

---

## Table of Contents

<b>PART I. INTRODUCTION</b> .....	27
Chapter 1. <u>I</u> ntroduction.....	29
1.1 Problem definition and Motivation .....	31
1.2 Research Questions.....	33
1.3 Research context.....	33
1.4 Research Method .....	36
1.5 Outline of the Thesis.....	39
1.6 References .....	42
<b>PART II. REVIEW</b> .....	47
Chapter 2. <u>A</u> review of Models, Guidelines and Tools for the establishment of Collaborative Processes .49	
2.1 Introduction .....	51
2.2 Problem Formulation and Literature Review Methodology .....	51
2.3 Collaborative Processes in Manufacturing Networks: A Literature Review .....	54
2.4 Collaborative Processes Matrix: Classification and Analysis.....	59
2.5 Conclusions .....	75
2.6 References .....	77
Annex 2.1. Acronyms .....	92
Chapter 3. <u>A</u> review of Models, Guidelines and Tools to deal with the Strategies Alignment Process .....93	
3.1 Introduction .....	95
3.2 Strategies Alignment Concept .....	95
3.3 Background of topic under study: Strategies Alignment Process .....	98
3.4 Discussion of the reviewed works .....	106
3.5 Conclusions .....	108
3.6 References .....	109
Chapter 4. <u>A</u> review of Approaches and Tools for Supply Networks Simulation.....115	
4.1 Introduction .....	117
4.2. Supply Network Simulation Approaches.....	119
4.3 Simulation approaches comparison .....	123
4.4 Simulation Tools.....	127
4.5 Conclusions .....	127
4.6 References .....	130
<b>PART III. PROPOSAL</b> .....	135
Chapter 5. <u>M</u> odel to represent the Strategies Alignment Process in a CN .....	137
5.1 Introduction .....	139

5.2 Formal definition of a Collaborative Network System .....	140
5.3 Formal definition of Strategies Alignment .....	141
5.4 Strategies Alignment Model .....	147
5.5 Example 5.5. Illustrative Example .....	157
5.6 Chapter discussion and conclusions .....	164
5.7 References .....	166
Chapter 6. Method to solve the Strategies Alignment Process in a CN .....	167
6.1 Introduction .....	169
6.2 System Dynamics application in the Strategies Alignment .....	169
6.3 Model construction in System Dynamics .....	170
6.4. <i>Example 6.1</i> : Formulating the equations of the SAM in SD .....	180
6.5 Conclusions .....	183
6.6 References .....	184
Chapter 7. Tools to support the Strategies Alignment Process in a CN .....	185
7.1 Introduction .....	187
7.2 System Dynamics Simulation Software .....	187
7.3 Structure of the SAM input data .....	201
7.4 Strategies Alignment Model Generator .....	209
7.5 Application Examples .....	214
7.6 Chapter discussion and conclusions .....	227
7.7 References .....	228
Annex 7.1. Set of optimum solutions that maximise the objective .....	229
Annex 7.2. Introduction of the data required to feed the SAM in SAGEN application .....	229
Annex 7.3. Strategies alignment model in XML language. Modelling a CN of 2 enterprises each one defining 2 KPIs and 2 Strategies .....	229
Annex 7.4. Strategies alignment model in XML language for a CN of 10 enterprises defining 4 KPIs and formulating 4 strategies each one .....	229
Chapter 8. Guideline to deal with the Strategies Alignment Process in a CN .....	231
8.1 Introduction .....	233
8.2 SAM application contexts .....	233
8.3 Guideline Description .....	237
8.4 Conclusions .....	288
8.5 References .....	289
<b>PART IV. VALIDATION</b> .....	291
Chapter 9. Experiments .....	293
9.1 Introduction .....	295
9.2. Validation Elements .....	296

