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Testing successful Business Model using System Dynamics

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Abstract: In our increasingly globalised economy, managing continuous change whilst remaining competitive and dynamic has become a central issue for firms in the industrial sector. One of the elements for obtaining this competitiveness is the value creation model of the firm. The most important challenges in firms are characterised by dynamic complexity which makes it difficult to understand factors in their context. Consequently management and decision making is hindered (Antunes *et al.*, 2011). Business models are characterised by complexity and dynamism. Performance of the firm is a complex topic determined by the large amount of variables that can be involved in the system, and the different effects that influence the system in the short and long term. Due to this complexity a systemic view is required, that is, an holistic view of the whole system. Such a systemic view enables managers to make decisions based on evidence rather than intuition and personal experiences, as they understand how the whole system works. Thus, the main aim of this research is to use an empirical tool such as System Dynamics (SD), to support and sustain firms in the identification of new constructs related to their Business Model (BM).

Key words: Business Model, Business Model Design, firm performance, System Dynamics, Decision Making.

1. Introduction

In this paper we establish and build a system dynamics (SD) model which enables companies to take most effectively their value creation model. In addition, this facilitates the analysis of the consequences of their decisions and their impact on competitiveness.

The aim is to support and sustain companies in the identification of new constructs related to the design of the Business Model (BM) and how it is measured is integrately linked to their long-term financial performance. The BM theoretical construct can be represented as an analysis unit of the creation of value for the sustainable competitiveness of the company. The BM is a new way of making coherent strategy business based on different mechanisms of economic, social and sustainable relationship between companies, suppliers, partners and customers. In this paper the novelty and efficiency have been selected as the main specific components composing the Business Model Design (BMD) (Miller, 1996) and the main goal is to analyse how these two components are affecting on the performance of the firm. This model is the tool used to guide and help companies to take decisions about their current BMD.

The objective of the article was to establish an SD simulation model as a useful tool to explain decision makers how they can redesign their Business Model taking into account the theory originally proposed by Amit and Zott (2001). This technique enables the understanding and dynamic representation of each of the variables that compose the whole business model system.

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2. Success of Business Models: Business Model Design and the Performance of the firm

According to the literature, a successful BM takes place when two aspects are met: 1) there is a gap between the necessity and existing offers in the market and 2) the company has the resources necessary to fill this goal. BM pioneers understand what customers want and have the ability to fulfill them (Teece, 2010). In summary, in this investigation we analyze the success of the BM and the two main components, the novelty and efficiency as mentioned before.

2.1. Business Model Design

According to Zott and Amit (2007), the design of a company's business model, which focuses on the issues of novelty and efficiency, is associated with the performance of companies. With respect to business model design (BMD) issues, there are different approaches to the components that make up the BMD (Zott and Amit, 2007). Miller (1996) highlights innovation and efficiency as the main themes due to their influence on the final performance of the company. Their decision is accepted for the study of the BM adopted by companies because innovation and efficiency show multiple solutions to create new value under uncertainty. Efficiency and innovation are not totally independent and exclusive, any BMD can focus on novelty and focus on efficiency at the same time.

According to Amit and Zott (2001), there are four different categories which represent main factors that can increase the total value created by firms: Novelty, Efficiency, Lock-in, and Complementarities.

As we mentioned earlier, and referring to Miller (1996) in an attempt to understand the novelty and efficiency of the BM and how these two components influence the performance of the company, we will focus on these specific components of BMD, Figure 1.

