,1% in the collaborative scenario. The increased performance level of the distributor allows the performance improvement at the network level.

10.7 Pilot 2: Automotive Industry

In this section the application of the strategies alignment model in the automotive industry consisting of a network of two enterprises (OEM, first and second tier) is presented. The process followed to collect and exchange the data required to feed the SAM has been done following the SAG described in Chapter 8 for CS1, in which the network partners only exchange the information regarding the KPIs without exchanging any information regarding the strategies each enterprise formulates.

10.7.1. Information gathering

A set of meetings were arranged in order to gather the required information and have the feedback from the enterprises once the strategies alignment process was implemented. The collaboration scenario applied in Pilot 2 is characterised by the minimum exchange of information, therefore, the CS1 is applied. In Pilot 2 the data required to feed the SAM, unlike Pilot 1 in which the data was gathered in a simplified template, is gathered in the complete template (*Chapter 8*. *Guideline*. Table 8.3 Complete template to gather information for the SAM). The structure and operation characteristics of Pilot 2 have allowed obtaining all the data required to feed the SAM. In order to collect all the data required to feed the SAM the steps presented in Section 10.5 were followed. All the parameter values, gathered from the enterprises, required to feed the SAM are presented in Table 10.6. When simulating the SAM, in AnyLogic Simulation Software, all the restrictions defined, including the non-negativity of the KPIs, were considered.

10.7.2. Implementation of the strategies alignment model

The implementation of the Strategies Alignment Model (SAM) has allowed identifying, out of all the strategies formulated by the partners of Pilot 2, the set of strategies whose activation maximises the performance level of the whole network. The SAM will allow identifying the strategies that maximize the positive impacts and minimize negative ones in the KPIs defined by the both enterprises, manufacturer and distributor.

The network manager is in charge of gathering all the data and use this data for the implementation of the strategies alignment model. Considering the data gathered (all stored Table 10.6), two scenarios are modelled in Pilot 2:

- Non-collaborative Scenario (NCS), in which each enterprise in isolation (the enterprises do not collaborate) makes the decision of which strategies to activate by only considering the data of influence of their own strategies. This scenario only models the intra-enterprise influences, without modelling the external or inter-enterprise influences, that is how the strategies activated in one network partner affect the objectives of other network partner.

- Collaborative scenario (CS1), in which the decision of identifying which are the aligned strategies to activate, from all the formulated strategies, is made from a collaborative perspective. The data used in the collaborative scenario correspond to all the data gathered by the enterprises of Pilot 2 (intra and inter-enterprise influences).

In the SAM (Chapter 5), the curve that models the influence of str_{is}on the kpi'_{ixk}: $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$ is modelled by considering that at the end of the strategy lifecycle the influence is progressively reduced in the same way as it behaves at the beginning, when the strategy starts influencing the KPIs. In the particular case of the automotive industry, the enterprises have considered to model the function of influence $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$ by taking into account that when the strategy finishes no influence is exerted to the KPIs. Therefore, the shape of the curve $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$ changes as it is shown in Figure 10.11.

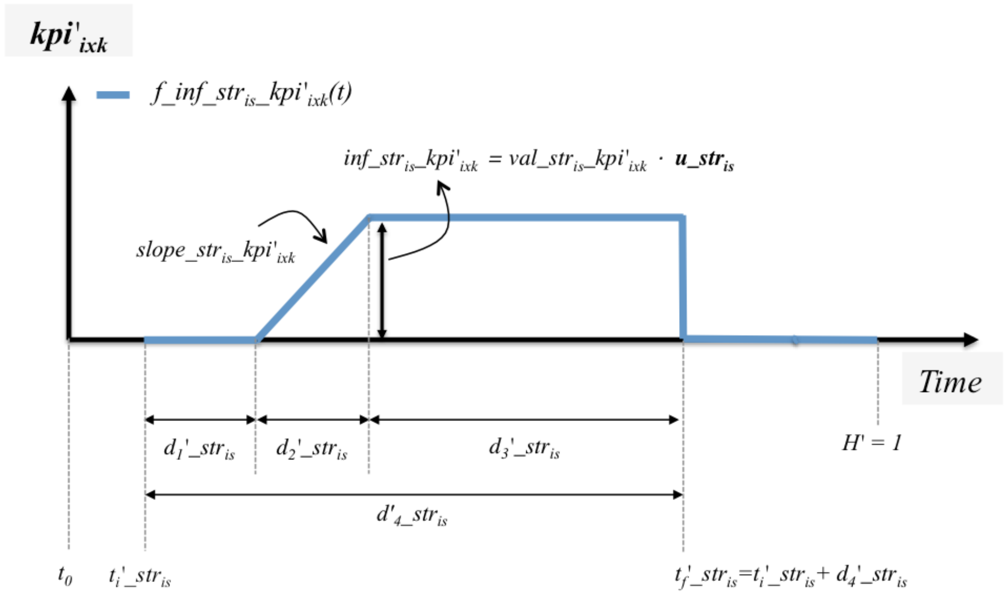

Figure 10.11. Curve that models the influence of str_{is}on the kpi'_{ixk}: $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$

Taking into account the aforementioned, the formal mathematical representation of the function of influence, $f\_inf\_str_{is}\_kpi'_{ixk}\ (t)$, is as follows:

$$f\_inf\_str_{is}\_kpi'_{ixk}\ (t) = \begin{cases} 0 \ \longrightarrow \ t \leq t'_{i\,str_{is}} + d'_{1\,str_{is}} \wedge t > t'_i\_str_{is} + d'_4\_str_{is} \\ slope\_str_{is}\_kpi'_{ixk} \longrightarrow \ t'_i\_str_{is} + d'_1\_str_{is} < t < t'_i\_str_{is} + d'_1\_str_{is} \ + d'_2\_str_{is} \\ inf\_str_{is}\_kpi'_{ixk} \longrightarrow t'_i\_str_{is} + d'_1\_str_{is} + d'_2\_str_{is} \leq t < t'_i\_str_{is} + d'_4\_str_{is} \end{cases}$$

(10. 1)

Considering the System Dynamics Notation the $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$ is initially represented by `Inf_Sis_KPIixk [dimensión_KPIik]`, flow variable:

```
Inf_Sis_KPIixk [dimensión_KPIik] = delay (ramp
(slope_Sis_KPIixk[dimension_KPIixk], ti_Sis, ti_Sis +
d2_Sis.get(index_Sis)) - ramp (1, ti_Sis + d2_Sis.get(index_Sis) +
d3_Sis, ti_Sis + 2 · d2_Sis.get(index_Sis) + d3_Sis) ,
d1_Sis.get(index_Sis))
```

A new relation, in the SAM SD model, between the flow variable `Inf_Sis_KPIik [dimensión_KPIik]` and the parameter `val_Sis_KPIik [dimension_KPIik]`, is generated due to the new shape acquired by curve that models the influence of u_str_{is}on the kpi'_{ixk}: $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$, changing as follows:

```
Inf_Sis_KPIik [dimensión_KPIik] = delay (ramp (slope_Sis_KPIik[
dimension_KPIik ], ti_Sis, ti_Sis + d2_Sis.get(index_Sis)) - step
(val_Sis_KPIik[ dimension_KPIik ], ti_Sis +d2_Sis.get(index_Sis) +
d3_Sis) , d1_Sis.get(index_Sis) )
```

Moreover, a new formulation for the auxiliary variable `d3_Sis` is considered with the new shape acquired by curve that models the influence of u_str_{is}on the kpi'_{ixk}: $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$.

```
d3_Sis = d4_Sis.get(index_Sis) - d1_Sis.get(index_Sis) -
d2_Sis.get(index_Sis)
```