---

9.3. Chapter discussion and conclusions.....	313
9.4 References .....	314
Annex 9.1. Example 9.1: Solutions for the Collaborative Scenario .....	316
Annex 9.2. Example 9.2: Data.....	316
Chapter 10. Real Application .....	317
10.1 Introduction .....	319
10.2. Pilots Description.....	320
10.3. Identification of the Pilots needs .....	321
10.4. Kick of meeting .....	322
10.5. Detailed Guide for Data Collection .....	324
10.6 Pilot 1: Food Industry .....	329
10.7 Pilot 2: Automotive Industry .....	339
10.8 Questionnaire .....	349
10.9 Conclusions .....	350
Annex 10.1. Questionnaire to assess the Validity of the Strategies Alignment Model.....	351
<b>PART V. CONCLUSIONS</b> .....	<b>353</b>
Chapter 11. Conclusions and Future Research Work .....	355
11.1 Research Contribution .....	357
11.2. Research timeline.....	360
11.3. Application of the Strategies Alignment Approach within the collaborative NHN context .....	361
11.4. Discussion of results .....	361
11.5. Theoretical implications .....	362
11.6. Practical Implications .....	363
11.7. Limitations .....	364
11.8 Future Research Lines .....	365
11.8 References .....	367



---

## List of Tables

Table 1.1. Collaborative Processes arranged according to the decision making level (Andres and Poler, 2015).....	31
Table 1.2. Main Concepts Definition (Andres and Poler 2015) .....	35
Table 2.1. Summary of citations.....	53
Table 2.2. Relevant Collaborative Processes: identification and research topics .....	55
Table 2.3. Collaborative Processes at the Strategic decision-making level.....	57
Table 2.4. Collaborative Processes at the Tactical decision-making level .....	57
Table 2.5. Collaborative Processes at the Operational decision-making level and .....	58
Table 2.6. Solution classification criteria .....	59
Table 2.7. Collaborative Processes & Contributions Matrix .....	61
Table 2.8. Classification Scheme for collaborative processes according to the classification criteria and the type of solution .....	68
Table 2.9. Solutions Degree of Coverage.....	69
Table 2.10. Collaborative Processes, Degree of Coverage associated and Justification .....	70
Table 3.1. Strategies Alignment vs. Strategies Compatibility .....	97
Table 3.2. Definition of the <i>alignment</i> concept .....	98
Table 3.3. Summary of works considering the alignment of specific strategies.....	99
Table 3.4. Contributions dealing with the research issue: decisions alignment .....	103
Table 3.5. Gaps and Trends: Clues of the work to be developed on strategies alignment.....	107
Table 3.6. Analogy between the research question formulated (RQx) and the proposed actions (Ax) ....	108
Table 4.1. Simulation approaches comparison: DES vs. SD vs. ABS.....	125
Table 4.2. Comparison of tools characteristics of the studied simulation approaches.....	127
Table 4.3. Simulation Approaches Tools .....	129
Table 5.1. Nomenclature to formally define a CN .....	140
Table 5.2. Data: <i>kpiixk</i> values in scenarios 1 and 2 .....	145
Table 5.3. Nomenclature of SAM .....	148
Table 5.4. Numerical Example: Enterprises Data.....	159
Table 5.5. Homogenised and normalised data .....	160
Table 5.6. Contribution of the provided numerical examples .....	165
Table 6.1. Elements of the Causal Loop Diagram.....	171
Table 6.2. Stock, Flow and Auxiliary Variables in the Strategies Alignment Process .....	175
Table 6.3. Equations for the SAM in SD.....	176
Table 6.4. Equations for Enterprise 1 to model the strategies alignment process in SD.....	180
Table 6.5. Equations for Enterprise 2 to model the strategies alignment process in SD.....	181
Table 6.6. Equations for Enterprise 1 and Enterprise 2 to model the strategies alignment process in SD from a collaborative context .....	182