In this article we identify two critical dimensions of BMD, which are called "efficiency-centered" and "novelty-centered" design themes. The origin is on the theory of innovation which is based on the transaction cost perspective (Milgrom, 1992) and in Schurnpeter's (1934). We analyse the

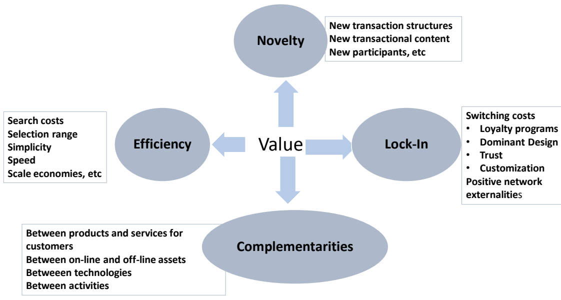

Figure 1. Sources of value creation in firms (Amit and Zott, 2001).

impact of novelty and efficiency BMD themes on the performance of the firm. Efficiency-centered BMD is focused on reducing transaction costs for all transaction participants, while novelty-centered BMD refers to new ways of conducting economic exchanges among several stakeholders (Zott and Amit, 2007).

2.2. Business Model Outcomes and firm's Performance

Literature regarding the BM and its effect in economic performance is based on both real economic performance and perceived economic performance. The real economic performance show quantitative evidence of the impact of BMI on firm performance (Zott and Amit, 2007, Demil and Lecocq, 2010, Nair *et al.,* 2013, Giesen *et al.*, 2007, Weill *et al.*, 2005), while the perceived economic performance takes into account managers' perception of BM impacts on the economic performance of companies.

According to Zott and Amit (2007) the business models of multiple innovative firms were classified based on whether they are efficiency-centered or novelty-centered, concluding that the design of a business model focused on novelty has a great impact on the financial performance. The research points out that the options of the companies to support innovation paths have repercussions on the success of the designs of the business models.

According to Zott and Amit these two categories represent variables that can enhance the total value created by firms (Zott and Amit, 2007). In particular they refer the following specific kinds of business solutions:

2.2.1. Novelty

The basis of novelty-centered BMD is identification and definition of new ways of arranging economic exchanges, by connecting different independent parties, linking transaction participants in new ways, or designing new transaction mechanisms (Zott and Amit, 2007).

The novelty could be measured taking into account different items like (Zott and Amit, 2007): i) the new business model offers new combinations of products, services and information, ii) the new business model brings together new participants.

Therefore, according to Zott and Amit (2007), we confirm that there is a positive effect of novelty-centered BMD on the performance of a company.

2.2.2. Efficiency

Another solution to create value for companies is to imitate rather than innovate: creating different solutions to established firms, but in a more efficient way (Aldrich, 1999, Zott, 2003). To analyse the performance implications of efficiency-centered BM, we build on transaction cost perspective, which refers to the design of economic transactions (Milgrom, 1992). Efficiency-centered design refers to the key indicators that companies may identify to achieve transaction efficiency through their business models. The main pillar of a business model focused on efficiency is the reduction of transaction costs.

There is an influencing direct relationship between the design of transactions and firm performance. So, based on the results of the study carried out by Zott and Amit (2007), a main positive effect is expected from the BMD focused on efficiency in the performance of a firm. The efficiency could be measured taking into account different items like (Zott and Amit, 2007): i) Inventory costs for participants in the business model are reduced, ii) Marketing and sales costs, transaction processing costs and communication costs.

2.2.3. Firm Performance

The BMD can be an important factor in the performance of the firm. In addition, there is an increasingly interest in the field of how BM typology outperform others (Weill *et al.*, 2005).

The competitiveness of the companies is directly affected by the design of the Business Model (Andreini and Bettinelli, 2017). Thus, several authors confirm the relationship between business model and the competitive advantage of the firm. “The competitive advantage explains how the firm will do better than its rivals, and doing it better, by definition, means being different” (Magretta, 2002). Overall, studies focuses on measuring the impact of BM on firm’s performance and innovativeness: i) The design of BM, impacts on the level of sales exceeding the objectives., ii) The design of BM, impacts on market share and sales level objectives, iii) The design of BM, impacts on the profitability.

Therefore, considering the positive effect of novelty-centered BMD, it is confirmed a positive effect of novelty-centered BMD on the performance of a firm (Zott and Amit, 2007). Consequently, there exist a positive main effect of efficiency-centered BMD on the performance of a firm.