Table 10.6. Pilot 2: SAM Data

Second Tier

b1 = 25

												KPI11		KPI12		KPI13		KPI14		KPI15	
												W11	0,2	W12	0,35	W13	0,15	W14	0,05	W15	0,25
												Threshold_KPI11	2,18	Threshold_KPI12	0,87	Threshold_KPI13	2,21	Threshold_KPI14	2,66	Threshold_KPI15	0
												KPI11_min	0,53	KPI12_min	0,3	KPI13_min	3,22	KPI14_min	1,03	KPI15_min	2
u_S11	DIS	c_S11	5	d1_S11	0,083	d2_S11	0,125	d4_S11	0,65	ti_S11	CONT	val_S11_KPI11	4	val_S11_KPI12	2	val_S11_KPI13	0,5	val_S11_KPI14	4	val_S11_KPI15	0
u_S12	DIS	c_S12	5	d1_S12	0,083	d2_S12	0,125	d4_S12	0,65	ti_S12	CONT	val_S12_KPI11	0,5	val_S12_KPI12	0	val_S12_KPI13	4	val_S12_KPI14	4	val_S12_KPI15	0
u_S13	DIS	c_S13	10	d1_S13	0,083	d2_S13	0,125	d4_S13	0,65	ti_S13	CONT	val_S13_KPI11	2	val_S13_KPI12	4	val_S13_KPI13	10	val_S13_KPI14	4	val_S13_KPI15	0
u_S14	DIS	c_S14	5	d1_S14	0,083	d2_S14	0,125	d4_S14	0,65	ti_S14	CONT	val_S14_KPI11	4	val_S14_KPI12	0	val_S14_KPI13	4	val_S14_KPI14	7	val_S14_KPI15	0
u_S15	DIS	c_S15	10	d1_S15	0,083	d2_S15	0,125	d4_S15	0,65	ti_S15	CONT	val_S15_KPI11	0	val_S15_KPI12	0	val_S15_KPI13	-4	val_S15_KPI14	-2	val_S15_KPI15	4
max_u_S11	1											val_S21_KPI11	0	val_S21_KPI12	0	val_S21_KPI13	-4	val_S21_KPI14	0	val_S21_KPI15	10
max_u_S12	1											val_S22_KPI11	-3	val_S22_KPI12	-3	val_S22_KPI13	-5	val_S22_KPI14	-1	val_S22_KPI15	8
max_u_S13	1											val_S23_KPI11	0	val_S23_KPI12	0	val_S23_KPI13	-3	val_S23_KPI14	0	val_S23_KPI15	8
max_u_S14	1											val_S24_KPI11	7	val_S24_KPI12	6	val_S24_KPI13	5	val_S24_KPI14	5	val_S24_KPI15	2
max_u_S15	1											val_S25_KPI11	0	val_S25_KPI12	0	val_S25_KPI13	0	val_S25_KPI14	0	val_S25_KPI15	0
												val_S26_KPI11	0	val_S26_KPI12	3	val_S26_KPI13	3	val_S26_KPI14	0	val_S26_KPI15	0
												val_S27_KPI11	2	val_S27_KPI12	2	val_S27_KPI13	2	val_S27_KPI14	2	val_S27_KPI15	7

First Tier

b2 = 30

												KPI21		KPI22		KPI23		KPI24		KPI25		KPI26		KPI27	
												W21	0,2	W22	0,05	W23	0,05	W24	0,3	W25	0,15	W26	0,15	W27	0,1
												Threshold_KPI21	0	Threshold_KPI22	0	Threshold_KPI23	3,5	Threshold_KPI24	0	Threshold_KPI25	3,8	Threshold_KPI26	4,27	Threshold_KPI27	1,2
												KPI21_min	1,84	KPI22_min	1,5	KPI23_min	1,5	KPI24_min	2,26	KPI25_min	0,86	KPI26_min	0,9	KPI27_min	1,2
u_S21	DIS	c_S21	3	d1_S21	0,00274	d2_S21	0,1667	d4_S21	0,65	ti_S21	CONT	val_S11_KPI21	0	val_S11_KPI22	0	val_S11_KPI23	0	val_S11_KPI24	1	val_S11_KPI25	3	val_S11_KPI26	1	val_S11_KPI27	2
u_S22	DIS	c_S22	4	d1_S22	0,0137	d2_S22	0,00274	d4_S22	0,65	ti_S22	CONT	val_S12_KPI21	2	val_S12_KPI22	0	val_S12_KPI23	0	val_S12_KPI24	1	val_S12_KPI25	1	val_S12_KPI26	1	val_S12_KPI27	2
u_S23	DIS	c_S23	2	d1_S23	0,0274	d2_S23	0,0274	d4_S23	0,65	ti_S23	CONT	val_S13_KPI21	5	val_S13_KPI22	0	val_S13_KPI23	0	val_S13_KPI24	1	val_S13_KPI25	3	val_S13_KPI26	1	val_S13_KPI27	2
u_S24	DIS	c_S24	6	d1_S24	0,0833	d2_S24	0,25	d4_S24	0,65	ti_S24	CONT	val_S14_KPI21	0	val_S14_KPI22	0	val_S14_KPI23	0	val_S14_KPI24	1	val_S14_KPI25	3	val_S14_KPI26	1	val_S14_KPI27	2
u_S25	DIS	c_S25	10	d1_S25	0,06849	d2_S25	0,417	d4_S25	0,65	ti_S25	CONT	val_S15_KPI21	10	val_S15_KPI22	0	val_S15_KPI23	0	val_S15_KPI24	-10	val_S15_KPI25	0	val_S15_KPI26	1	val_S15_KPI27	3
u_S26	DIS	c_S26	7	d1_S26	0,0411	d2_S26	0, 0411	d4_S26	0,65	ti_S26	CONT	val_S21_KPI21	10	val_S21_KPI22	0	val_S21_KPI23	1	val_S21_KPI24	1	val_S21_KPI25	0	val_S21_KPI26	0	val_S21_KPI27	2
u_S27	DIS	c_S27	7	d1_S27	0,0411	d2_S27	0,333	d4_S27	0,65	ti_S27	CONT	val_S22_KPI21	0	val_S22_KPI22	10	val_S22_KPI23	3	val_S22_KPI24	2	val_S22_KPI25	0	val_S22_KPI26	0	val_S22_KPI27	1
max_u_S21	1											val_S23_KPI21	-1	val_S23_KPI22	0	val_S23_KPI23	10	val_S23_KPI24	2	val_S23_KPI25	0	val_S23_KPI26	0	val_S23_KPI27	2
max_u_S22	1											val_S24_KPI21	0	val_S24_KPI22	0	val_S24_KPI23	0	val_S24_KPI24	4	val_S24_KPI25	7	val_S24_KPI26	0	val_S24_KPI27	0
max_u_S23	1											val_S25_KPI21	0	val_S25_KPI22	0	val_S25_KPI23	0	val_S25_KPI24	7	val_S25_KPI25	9	val_S25_KPI26	10	val_S25_KPI27	0
max_u_S24	1											val_S16_KPI21	0	val_S16_KPI22	-2	val_S16_KPI23	0	val_S16_KPI24	10	val_S16_KPI25	-1	val_S16_KPI26	8	val_S16_KPI27	0
max u_S25	1											val_S17_KPI21	5	val_S17_KPI22	0	val_S17_KPI23	0	val_S17_KPI24	2	val_S17_KPI25	5	val_S17_KPI26	0	val_S17_KPI27	10
max u_S26	1																								
max u_S27	1																								

10.7.3. Results of the Non-Collaborative Scenario

In this sub-section the results obtained from the non-collaborative scenario (NCS) are presented. The enterprises of Pilot 2 only consider the intra-enterprise influences without taken into account the inter-enterprise ones. The results for the Second Tier are presented in Table 10.7, which have been obtained from the optimisation experiment of the simulation software (Figure 10.12). The results obtained for the First Tier are shown in Table 10.8, derived from the optimization experiment carried out (Figure 10.13). In Table 10.7 and Table 10.8 the initial day of the Strategy (ti_str_{is}) is provided in days, considering that the $H = 365$ *days*. The duration of the optimization experiment for the Second Tier is 19,60 minutes and for the First Tier is 34,27 minutes; and 100000 iterations were performed for reaching the optimal solution ($max\ kpi_{net}$). The higher number of iterations and the and longer length of the experiments, compared to the experiments carried out in the Pilot 1, is due to the greater number of parameters and the complexity of the experiment in the Pilot 2, in which all the parameters of the SAM and all restrictions on non-negativity are considered.

Table 10.7. Pilot 2: Results of the Second Tier (non-collaborative scenario)

	Strategy	**Result**	**Initial day of the Strategy**
Second Tier (Enterprise 1)	*u_S11*	0	-
	u_S12	0	-
	u_S13	1	40,88
	u_S14	1	40,88
	u_S15	1	4,38

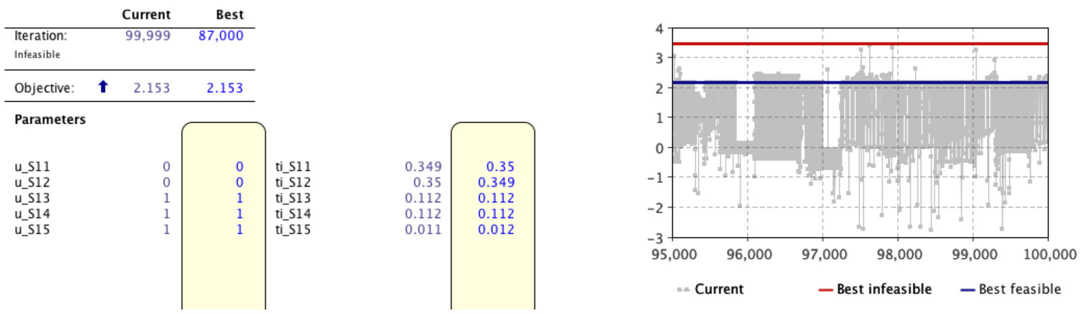

Figure 10.12. Pilot 2: Non-Collaborative Scenario Optimisation Results for the Second Tier

Table 10.8. Pilot 2: Results of the First Tier (non-collaborative scenario)

	Strategy	**Result**	**Initial day of the Strategy**
Fist Tier (Enterprise 2)	*u_S21*	1	103,2
	u_S22	1	106,8
	u_S23	1	101,3
	u_S24	1	111,1
	u_S25	0	-
	u_S26	1	68,7
	u_S27	1	110,6