Table 7.1. Summary of Simulation Tools used in SD .....	188
Table 7. 2. Equations for Enterprise 1 and Enterprise 2 to model the strategies alignment process in SD from a collaborative context .....	192
Table 7.3. Examples of Selection Rules .....	199
Table 7.4. Connection between the DMS tables and model input parameters (I) .....	204
Table 7.5. Connections between the DMS tables and SAM input parameters (II) .....	205
Table 7.6. Connections between tables and model output data .....	206
Table 7.7. XML Schema to define a Parameter.....	209
Table 7.8. XML Schema to define an Auxiliary Variable.....	210
Table 7.9. XML Schema to define a Flow Variable.....	210
Table 7.10. XML structure to define a Stock Variable.....	210
Table 7.11. Example 7.3: Distributor and Manufacturer Input Data .....	217
Table 7.12. Example 7.4: Manufacturer and Supplier Input Data .....	222
Table 7.13. Contributions of the provided numerical examples .....	227
Table 8.1. Comparing the notation defined in the original SAM ( $kpi_{ixk}$ ) vs. the notation used in the implementation ( $kpi_{ik}$ ).....	241
Table 8.2. Likert Scale for estimating the parameter $val\_str_{is\_kpi_{ik}}$ .....	258
Table 8.3. Complete template to gather information for the SAM .....	261
Table 8.4. Simplified Template to gather information for the SAM .....	262
Table 8.5. Parameters used in NP_CS1 .....	265
Table 8.6. CS1: Alternative of solution $n$ .....	268
Table 8.7. Parameters used in NP_CS2.....	271
Table 8.8. CS2: Alternative of solution $n$ .....	275
Table 8.9. Parameters used in NP_CS3.....	279
Table 9.1. Example 9.1:Data (Mix of Strategies).....	299
Table 9.2. Optimisation results considering the activation of strategies as soon as possible .....	300
Table 9.3. Optimisation results considering the activation of strategies as late as possible .....	300
Table 9.4. Example 9.1: Comparison of the collaborative and non-collaborative scenario .....	307
Table 9.5. Example 9.1: Sensitivity Analysis ( $val\_str_{11\_kpi_{11}}$ ) .....	308
Table 9.6. Example 9.1: Sensitivity Analysis ( $val\_str_{11\_kpi_{12}}$ ) .....	308
Table 9.7. Example 9.2: Comparison of the collaborative and non-collaborative scenario .....	312
Table 9.8. Contribution of the provided numerical examples .....	313
Table 10.1. Pilot 1: SAM Data .....	332
Table 10.2. Pilot 1: Results of the Manufacturer (non-collaborative scenario).....	333
Table 10.3. Pilot 1: Results of the Distributor (non-collaborative scenario) .....	333
Table 10.4. Pilot 1: Results of the Collaborative scenario.....	336
Table 10.5. Pilot 1: Results comparison .....	338

Table 10.6. Pilot 2: SAM Data .....	342
Table 10.7. Pilot 2: Results of the Second Tier (non-collaborative scenario) .....	343
Table 10.8. Pilot 2: Results of the First Tier (non-collaborative scenario).....	343
Table 10.9. Pilot 2: Results of the Collaborative scenario.....	346
Table 10.10. Pilot 2: Results comparison .....	348





## List of Figures

Figure 1.1. Position of Constructive approach (Kasanen et al., 1993) .....	36
Figure 1.2. Constructive Research Approach (CRA) (Kasanen et al., 1993) .....	37
Figure 1.3. Thesis Structure and parallelism with the CRA .....	39
Figure 2.1. Papers Distribution according to year of publication and solution approach type .....	53
Figure 2.2. Summary of collaborative processes classified according to the degree of coverage .....	75
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.....	97
Figure 4.1. Simulation Approaches (adapted from Borshchev and Filippov (2004)).....	120
Figure 5.1. Scheme of Fully Aligned Strategies.....	143
Figure 5.2. Network diagram for the numerical example.....	145
Figure 5.3. Scenario 1: Results from the numerical example .....	146
Figure 5.4. Scenario 2: Results from the numerical example .....	147
Figure 5.5. Relationship between the strategies and the KPIs.....	148
Figure 5.6. Procedure to follow for computing $\Delta kpinet'$ .....	150
Figure 5.7. Curve that models the influence of <i>strison</i> on the <i>kpiixk'</i> : $f\_inf\_stris\_kpiixk'(t)$ .....	153
Figure 5.8. Inter-enterprise influence curve. Modelling the influence of <i>strjson</i> on the <i>kpiixk'</i> : $f\_inf\_strjs\_kpiixk'(t)$ .....	154
Figure 5.9. a) $f\_inf\_stris\_kpiixk'(t)$ and $f\_inf\_strjs\_kpiixk'(t)$ . b) $f\_kpiixk'$ .....	155
Figure 5.10. Threshold value consideration ( <i>Threshold_kpiixk'</i> ).....	156
Figure 5.11. Scenarios description .....	158
Figure 5.12. Graphical Example for <i>kpi111'</i> .....	162
Figure 5.13. Graphical Example for <i>kpi121'</i> .....	162
Figure 5.14. Graphical Example for <i>kpi211'</i> .....	162
Figure 5.15. Graphical Example for <i>kpi221'</i> .....	162
Figure 6.1. Building steps: Causal Loop Diagram.....	170
Figure 6.2. Causal Loop Diagram: Strategies Alignment Process.....	174
Figure 6.3. Building steps: Flow Diagram .....	175
Figure 6.4. Flow diagram: SAM.....	179
Figure 7.1. Tools to support the Strategies Alignment Process in CN .....	187
Figure 7.2. Flow Diagram: CN.....	195
Figure 7.3. Representation of the functions of influence $f\_inf\_stris\_kpi111'(t)$ and $f\_inf\_stris\_kpi121'(t)$ that the strategies <i>str11</i> , <i>str12</i> , <i>str21</i> and <i>str22</i> exert over the <i>kpi111'</i> and <i>kpi121'</i> defined by Enterprise 1 .....	196
Figure 7.4. Representation of the function of influence $f\_inf\_stris\_kpi211'(t)$ and $f\_inf\_stris\_kpi221'(t)$ that the strategies <i>str11</i> , <i>str12</i> , <i>str21</i> and <i>str22</i> exert over the <i>kpi211'</i> and <i>kpi221'</i> defined by Enterprise 2 .....	196
Figure 7.5. Configuration of the Optimisation Experiment in the CN .....	197