3. System Dynamics for Business Model Decision Making

The most important occurrences, systems and challenges in firms are characterised by dynamic complexity (heterogeneous agents, behaviours and rules). Dynamic complexity makes it difficult to understand these factors in their context, and consequently management and decision making is hindered (Antunes & Respício 2008; Janssen *et al.*, 2015). One of the factors which drives this complexity is the lack of consistency to define BMs. How to define a consistant organizational strategy is a complex topic determined by the large amount of variables that could be involved in the system, and the different effects that influence the system in the short and long term.

Such complexity requires a systemic view, that is, a holistic view of the whole system. This systemic view enables the understanding of the interrelationships between the different constructs by which BMs are composed. These interrelationships are not linear, they are circular, defined by feedback loops. This requires systems thinking to be understood. The short and long term perspective of BMs helps to predict and define more consistent organisational strategies. Both the qualitative and quantitative analysis of the variables (measurable and non measurable) are required for obtaining the most accurate understanding of the complex issue of successful BM design.

Such a systemic view enables managers to make decisions based on evidence rather than intuitions and personal experiences, as they understand how the whole system works. Decision making is one of the most vital processes to achieve the objectives of a firm, however many decisions are made without evidence based management. To compound the problem, future decision makers are often not able to take advantage of the experience of their predecessors (Schalk *et al*., 2013). It is clear that the most effective firms of the future will be those which make decisions focused on evidence based predictions (DeGregorio, 1999). When decisions are made with no evidence, ineffective practices and experiences in the workplace are dominant.

The increasingly competitive nature of the global economy has left many firms searching for new strategies to build capacity and sustainable competitive advantage. Key to achieving this result is an effective decision making process. Computational tools show great potential to assist decision makers, due to the speed and efficiency with which they are able to identify emergent behaviours (Antunes & Respício 2008; Janssen *et al*., 2015).

With the purpose of developing a more effective decision making processes, it is necessary to: (i) to conceptualise the system of causes and effects related to Business Model design in order to achieve a full understanding, and (ii) to model it using simulation to facilitate the interactive manipulation and generation of real scenarios.

The final aim of (i) conceptualisation and, (ii) modelling is: to define a systemic and real perspective of the Business Model so as to facilitate a learning process for more effective decision making, and thus to fostering competitivity and improving firm sustainability.

4. Methodology

This research uses modelling to understand the impact of the success of the Business Model on firm performance using an SD model. Firstly, the gap in the literature was defined (problem identification) to provide a clear focus for the subsequent phase. Secondly, input collection was undertaken, variable identification and input collection was done. Once this phase was completed, the simulation model was built, and finally policy testing was done. The process was iterative based on Sterman (2002) which is standardized and the most commonly used methodology for modelling.

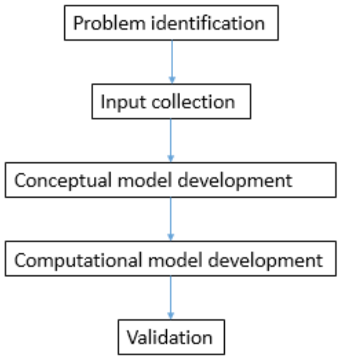

Figure 2. Methodology for simulation (Sterman, 2000).

Modelling is essentially creative, and is not a standardised process (Morecroft, 2015). At the same time, however, it is a disciplined, scientific and rigorous procedure that involves observing dynamic phenomena in the real world, analysing hypotheses, collecting data and improving the model to obtain a better understanding of the issue of analysis. Modelling is iterative, it begins with a concern about dynamics (performance over time) and preliminary ideas about feedback structure (Morecroft, 2015). Some examples of modelling processes are presented by Morecroft (2015), Sterman (2000), and Warren (2002).

The purpose is not to create a perfect model that replicates the real world situation in every detail. It is to engage in a learning process using the model as a tool for research, clarification, and discovery. The real value of modelling becomes evident when models are used to support organisational redesign. The final goal should be to design management policies and organisational structures that lead to greater success (Sterman, 2000).