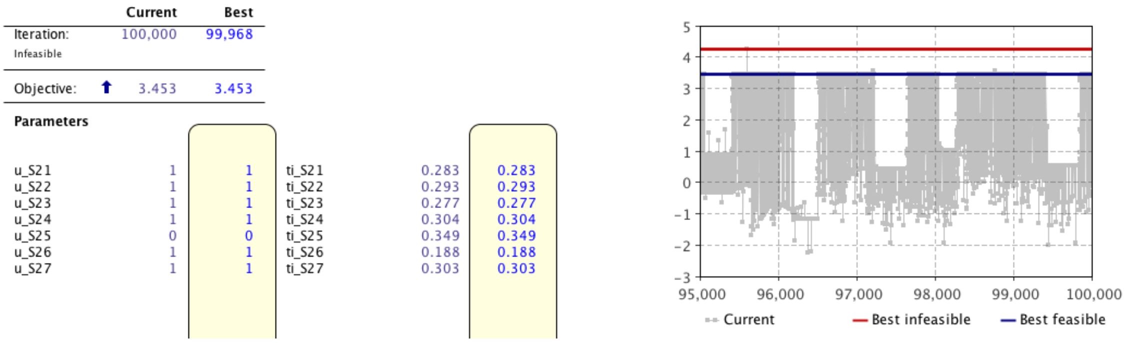

Figure 10.13. Pilot 2: Non-Collaborative Scenario Optimisation Results for the First Tier

The simulation experiment has been performed after obtaining the optimisation results (Figure 10.14). In order to compare the collaborative and non-collaborative scenario the procedure described in Figure 9.2 (*Chapter 9. Experiments*) has been folloewd. Accoridng to Figure 9.2. the input data of the simulation experiment comes from the output data obtained from the optimization experiments of both enterprises.

Using the results obtained in the optimisation experiments carried out in both enterprises the simulation experiment leads Second Tier to have a performance of *7,561*; and First Tier to reach a performance of *7,783*. The network performance results in the average of both enteprises: *7,717*.

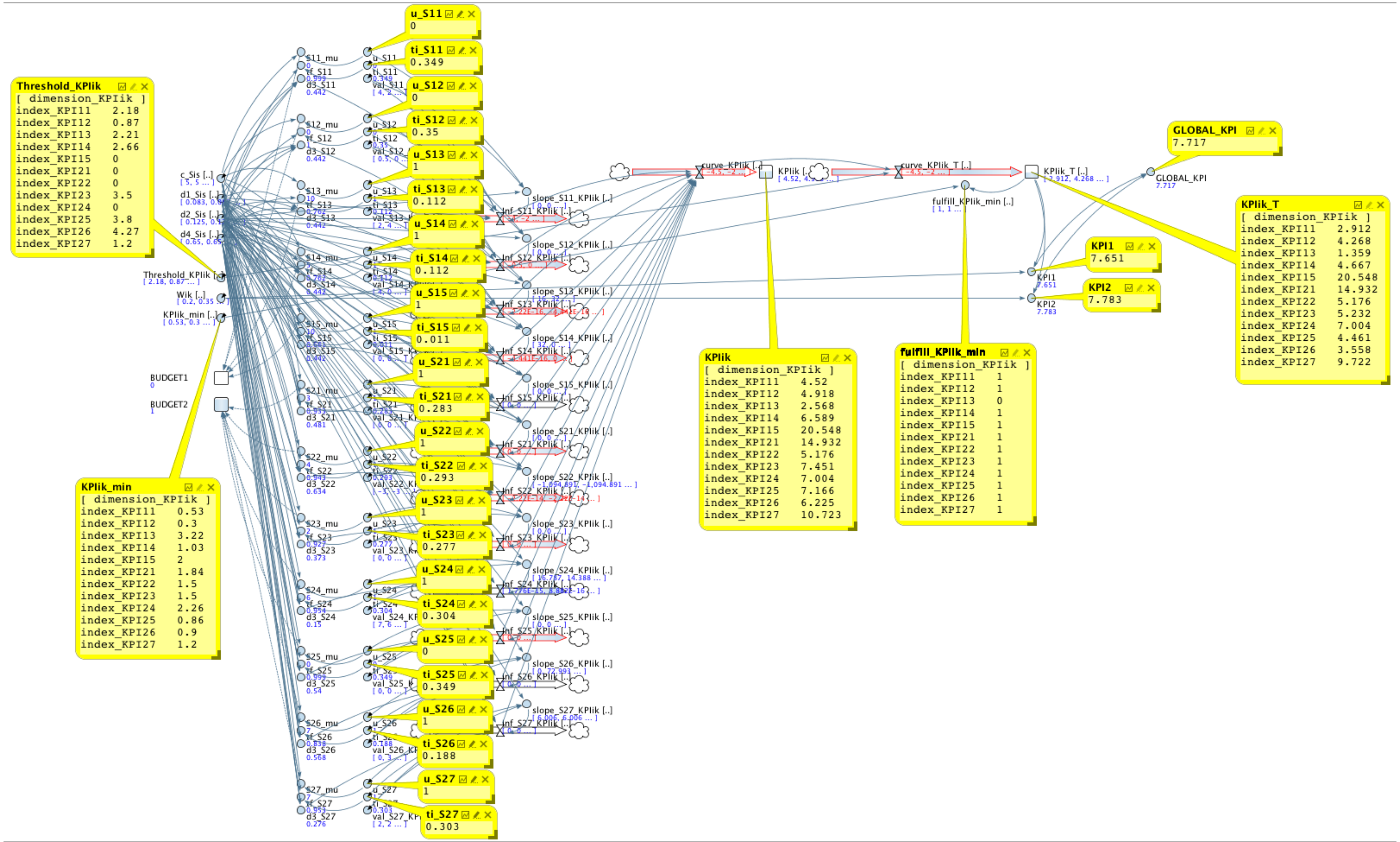

Figure 10.14. Pilot 2: Non-Collaborative Scenario Simulation Results

10.7.4. Results of the Collaborative Scenario

Considering one year of simulation horizon (365 days) the results of the collaborative scenario are presented in Table 10.9. The results are obtained from the optimisation and simulation experiments of the strategies alignment process modelled using SD method in the simulation software AnyLogic (see Figure 10.15 and Figure 10.16). The duration of the optimization experiment for the collaborative scenario is 12,73 hours and 100000 iterations were performed for reaching the optimal solution ($max\ kpi_{net}$).

Table 10.9. Pilot 2: Results of the Collaborative scenario

	Strategy	Result	Initial day of the Strategy
Second Tier (Enterprise 1)	*u_S11*	1	37,2
	u_S12	1	36,9
	u_S13	1	35,8
	u_S14	1	37,2
	u_S15	0	0,0
First Tier (Enterprise 2)	*u_S21*	1	74,4
	u_S22	1	124,7
	u_S23	1	43,2
	u_S24	1	36,2
	u_S25	0	127,7
	u_S26	1	49,4
	u_S27	1	37,3