Figure 7.6. Network: Optimisation Results ..... 197

Figure 7.7. Screenshot of the spreadsheet gathering the results obtained in scenarios generated in the optimisation experiment ..... 198

Figure 7.8. Flow diagram with the optimised results of the CN ..... 200

Figure 7.9. Graphical optimisation results of the CN ..... 201

Figure 7.10. Data related to the SAM input data ..... 203

Figure 7. 11. Data related to the SAM input data: Auxiliary Variables ..... 204

Figure 7.12. Data related to the SAM input data: Flow Variables ..... 205

Figure 7.13. Data related to the SAM input data: Stock VariablesTable 7.5..... 205

Figure 7.14. Tables used for storing SAM output data..... 206

Figure 7.15. Relationship between tables of input and output data designed to implement the SAM ..... 207

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 ..... 208

Figure 7.17. Scheme for the automatic creation of the SAM ..... 212

Figure 7.18. SAGEN application..... 213

Figure 7.19. XML file: strategies alignment simulation model in XML language..... 213

Figure 7.20. Strategies alignment model automatically build through the creation of an XML file, using SAGEN..... 214

Figure 7.21. Optimisation UI derived from the automatic generation of the strategies alignment model, using SAGEN ..... 214

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 ..... 218

Figure 7.23. Example 7.3: Simulation experiment. Flow diagram with the optimised results ..... 219

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 ..... 223

Figure 7.25. Example 7.3: Simulation experiment. Flow diagram with the optimised results ..... 224

Figure 7.26. Example 7.5: Optimisation Experiment for a CN of 10 enterprises ..... 225

Figure 7.27. Example 7.5: Flow diagram for a CN of 10 enterprises ..... 226

Figure 8.1. Dimensions used for defining the application of the SAM ..... 233

Figure 8.2. Strategies Alignment Guideline (SAG)..... 238

Figure 8.3. SAM Data ..... 245

Figure 8.4. Application of SAM in a non-collaborative scenario ( $SAM^{NCS}$ )..... 246

Figure 8.5. Application of SAM in the Collaborative Scenario 1 ( $SAM^{CS1}$ )..... 247

Figure 8.6. Application of SAM in the Collaborative Scenario 2 ( $SAM^{CS2}$ )..... 248

Figure 8.7. Application of SAM in the Collaborative Scenario 3 ( $SAM^{CS3}$ )..... 249

Figure 8.8. Estimation of the values of influences at the Level 1 of Collaboration: EVI\_CS1 ..... 251

Figure 8.9. Estimation of the values of influences at the Level 2 of Collaboration: EVI\_CS2 ..... 253

Figure 8.10. Estimation of  $val\_str\_is\_kpi_{ik}$  in the Level 3 of Collaboration: EVI\_CS3..... 256