The structure of modelling is based on two different points: i) hypotheses about the physical and institutional environment, and ii) hypotheses about the decision processes of the agents who act in those structures (Sterman, 2000). A description of these hypotheses is set out below.

The physical and institutional environment of a model includes the model boundary and stock and flow structures of people, material, money, information, and so forth that characterise the system.

One of the examples that showed this environment in the literature, was presented by Sterman (2000), who used Forrester's (1969) Urban Dynamics to understand why America's large cities continued to decay despite massive amounts of aid and numerous renewal programs. Factors describing the physical and institutional setting were included in the model, such as, size, quality of the housing stock, and attributes of population.

Decision processes refer to the decision rules that determine the behaviour of the agents in the system. These rules are represented through behavioural hypotheses. These hypotheses of a simulation model describe the way in which the system evolves over time. The most important value of simulation is to identify both observed behaviours and future possible circumstances (Sterman, 2002). The behavioural hypotheses of a simulation model describe the way in which people respond to different situations. Again, Sterman (2000) used the Urban Dynamics model as an example, which included decision rules, governing migration and construction. Essentially, the rule was to mark up the wholesale cost of the goods and the mark up was gradually reduced until the goods were sold.

Thus, it is not enough to model a particular decision. Modellers must also detect and represent "the guiding policy" that yields the stream of decisions (Forrester, 1961). Each detail and characteristic in the model related to stocks and flows creates a decision point, and the modeller must specify accurately the decision rule determining the variable of analysis (Sterman, 2000).

4.1. Input Collection

The principal variables in our model are: i) Business Model design, the core of this research, ii) performance- the variable to be measured iii) novelty- one of the principal links between BMD and Performance, and iv) efficiency- a second connection between BMD and performance. In Table 1 presents the different variables that compose the model and their functions. The variables are categorized in three different groups: i) literature about "Success of Business Models", ii) variables selected for measurement in this research and iii) variables which belong to an example of an SD to analyse the impact of business models ("Impacto de los planes de negocio").

Table 1. Methodology for simulation (Sterman, 2000).

Variable	Functions
Number of Sales	Belongs to the construct "Success of Business Models"
Perceived Image	Belongs to the construct "Success of Business Models"
Costs	Is used to define Efficiency
New Products	Refers to the general launch of new products, services, and information
New Participants	Is connected to novelty
Group i	
Efficiency	Refers to inventory, marketing and sales. Key variable for performance
Novelty	Key variable for performance
Group ii	
Competition (García, 2017)	Is based on the model "Impacto de los planes de negocio"
Conjunction (García, 2017)	Represents the impact of the external factors
Group iii	

4.2. Conceptual model development

The next step of the process was "Conceptual model development". In this phase the causal loop diagrams were drawn.

Challenges to be analysed with SD are represented through feedback and causal loop diagrams (CLD). They are a standard code to represent the structure of the issue of analysis. When an element of a system indirectly influences itself it is called a feedback loop or causal loop. More explicitly, a feedback loop is a closed sequence of causes and effects, that is, a closed path of action and information (Richardson & Pugh, 1981).

Such diagrams are useful to analyse relationships that are difficult to describe and understand because of the circular character of the system. In addition, these diagrams can show the cause and effect circularities (Kirkwood,1998).

Causal loop diagrams (CLDs) are relevant effective tools to represent the feedback structure of systems. They are particularly useful for: (i) quickly defining hypotheses about the causes of dynamics, (ii) obtaining the mental models of individuals or teams, and (iii) communicating the important feedback to be considered in the problem (Kirkwood,1998). They consist of variables connected by arrows denoting the causal influences between the variables. Variables are related by causal links, shown by arrows.