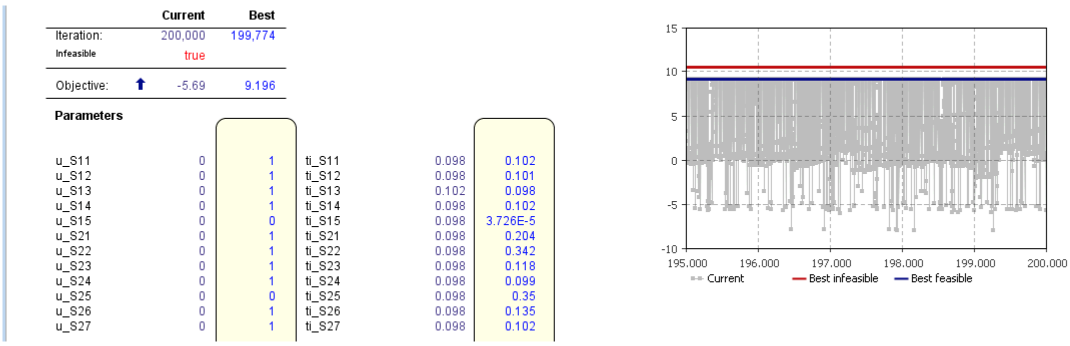

Figure 10.15. Pilot 2: Collaborative Scenario Optimisation Results

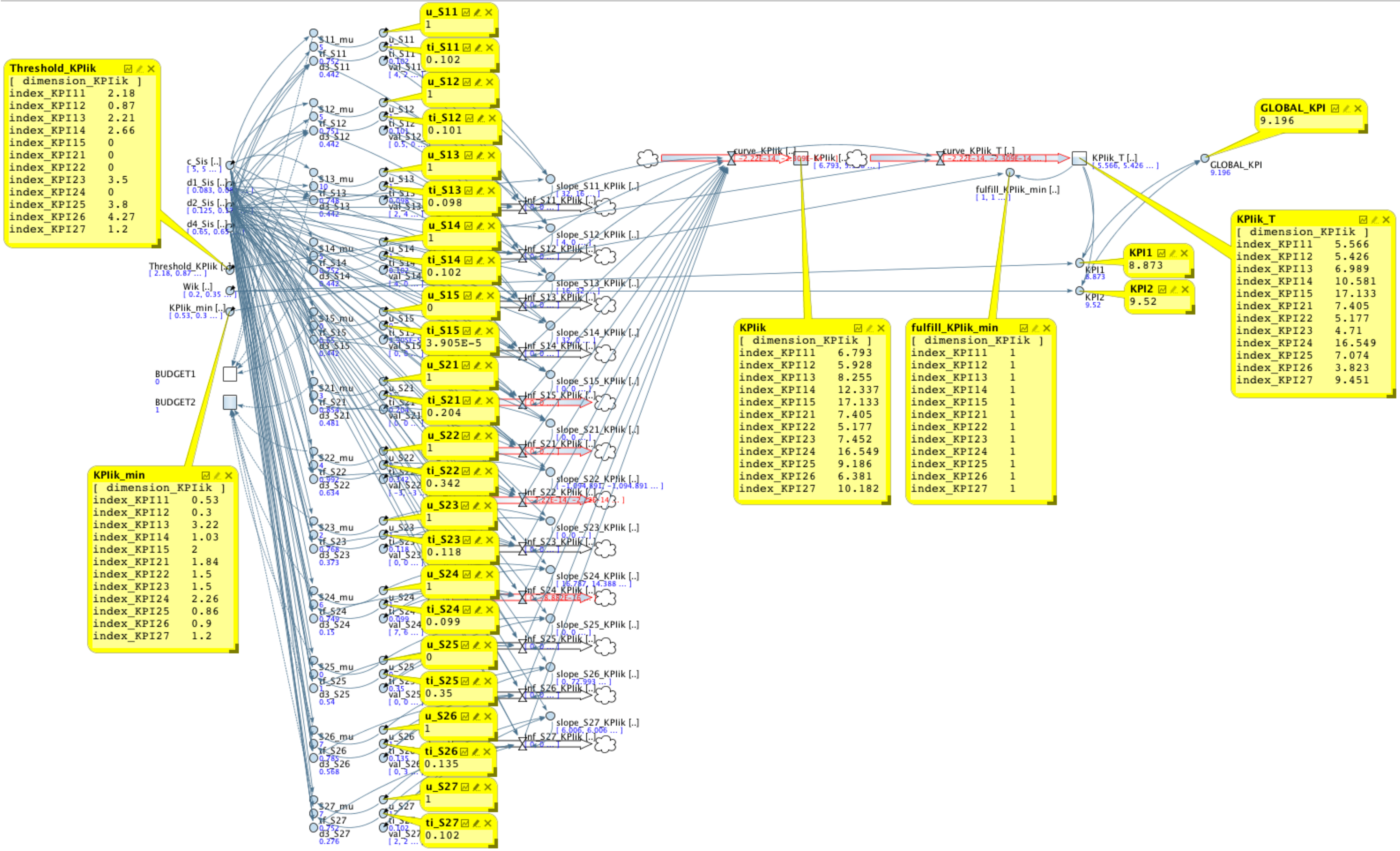

Figure 10.16. Pilot 2: Collaborative Scenario Simulation Results

10.7.5. Performance levels comparison in both scenarios

In this subsection the results of both scenarios modelled in the strategies alignment process, collaborative and non-collaborative, are compared (Table 10.10).

Table 10.10. Pilot 2: Results comparison

		Non-Collaborative Scenario	Collaborative Scenario	Performance Improvement
Second Tier (Enterprise 1)	u_S11	No to Activate	Activate	
	u_S12	No to Activate	Activate	
	u_S13	Activate	Activate	
	u_S14	Activate	Activate	
	u_S15	Activate	No to Activate	
	ti_S11	0	37,2	
	ti_S12	0	36,9	
	ti_S13	40,88	35,8	
	ti_S14	40,88	37,2	
	ti_S15	4,38	0	
	∇kpi_{11}	2,912	5,566	91,14%
	∇kpi_{12}	4,268	5,426	27,13%
	∇kpi_{13}	1,359	6,989	414,28%
	∇kpi_{14}	4,667	10,581	126,72%
	∇kpi_{15}	2,055	17,133	733,80%
	$fulfilment\_kpi_{11}$	Yes	Yes	
	$fulfilment\_kpi_{12}$	Yes	Yes	
	$fulfilment\_kpi_{13}$	No	Yes	
	$fulfilment\_kpi_{14}$	Yes	Yes	
	$fulfilment\_kpi_{15}$	Yes	Yes	
First Tier (Enterprise 2)	u_S21	Activate	Activate	
	u_S22	Activate	Activate	
	u_S23	Activate	Activate	
	u_S24	Activate	Activate	
	u_S25	No to Activate	No to Activate	
	u_S26	Activate	Activate	
	u_S27	Activate	Activate	
	ti_S21	14,932	74,4	
	ti_S22	5,176	124,7	
	ti_S23	5,232	43,2	
	ti_S24	7,004	36,2	
	ti_S25	4,461	127,7	
	ti_S26	3,558	49,4	
	ti_S27	9,722	37,3	
	∇kpi_{21}	14,932	7,405	-50,41%
	∇kpi_{22}	5,176	5,177	0,02%
	∇kpi_{23}	5,232	4,710	-9,98%
	∇kpi_{24}	7,004	16,549	136,28%
	∇kpi_{25}	4,461	7,074	58,57%
	∇kpi_{26}	3,558	3,823	7,45%
	∇kpi_{27}	9,722	9,451	-2,79%
	$fulfilment\_kpi_{21}$	Yes	Yes	
	$fulfilment\_kpi_{21}$	Yes	Yes	
	$fulfilment\_kpi_{23}$	Yes	Yes	
	$fulfilment\_kpi_{24}$	Yes	Yes	
	$fulfilment\_kpi_{25}$	Yes	Yes	
	$fulfilment\_kpi_{26}$	Yes	Yes	
	$fulfilment\_kpi_{27}$	Yes	Yes	
Second Tier	Δkpi_1	7,651	8,873	15,97%
First Tier	Δkpi_2	7,783	9,520	22,32%
Pilot 2	Δkpi_{net}	7,717	9,196	19,17%

Analysing the KPIs defined by the Second and First Tiers

With regards to the Second Tier, the kpi_{11} is increased by 91,14% in the collaborative scenario, with respect the results obtained in the non-collaborative scenario. The kpi_{12} is increased by 27,13% in the collaborative scenario. The kpi_{13} has a 414,28% of increase in the collaborative scenario, comparing with the non-collaborative scenario. In the kpi_{14} an increase of 126,72% is observed in the collaborative scenario. Finally, in the kpi_{15} an increase of 733,80% is observed in the collaborative scenario. In general, the KPIs defined by the Second Tier presents a significant improvement in the collaborative scenario.

Considering the results of the First Tier, the kpi_{21} reduces the performance level by 50,41% in the collaborative scenario, comparing the results in the non-collaborative scenario. The kpi_{22} is almost equal in both scenarios. The kpi_{23}, presents a worsening of 9,98% in the results of the collaborative scenario with respect to the non-collaborative one. The kpi_{24} has a 136,28% of increase in the collaborative scenario, comparing with the non-collaborative scenario. In the kpi_{25} an increase of 58,57% is observed in the collaborative scenario. In the kpi_{26} an increase of 7,45% is observed in the collaborative scenario. Finally, the kpi_{27} presents a slight worsening of 2,79% in the results of the collaborative scenario with respect to the non-collaborative one. In general, the performance levels of kpi_{23}, kpi_{24}, kpi_{25} and kpi_{26}have a significant improvement in the collaborative scenario at the expense of reducing the performance level of the kpi_{21} and kpi_{27}.

Analysing the KPIs at the enterprises level: KPI_Second Tier and KPI_First Tier

With regards the Second Tier, the solution obtained for the collaborative scenario makes that the Δkpi_1 is increased by 15,97% ($\Delta kpi_1^{col} = 8{,}873$ respect the $\Delta kpi_1^{non-col} = 7{,}651$). On the other hand, the First Tier increases its performance level by 22,32% in the results obtained from the collaborative scenario (thus, $\Delta kpi_2^{non-col} = 7{,}783$ respect $\Delta kpi_2^{col} = 9{,}520$). In general, both enterprises increase its performance level.

Analysing the network performance

The of network performance level, Δkpi_{net}, presents an improvement of 19,17% in the collaborative scenario. The increased performance levels of both the Second and First Tiers allows the performance improvement at the network level.

10.8 Questionnaire

A questionnaire (Annex 10.1) was designed to collect the opinions of the enterprises, participating in the Pilot 1, considering the results obtained in the implementation of the Strategy Alignment Model, both in collaborative stage and in the non-collaborative.

This questionnaire is designed to assess the performance of the SAM in terms of usability and utility. The questionnaire consisted of 7 closed questions and a final open question for collecting feedback on the usability and usefulness of the analysis SAM.