---

Figure 8.11. Curve that models the influence of <i>strison</i> on the <i>kpiixk'</i> : $f\_inf\_stris\_kpiixk'(t)$ .....	259
Figure 8.12. Simplified representation of $f\_inf\_stris\_kpiixk'(t)$ .....	260
Figure 8.13. External centralised DMS .....	263
Figure 8.14. SAGEN: SAM Automatic creation .....	263
Figure 8.15. Spreadsheet gathering the solutions generated in the optimisation experiment .....	264
Figure 8.16. Negotiation Process CS1 .....	270
Figure 8.17. Negotiation Process CS2.....	278
Figure 8.18. Negotiation Process CS3.....	286
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) .....	296
Figure 9.2. Procedure followed to obtain optimised solutions in the Collaborative and Non-Collaborative Scenarios .....	297
Figure 9.3. Example 9.1: Optimisation Experiment for the Collaborative Scenario .....	301
Figure 9.4. Example 9.1: Optimisation Experiment results for the Collaborative Scenario .....	301
Figure 9.5. Example 9.1: Simulation Experiment Results. Flow diagram for the Collaborative Scenario .....	302
Figure 9.6. Example 9.1: Optimisation experiment results for the Distributor in the Non-Collaborative Scenario.....	303
Figure 9.7. Example 9.1:Optimisation experiment results for the Manufacturer in the Non-Collaborative Scenario.....	303
Figure 9.8. Example 9.1: Simulation Experiment Results. Flow diagram for the Distributor in the Non-Collaborative Scenario .....	304
Figure 9.9. Example 9.1: Simulation Experiment Results. Flow diagram for the Manufacturer in the Non-Collaborative Scenario .....	304
Figure 9.10. Example 9.1: Simulation Experiment Input .....	305
Figure 9.11. Example 9.1: Simulation Experiment. Performance Results at enterprise and network levels considering the inter-enterprise influences.....	306
Figure 9.12. Example 9.2: Optimisation Experiment for the Collaborative Scenario .....	309
Figure 9.13. Example 9.2: Optimisation Experiment results for the Collaborative Scenario .....	309
Figure 9.14. Example 9.2: Simulation Experiment Results. Flow diagram for the Collaborative Scenario .....	310
Figure 9.15. Example 9.2: Simulation Experiment Results. Flow diagram for the Non-Collaborative Scenario.....	311
Figure 10.1. First Meeting: Non-Collaborative Scenario Illustrative Example .....	324
Figure 10.2. First Meeting: Collaborative Scenario Illustrative Example .....	324
Figure 10.3. Illustrative Example: Graphical representation of SAM parameters.....	326
Figure 10.4. Graphical representation of $f\_kpiik't$ to calculate the <i>Threshold_kpiik</i> .....	328
Figure 10.5. Computing the <i>Threshold_kpiik</i> .....	328
Figure 10.6. Pilot 1: Non-Collaborative Scenario Optimisation Results for the Manufacturer.....	333

---

Figure 10.7. Pilot 1: Non-Collaborative Scenario Optimisation Results for the Manufacturer..... 334

Figure 10.8. Pilot 1: Non-Collaborative Scenario Simulation Results ..... 335

Figure 10.9. Pilot 1: Collaborative Scenario Optimisation Results ..... 336

Figure 10.10. Pilot 1: Collaborative Scenario Simulation Results ..... 337

Figure 10.11. Curve that models the influence of *strison* the  $kpiixk'$ :  $f\_inf\_stris\_kpiixk'(t)$ ..... 340

Figure 10.12. Pilot 2: Non-Collaborative Scenario Optimisation Results for the Second Tier ..... 343

Figure 10.13. Pilot 2: Non-Collaborative Scenario Optimisation Results for the First Tier..... 344

Figure 10.14. Pilot 2: Non-Collaborative Scenario Simulation Results ..... 345

Figure 10.15. Pilot 2: Collaborative Scenario Optimisation Results ..... 346

Figure 10.16. Pilot 2: Collaborative Scenario Simulation Results ..... 347

Figure 10.17. Survey Results: Strategies Alignment Approach Usability and Utility..... 350

Figure 11.1. Research Contribution: Strategies Alignment Process ..... 357

Figure 11.2. Timeline of the Thesis..... 361

Figure 11.3. Distributed Model ..... 366