A summary of the feedback obtained from the application of the SAM in real cases (Figure 10.17):

- All the decision makers participating in the decision making process of selecting aligned strategies found that the process of data gathering was relatively easy
- All the decision makers considered that level of understanding of the results generated by the SAM was relatively affordable with the help of an expert
- All the decision makers hold that the results obtained from applying the SAM in the collaborative scenario were close to what the company had decided
- 100% of the enterprises indicated that the level of usefulness of the results generated by the SAM in the collaborative scenario were rather useful

- 60% of the decision makers found very important the improvement in network performance when considering the results generated in the SAM in the collaborative scenario. The other 40% of decision makers found important the improvement achieved with SAM in the collaborative scenario.
- All the decision makers would choose to make the decision of what strategies to activate from a collaborative scenario by establishing negotiations on the activation of those strategies in which the enterprise does not fully agree

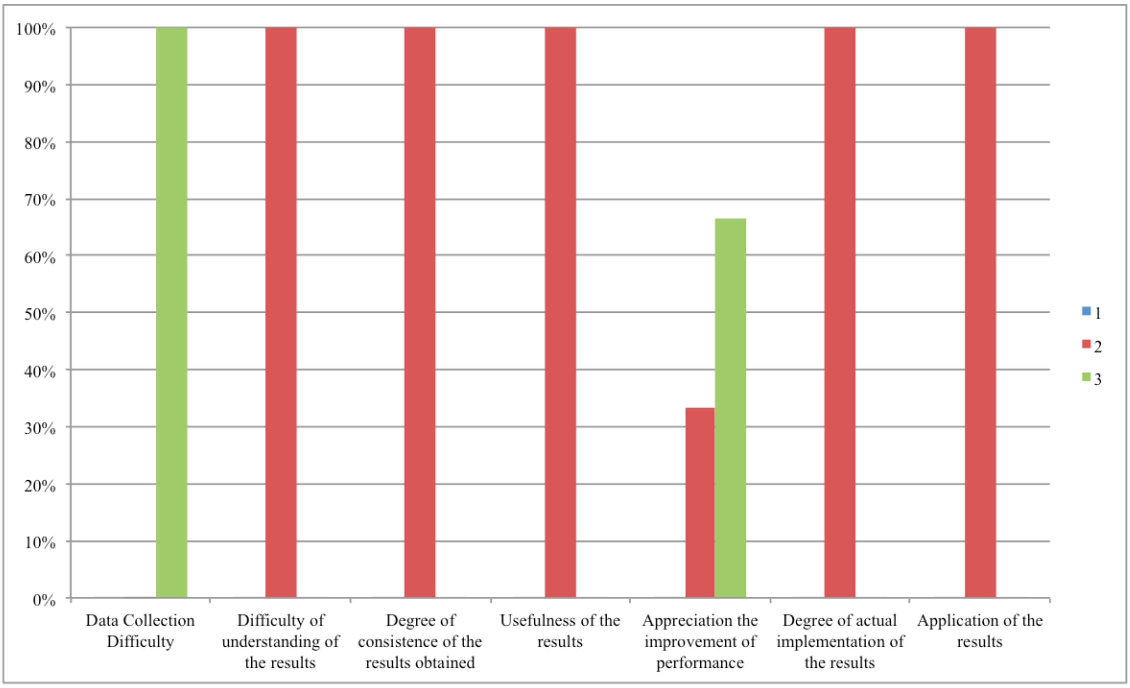

Figure 10.17. Survey Results: Strategies Alignment Approach Usability and Utility

Legend:

1	*Very Difficult/Inconsistent/Not useful/Not important/Low degree of implementation/Not Applicable*
2	*Affordable/Consistent/Useful/Important/Medium degree of implementation/Applicable with negotiations*
3	*Easy/Entirely Consistent/Very Useful/Very Important/High degree of implementation/Applicable*

10.9 Conclusions

Pilot 1 uses a simplified version of the model (SAM); nevertheless, logical and consistent results are obtained, so that a good validation is carried out. Pilot 1 allows demonstrating that not always the necessary data is available in the enterprises, and that despite this, the solution obtained in the strategies alignment approach can be equally valid.

The reformulation carried out, in the curve $f\_\inf\_str_{is}\_kpi'_{ixk}\ (t)$, such as done in the particular case of study of Pilot 2: Automotive Industry, allows modelling as many behaviours as the enterprises require according to their needs and according how the strategies u_str_{is} formulated influence the kpi'_{ixk} defined. The representation of the curve will be limited by the System Dynamics Functions provided by the simulation software (*AnyLogic*).

In both cases the results given for the collaborative scenario provides improved levels of performance at the network level. Nevertheless, the increase of the network performance can be given due to the decrease of the some enterprises performance, as it can be seen in Pilot 1. Each of the enterprises of the two studied Pilots have analysed the set of strategies to activate.

The selection of strategies given by the optimisation experiment in the simulation software is one of the potential solutions that the enterprises can acquire. The application of the strategies alignment approach (SAM, SD, SAGEN and SAG) has been limited to the data collection and implementation in order to validate the proposed contribution. Nevertheless, no negotiation processes have been conducted among the partners, in order to select other potential set of aligned strategies. The validation of the negotiation process was out of the scope of this thesis.

Generally, the enterprises of the studied Pilots have observed that (i) the process of gathering the data required for feeding the SAM was relatively easy, (ii) the level of understanding of the results generated by the Strategies Alignment Approach was relatively affordable with the help of an expert, (iii) the results obtained from applying the Strategies Alignment Approach in the collaborative scenario are consistent with what the company had decided, (iv) the usefulness of the results generated by the Strategies Alignment Approach in the collaborative scenario were rather useful, (v) the improvement in network performance achieved with the strategies obtained in the Strategies Alignment Approach is very important, so that the strategies to be selected applying the collaborative scenario is favourable to the CN operation in the long term.

The main aim of this validation is to show enterprises another way of proceeding in the decision-making of selecting strategies, based on the degree of alignment; that is by considering not only the achievement of the own objectives but also the objectives of other enterprises of the CN.

Experiments can be also used to simulate scenarios in which different set of strategies are activated. The simulation software will show the degree of alignment of the selected strategies and the way in which these strategies allow to fulfil all the KPIs defined by the enterprises of the CN.

The degree of alignment is defined by the binary parameter $fulfillment\_kpi_{ixk}$ that indicates if increase experienced by the kpi_{ixk} is higher than the minimum increase that the enterprise estimates for the kpi_{ixk}, once the $Threshold\_kpi_{ixk}$ is computed. If all the parameters equal 1, $fulfillment_{kpi_{ixk}} = 1$, the degree of alignment is 100%. Otherwise, the degree of alignment is computed taking into account as a base this 100%.

Annex 10.1. Questionnaire to assess the Validity of the Strategies Alignment Model

Accessible in: https://goo.gl/eB33Uu

PART V. CONCLUSIONS

Chapter 11

Conclusions and Future Research Work

In this chapter the conclusions of the thesis are proposed, focusing on the contributions of the study and the discussion of the results considering the model, method, the se of tools and guideline proposed. Implications for research and practitioners are also proposed. Moreover, research limitations are listed. Finally, derived from the research carried out in the area of Strategies Alignment, in the CN context, a set of open issues are proposed and described for future research work.

11.1 Research Contribution

In this thesis the Strategies Alignment Process has been tackled, considering the Collaborative Networks context. A previous and extensive literature review has been carried out in order to identify the existence of a gap in this research area. Along the development of this thesis, the strategies alignment concept, apart from being described, has been formally defined using a mathematical notation. The main contribution related to the developed work is the proposed complete approach, consisting of a model, a method, a set of tools and a guideline. The four artefacts, proposed to address the strategies alignment process, are defined complementing each other. Figure 11.1 shows the key points developed in each part of the developed dissertation research.

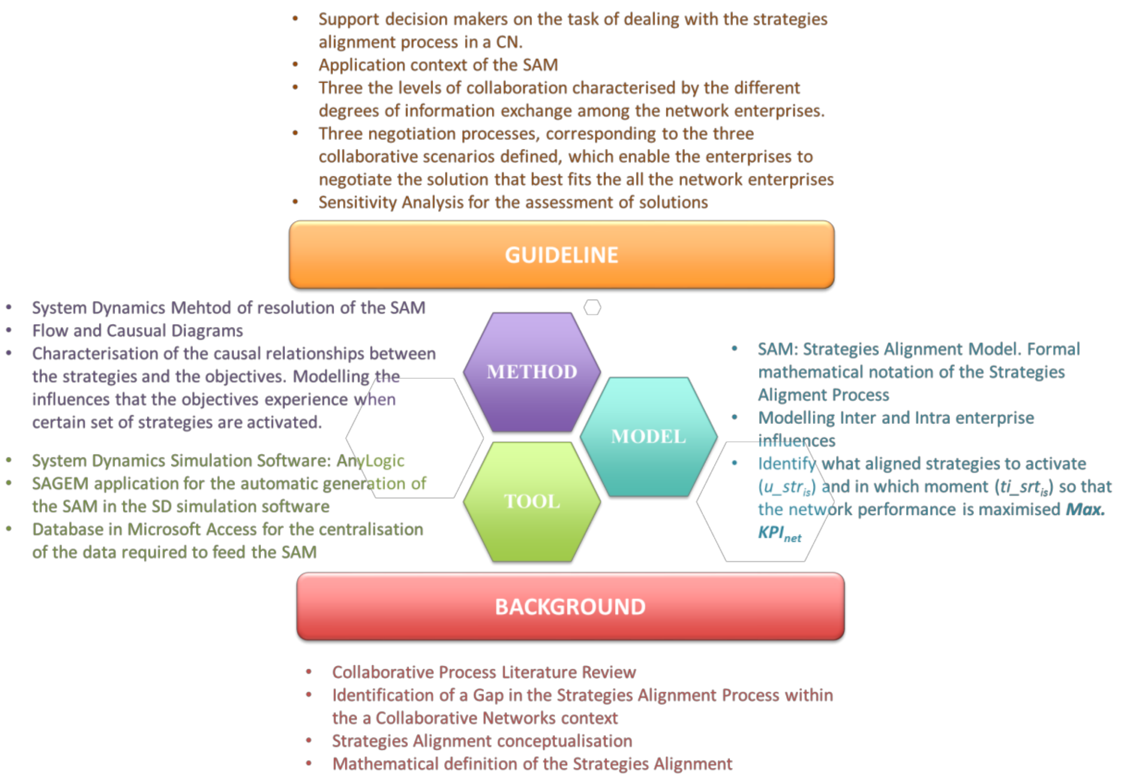

Figure 11.1. Research Contribution: Strategies Alignment Process

The research questions proposed in Chapter 1 and the Proposed Actions described in Chapter 3 (Table 3.6) are considered fulfilled with the research contribution:

General research question raised

***GenQ.* What would be a complete approach to adequately support enterprises on the modelling, assessment and resolution of the strategies alignment process from a collaborative perspective?**

The general research question is fulfilled though the proposal of the four artefacts, that include the Strateiges Alignment Model (SAM); the System Dynamics (SD) method, used to solve and model the SAM; the set of tools, including the SD simulation software (for this AnyLogic), the Database Management System (DMS), the Strategies Alignment Generator (SAGEN application); and the Strategies Alignment Guideline (SAG). The proposed actions A2, A3 and A7 (defined in Table 3.6, Chapter 3) are satisfied with the proposal of an holistic and complete approach. Moreover, the definition of the concept of “Strategies Alignment”, using a mathematical formulation (being more rigorous its conceptualisation), allowed satisfying the proposed Action A1 of Table 3.6 (Chapter 3). Finally, the verification and validation, in different illustrative examples and two industrial Pilots, of the four artefacts allows to affirm that the general question raised has been fulfilled.

Specific research questions raised

***RQ1*. How to model the impact that each strategy, formulated by one enterprise, has on the objectives defined by the other network enterprises? That is, how to model the impact of the strategies at the inter-enterprise level?**

***RQ2*. What would be an adequate model to support the process of identification of aligned strategies, through modelling the strategies impact in the objectives, in CN context?**

These two specific research questions are fulfilled through the SAM design

Model

A mathematical programming model has been proposed to formally represent the collaborative process of strategies alignment: *Strategies Alignment Model* (SAM). This mathematical model defines (i) the objective function, which is based on maximizing the overall performance of the network, (ii) the decision variables though which the strategies to activate (amongst all the formulated by companies forming the network) and the time frame of activation of each strategy are identified and (iii) the restrictions associated with the strategies alignment process. The proposed mathematical model (SAM) allows modelling the behaviour of all the defined objectives (through its measurement KPIs) considering the activation of the strategies formulated. The set of aligned strategies to activate allows maximising the collaborative network performance. To this extent, inter and intra-enterprise influences are considered in order to model the causal relationships between the strategies and the objectives. Accordingly, the Action A4 is achieved. Besides, the SAM enables to model all the partners of the network and all the type of strategies and KPIs defined, using a holistic approach. Concluding, the Actions A1, A2, A3 and A5 are satisfied.

***RQ3*. What would be an adequate method to support the process of identification of aligned strategies, and to represent causal relationships (impacts) between the strategies and the objectives, in CN context?**

This specific research question is fulfilled through the SD method proposed

Method

SD method is selected enabling to characterise the causal relationships between the strategies and the objectives; modelling the influences that the objectives experience when certain set of strategies are activated. Moreover, SD will favour to understand the structure and dynamics of complex systems, such as the CN. Unlike discrete event or agent based simulation approaches, the use of SD method enables the representation of the strategies alignment process from an aggregated view. The main aim of this validation is to show enterprises another way of proceeding in the decision-making of selecting strategies, based on the degree of alignment; that is by considering not only the achievement of the own objectives but also the objectives of other enterprises of the CN.SD can be usefully applied in complex systems in which models are represented with less detail in order to predict the behaviour, given certain initial conditions. In SD the processes can be represented from a continuous perspective

The mathematical programming model, SAM, has been represented and adapted considering the concepts related to SD method. Through SD, the strategies alignment model is represented considering the causal and flow diagrams. The parameters and decision variables defined in SAM have been analogously categorized considering the variables proposed in SD: level variables, and auxiliary variables and flow variables. Representing the SAM in SD has allowed carrying out the Actions A2, A3, A4 and A5.

***RQ4*. What would be an adequate tool to support the process of identification and assessment of aligned strategies, and to compute the strategies impact on the objectives performance at enterprise and network level, in CN context?**

This specific research question is fulfilled through the design of a set of tools, allowing the resolution of the SAM, are proposed. Three are the proposed tools:

Set of Tools

- Simulation software that supports the SD method, with the main aim of solving the SAM. The simulation software *AnyLogic* is chosen in order to represent the SAM in DS. The simulation software allows carrying out simulation and optimization experiments to solve the SAM. The decision variables, related with the aligned strategies to activate and the time period in which to activate them, are identified by the resolution of the SAM in AnyLogic simulation tool.
- DMS that stores all data required to solve the SAM. The data associated to the parameters defined in the model are gathered in a DMS. The database has been specifically designed to collaboratively treat the strategies alignment process collaboratively.
- SAGEN Tool programmed ad-hoc, allows to automatically generate the SAM in the SD simulation software selected, *AnyLogic*. The DMS built in Microsoft Access contains the necessary data to automatically build the SAM in the simulation software, through SAGEN application. SAGEN generates automatically an XML file containing all the data parameters and has the specific structure required to build the SAM in AnyLogic simulation software, including the flow diagram, the simulation experiment and the optimisation experiment.

The simulation software proposed as well as the tools has allowed to solve and assess the strategies alignment process, fulfilling the proposed Actions A2, A3 and A4.

***RQ5*. What would be an adequate guideline to support the process of identification and assessment of aligned strategies, and to analyse the strategies impact on the objectives and identify misalignments, in CN context?**

This specific research question is fulfilled through the proposed guideline

Guideline

A SAG consisting of twelve phases has been developed to support the network enterprises in the implementation of the model (SAM), method (SD) and tools (SD simulation software, DMS and SAGEN) proposed to support the decision-making in the activation of aligned strategies. The proposed guideline involves the network characterisation; the data collection process; the definition of the collaboration level established to deal with the strategies alignment process; the estimation of the parameters required to feed the model; the introduction of data in the DMS; the automatic creation of the SAM in the simulation software; the assessment of solutions; and the negotiation process to agree the solution adopted by the enterprises willing to align their strategies, within the collaborative network context.

The proposed model and tools are applicable in a collaborative NHN context, in which all the network partners are equally considered, as well as, all the objectives and the strategies defined by each of them. Different negotiation processes have been proposed, with the main of supporting the enterprises on the process of deciding which solution to adopt. The negotiation processes are applicable in various levels of collaboration characterised by the degree of information exchange (complete, partial, minimum exchange of information). For higher levels of information exchange the degree of collaboration established among the enterprises increases.

The guideline has allowed considering all the partners of the network and all the strategies, satisfying the proposed Actions A2 and A3. Besides, the proposed guideline gives high importance to the negotiation and assessment of solutions, allowing to reach the proposed Action A6.

11.2. Research timeline

The timeline of the research work carried out along the three years of the thesis is shown in Figure 11.2.

This research has been granted by the Valencian Government with a pre-doctoral grant named *Programa VALi+d para Personal Investigador en Formación de Carácter Predoctoral de la Generalitat Valenciana ACIF/2012/006*. The pre-doc grant has been complemented with two more grants received for carrying out two research stays, in international Universities:

- Spanish Government Grant: *Orden ECD/3628/2011*, december 26th, M*inisterio de Educación Cultura y Deporte Beca de Movilidad de estudiantes en programas de doctorado con Mención hacia la Excelencia*. This grant aims to strengthen and promote the internationalisation of doctoral training in Spanish Universities, in 2011-2012 academic year, through student mobility stays as part of a corporate strategy in this area and, in particular, led to the consolidation of doctoral programs with Mention to Excellence. The PhD student could apply due to participates in a doctoral program with Mention to Excellence, "Programa de Postgrado Oficial en Ingeniería y Producción Industrial", in the Universitat Politècnica de València (UPV).
- Valencia Government Grant: *Order 79/2013*, July 30th, *Consellería de Educación, Cultura y Deporte*. This grant allows the promotion of scientific research and technological development in the Valencian Region: *Becas para estancias de becarios y contratados predoctorales en centros de investigación fuera de la Comunitat Valenciana: anexo III*. The purpose of this call is to award grants for stays of pre-doctoral training research staff in research centres outside Valencian Region. Aiming the acquisition of new skills, access to scientific installations, bibliographical funds, and perform other significant activities in the context of the thesis project of the beneficiary, and contribute to its scientific and technical training.

Research stays allowed the PhD student to carryout the tasks as regards the literature review and the tools implementation, specifically SAGEN application development. The *University of Liverpool* and the *Universidade Nova de Lisboa* were the two hosting centres, considering their alignment on the areas of research developed along this thesis.

Figure 11.2. Timeline of the Thesis

11.3. Application of the Strategies Alignment Approach within the collaborative NHN context

The proposed Strategies Alignment Approach has been proposed for its application within the collaborative network context. Nevertheless, due to its generic design, the Strategies Alignment Approach can be also applied by individual enterprises willing to identify the aligned strategies, previously formulated within the same enterprise. Coming back to the application in the collaborative networks context, the specific collaborative network topology in which the Strategies Alignment Approach is worth to be implemented is the Non-Hierarchical Network (NHN) context. The collaborative NHN are networks consisting of heterogeneous and autonomous entities each one defining its own objectives and formulating its own strategies. In NHN, all the network partners have an equivalent “power”; therefore, there are no objectives nor strategies more important than another within the network, being equally considered. The collaborative and decentralised perspective is contemplated in the application of the Strategies Alignment Approach, when the network topology is a NHN. In the light of this, each enterprise computes the SAM separately. There are as many models (SAM) as number of enterprises participating in the strategies alignment process. Thus, SAM^i is the model implemented in the *Enterprise i*, while SAM^j is the model implemented in the *Enterprise j*. The same model is reproduced in each enterprise and the same set of solutions is obtained. In order to compute the SAM in each enterprise, a minimum, partial, or complete exchange of information is to be carried out, depending on the collaborative scenario agreed. Each enterprise obtains the same set of solutions but each enterprise can decide the alternative of solution that best fits to its requirements. In this case, the negotiation process is initiated until an agreement is reached in terms of the aligned strategies to be activated.

11.4. Discussion of results

There are some authors in the literature that examine the importance of alignment to establish sustainable and stable relationships among the enterprises of the CN (Lee 2004) (Piedade, Azevedo, and Bastos 2010) (Macedo and Camarinha-Matos 2013). Nevertheless, the concept of strategies alignment treated in this dissertation research must not be confused with the concept of strategic alignment highly studied in the literature (Cuenca, Boza, and Ortiz 2011). The difference between the strategies alignment, addressed in this thesis, and the strategic alignment is discussed in Chapter 3.

The research work developed in this thesis provides an empirical support for the strategies alignment process, within the CN context. The holistic view of the contribution presented allows to model different types of strategies and objectives and takes into account the heterogeneity of the partners participating in a CN. The benefits of a holistic approach are related with the better understanding and modelling the complex relations established between the strategies and objectives. Moreover, the holistic characteristic enables to model any type of strategy and its influences in any type of objective. Modelling the causal relations between strategies and objectives, allows to accurately represent the influences between the enterprises performance and the activation of aligned strategies. The present doctoral thesis contributes to the theoretical and practical innovation, providing a new model, method, tools and guideline to support collaborative enterprises in the decision-making of selecting aligned strategies.

The enterprises participating in the collaborative process of strategies alignment induce the network to achieve improved performance levels. This increase on performance is also reflected at the enterprises level. Nevertheless, sometimes an increase in the network performance could be produced by the reduction of performance of some of the partners of the network. At the global level, the enterprises will foster in the network performance improvement, assuring its continuity. All in all, the proposed contribution strengthens the need to optimise the performance at the network level.

The illustrative examples and the Pilots emphasize the need of establishing collaborative relationships when dealing with the decision of which strategies activate in order to achieve higher levels of alignment. The non-collaborative behaviour does not guarantee the activation of adequate strategies, provoking the activation of conflicting strategies and leading to a situation of the strategies misalignment. With this misalignment, conflicts among the enterprises might emerge, endangering the continuity of the CN.

The strategies alignment model, and the method, tools and guideline proposed, establish an novel decision making mechanism by which enterprises can effectively identify the most valuable and aligned strategies to be activated. Dealing with the strategies alignment process, from a collaborative perspective, allows enterprises to upgrade their capability to identify misalignments, among the activated strategies; an essential role for the responsiveness, agility and resilience of the CN (Sanchis and Poler 2014).

The constructive research approach used in this dissertation makes us focus upon two relevant research areas (i) theoretical and (ii) practical.

11.5. Theoretical implications

The research carried out offers some theoretical implications, contributing to the research on operations management, system dynamics, collaborative networks, NHN, industrial management, alignment and performance. The results obtained in the research provide the evidence that the strategies alignment is useful at both enterprises and network level. The SAM has been designed modelling inter and intra-enterprise influences between the strategies formulated and objectives defined, considering all the enterprises of the network. The relevance for the theoretical body of knowledge resides in the consideration of a holistic approach to address the limitations founded in the strategies alignment process; by contributing with the Strategies Alignment Approach, which consist of model, method, tool and guideline.

A theoretical extension is offered from the point of view of the alignment in collaborative networks (Macedo, Abreu, and Camarinha-Matos 2010). A new view of alignment is considered, filling the gap founded in previous studies, in terms of providing a holistic construct to deal with strategies misalignments in the CN context, and particularly in the NHN topology. On the model side, the collaborative network is characterised by considering the specific process of strategies alignment. On the method side, SD is considered with a novel application to support the collaborative process of strategies alignment, using it as a starting point for future developments related with the strategies alignment from a completely distributed perspective. The developed work contributes with a new way to assess the alignment of strategies, through the application of SD method to adequately model the causal relationships between the strategies and the objectives and the use of qualitative indicators characterising this influences for the analysis of the strategies alignment in a collaborative context.

As regards the tool, system dynamics-based simulation software is used to support the selection of aligned strategies. A DMS that stores all the information, required to solve the problem of selecting aligned strategies, is specifically designed in *Microsoft Access*. Finally the *Strategies Alignment GENerator* (SAGEN) is programmed, as an application that automatically generates the strategies alignment model in the system dynamics-based simulation software.

Considering the guideline proposed (Strategies Alignment Guideline, SAG), negotiation processes are designed with the main aim of promoting collaboration within the network enterprises, not only when gathering the required information, to feed the SAM, but also in the process of selecting the solution alternative that best fits to all participating enterprises, as long as the optimal solution obtained, when solving the SAM in the SD simulation software, is not accepted.

11.6. Practical Implications

The main application of the Strategies Alignment Approach is focused on SMEs, willing to collaborate and align strategies, with balanced power within the network.

Sustainable and stable relationships are achieved, within the CN, with the implementation of the Strategies Alignment Approach. An increase on the network visibility is also achieved due to the contribution proposed considers all the enterprises of the CN. From the implementation of the Strategies Alignment Approach it is suggested that enterprises collaboratively deal with the strategies alignment. Dealing with the strategies alignment process from a common perspective will allow enterprises to have higher knowledge about the influences that all the strategies formulated have in the all KPIs, defined by each collaborative enterprise. The collaborative perspective allows enterprises to consider not only the individual strategies but also the strategies of other enterprises. Accordingly, the selection of aligned strategies not only promotes the attainment of the objectives of an individual enterprise, but also fosters the achievement of the objectives defined by the other network partners, positively affecting the majority of objectives (or minimising the negative influences).

The proposed guideline provides an important support on how the network and enterprise managers have to proceed when making the decision of which aligned strategies activate, from a collaborative perspective. The negotiation processes, included in the guideline, allows obtaining a solution that satisfies all the partners, providing that the network performance is maximised (or it is near to the optimum, sub-optimal solutions).

The tool that refers to the DMS allows practitioners to have a repository of data concerning the: (i) strategies and the parameters that characterise them, including the strategies costs, and duration; (ii) objectives and KPIs and the parameters that characterise them, including the KPIs importance, minimum levels of achievement of the KPIs and threshold values related to the KPIs; (iii) the budget owned to invest in formulated strategies and (iv) the influences estimated between the strategies and the performance levels of the defined objectives.

Enterprises participating should know that, at times, in the collaborative participation of the strategies alignment process, some partners would lose what the others gain. Although it is likely that some enterprises slightly reduce their performance, this reduction is limited in the model through the definition of the parameter that identifies the minimum performance level to be achieved by the KPIs (kpi_{ixk}_min). Thus, the individual objectives of each of the network enterprises will be attained. All in all, the network performance will be always maximised. Thus, it could occur that the enterprises do not have an immediate increase in their performance levels, but in the long term the partners, that initially reduced their performance, will be benefited, leading to a win-win situation for all the partners belonging to the CN.

Concluding, the Strategies Alignment Approach guides the enterprises towards a transformation in the way of operating in the current global and dynamic market, through establishing sustainable and stable relationships within the CN. So that, (i) it facilitates the identification, representation and storage of knowledge about strategies formulated and objectives defined, as well as the influences established between them; (ii) it uses quantitative inputs through performance indicators to model and solve the strategies alignment process, promoting higher levels of objectivity in the solution approach proposed; (iii) it allows all agents participating in the decision-making process to easily interpret the outputs in terms of identifying the strategies that are aligned, given in qualitative values and (iv) provides a space of solutions that allows decision makers to establish negotiations, according to their interests, so that a final agreement is reached as regards the solution of which strategies activate and when, achieving higher levels of alignment. Definitely, the Strategies Alignment Approach provides enterprises new ways of making the decision of selecting strategies, using as a base the degree of alignment, and considering a collaborative perspective.

11.7. Limitations

While it has been proved that the objectives of the developed research have been fulfilled, in this part of the document some limitations of the proposed Strategies Alignment Approach should be taken into account. These limitations are recognised from the utilization of the complete approach in real cases:

- Collaboration levels: For higher levels of collaboration (Collaborative Scenario 3) the enterprises require to exchange certain private information that sometimes are not willing to share. Therefore, the network manager has an important role for supportting the decision making process for selecting aligned strategies, considering the collaborative perspective.
- Data collection: Considering that a collaborative network is characterized by uncertainty and incomplete information, gathering all the data in an accurate way is seen as a drawback to feed the SAM. More concretely, the information as regards the value $val\_str_{is}\_kpi_{ixk}$, it is, sometimes, difficult to know specially if the strategy stris has never been activated before.
- Negotiation Process: In Chapter 8 the guidelines to follow in the negotiation process when the collaborative scenario, selected by the enterprises belonging to the network and participating in the strategies alignment process, has not been completely implemented, and therefore, validated. Moreover, the proposed negotiation process has to be implemented and validated in a real case. In this regard, for some cases the negotiation process could be not valid, so that after several iterations the enterprises could not reach a common solution in terms of aligned strategies.
- Model validation: Dealign with the validation of a network is a complex task due to the the heterogeneity of enterprises and the high amount of information to handle for implementing the strategies alignment model. The difficulty increases when the data required is to be estimated by the enterprises. The uncertainty associated with the values used to solve the strategies alignment model makes the solution less robust.
- Simulation and optimization: The optimisation is based on a combinatory resolution method, using metaheuristc algorithms, which are based on higher-level procedures or heuristics designed to find, generate, or select a heuristic (partial search algorithm) that may provide a sufficiently good solution. Metaheuristic algorithms use to implement random search and can find several solutions (it can not ensure optimum) using a search strategy which needs a stop rule (it can be time). Depending on the number of enterprises, the performance indicators defined and the strategies formulated in the problem, the number of iterations required to solve the modelled problem varies.

- Regarding the simulation software used to solve the SAM in SD, AnyLogic: When carrying out the optimisation experiment with a large amount of parameters, the decision variables remain in 0 and no solution can be obtained, even considering higher number of iterations (more than 100.000). Larger sizes of the SAM makes that the simulation software does not provide any solution due to there are too much variables and, therefore, to much combinations and restrictions to accomplish. At this point, it can be stated that the simulation software used to solve the SAM is not valid for big problems, with more than 40 decision variables and more than 40 restrictions. The time consuming of the optimisation experiment is more than one 24 hours when the number of variables increase.

11.8 Future Research Lines

According to the proposed contribution, a single SD model is created to represent the strategies alignment process, which considers all the enterprises of the network. In this single model, the information required by the enterprises is centralised in the same model. The data required to feed the SAM is also centralised in a database. This centralisation can generate in companies a reluctant behaviour to share the information they consider private. Therefore, in order to respect the organisation privacy a future solution could be based on creating a distributed SD model to represent the strategies alignment process. The consideration of the distributed model will not only ensure the enterprises privacy and improve the data exchange in a private way, but will also allow increasing the efficiency in the simulation and optimisation experiments. The distributed SD model could consist of different models (SAM_n), each one created to model the strategies alignment process in an individual enterprise. The distributed SD models, defined for each enterprise, will be linked so that the information is exchanged in an encrypted way. Accordingly, the output of one enterprise model will serve as input of another enterprise model and vice versa (see Figure 11.3).

More concretely, a distributed model is to be proposed so that each network node simulates, in its own hardware and software, one part of the strategies alignment model (its own part). At the micro level each part (or sub-model) of the strategies alignment model is defined for each enterprise in a distributed way. While the macro level will consist of all the sub-models, defined at enterprise level, linked. The exchanges of information among the enterprise models will be governed at a macro level, having the control of all the required inputs and outputs in each enterprise model (SAM_i).

Going further, each enterprise of the network could be represented as an agent that will behave according to the SD model defined to represent the strategies alignment process, at the micro level. The outputs generated in one agent will be the inputs of the other agents, of the network, representing the enterprises. Motivated by this, a multi-method approach using both SD and agents could be considered.

Another future research line is related with the design of a distributed database management system, gathering in each stage of the network the information required to feed the SAM. So far, in the SAM proposed in this thesis, the simulation software requires to have all the information centralised. The future research proposal is to design a distributed database management system, in which each company will manage its part and will exchange information in an encrypted form. Thus, further research lines will be related with the definition of a distributed DMS, which will allow modelling the strategies alignment process from a totally distributed perspective.

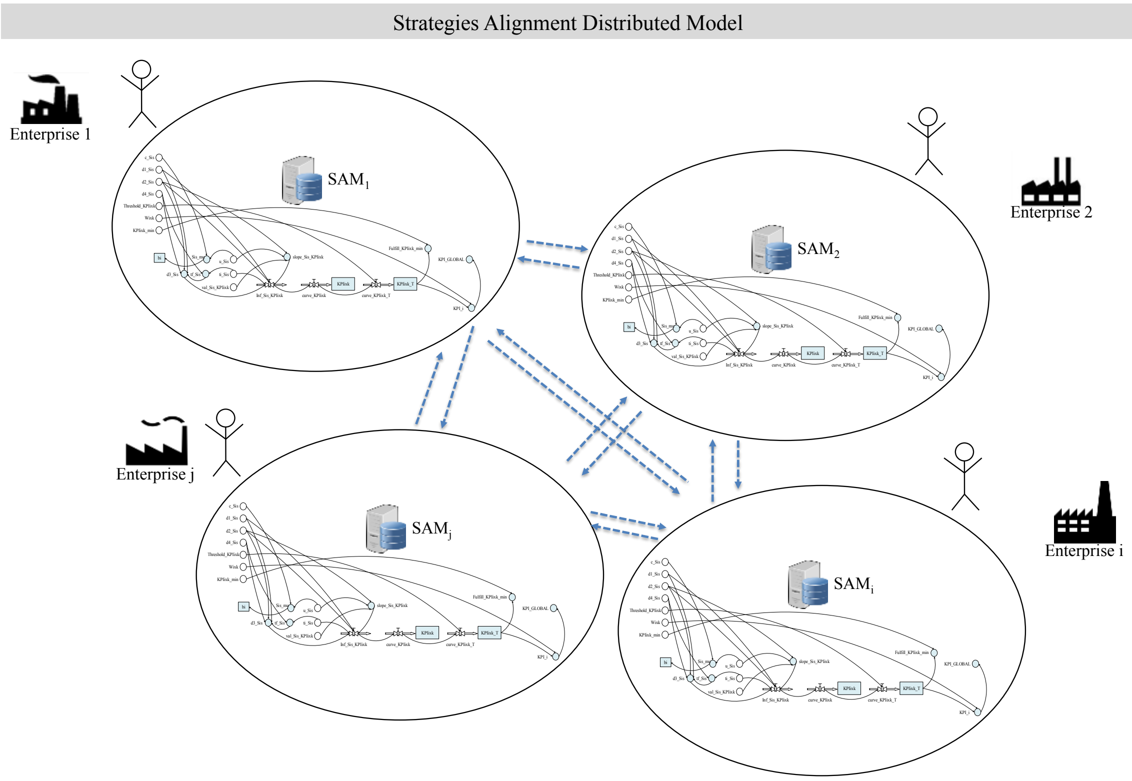

Figure 11.3. Distributed Model

With regards the method used to solve the SAM, an extended version of the SAM can be provided integrating Games Theory (Nash 1950). Using the research line of cooperative problems that looks to maximise the benefits. Cooperation using Games Theory involves complex resolutions due to higher amount of variables come into play.

The collaboration scenarios defined and the negotiation processes proposed, in Chapter 8, need further validation due to so far the model has only been implemented considering the non-collaborative scenario (NCS) and the complete collaborative scenario (CS3) in which all the information is exchanged. The negotiation process has not been validated, although it has been verified. In the light of this, simulation agents can be considered, using them as a software and coding them employing a dialog oriented to the negotiation and coordination to transfer information. These agents can be handled to perform activities aimed at developing communication, coordination and negotiation to resolve conflicts within the strategies alignment process.

Continuing with the validation started in this thesis, the SAM will be applied considering a network with significant number of partners. The proposed holistic approach needs to be applied in more complex environments. Thus, in the el future, other simulation softwares could be used in order to overcome the limitations associated with AnyLogic simulation software, used in this thesis.

It is predicted that the theoretical contribution proposed to address the strategies alignment process in a collaborative context, can be examined in order to deal with other collaborative processes, such as partner selection. And even implement the Strategies Alignment Approach in other network topologies such as VO, in which the strategies of the VO partners are aligned with the global objective defined at the network level.

The contribution developed in this thesis is implemented in two industrial Pilots, considering a reduced amount of enterprises. Nevertheless, the implementation of the complete approach to deal with the strategies alignment process could be extended in the future for modelling the strategies and KPIs of other network partners belonging to the network of the validated Pilots.

Finally, this work is intended to be the initial step in the research area of the strategies alignment process and can serve as a theoretical and practical basis for future developments.

11.8 References

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Books are not made to be believed, but to be subject to inquiry. When we consider a book, we musn't ask ourselves what it says but what it means.

The name of the Rose