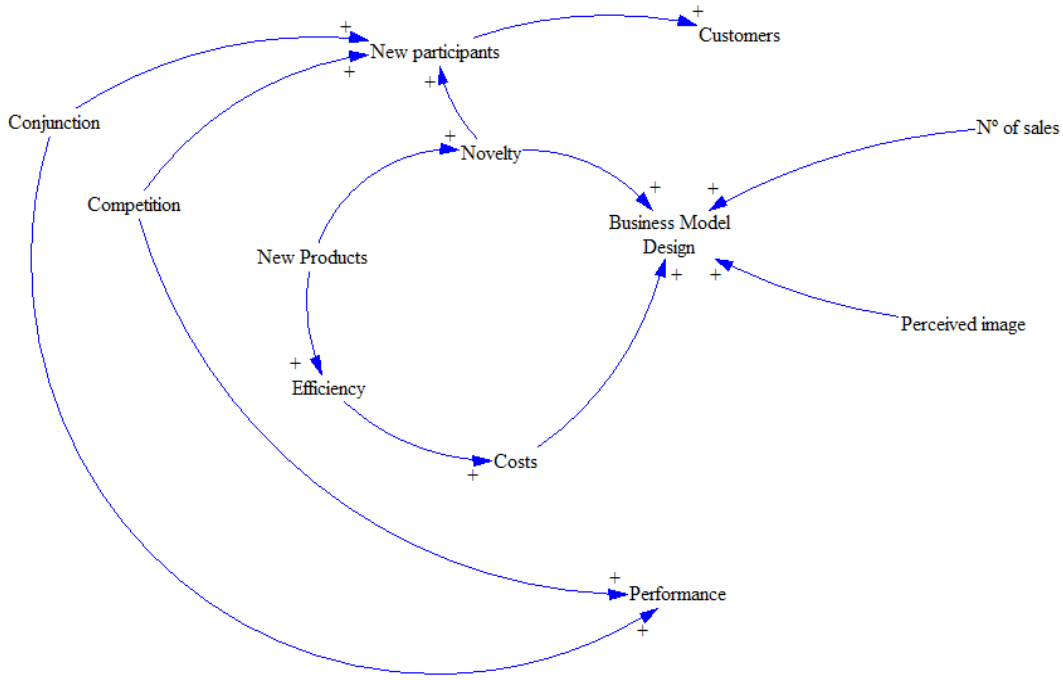

Figure 2. Conceptual model (own source)

A positive link means that if the cause increases, the effect increases above what it would otherwise have been, and if the cause decreases, the effect decreases below what it would otherwise have been.

Conversely, a negative link means that if the cause increases, the effect decreases below what it would otherwise have been, and if the cause decreases, the effect increases above what it would otherwise have been.

4.3. Computational model development

After conceptualisation, the model is transferred to a computational model. Stock and flow diagrams are used for computerisation of models under system dynamics. Stocks are accumulations. They characterise the state of the system sions and actions are based. Stocks give systems inertia and provide them with memory. Stocks create delays by accumulating the difference between inflow to a process and their outflow. By decoupling rates of flow, stocks are the source of disequilibrium dynamics in systems (Sterman, 2000). Three examples of stock are as follows: the inventory of a manufacturing firm is the stock of product in its warehouses, the number of people employed by a business is a stock, or the balance of checking account is a stock.

The characteristic particularities of stock and flow structures are the following: (i) stocks are represented by rectangles, (ii) inflows represented by a pipe pointing into the stock, (iii) outflows are represented by pipes pointing out of the stock, (iv) valves are reported by two inward pointing triangles and control the flows by opening or closing them, and (v) clouds represent the sources and sinks for the flows.

Stocks and flows are the elements used in the computational model of this research. Stocks for the variables that must be measured, such as customers and performance.

Flows for representing the variability of the system using the variables which change the measured stocks, such increase in performance.

The activities that define the modelling process are: (1) articulating the problem to be addressed, (2) formulating a dynamic hypothesis or theory about the causes of the problem, (3) developing a simulation model to test the dynamic hypothesis (Formulation of the simulation model), (4) testing the model until it suits the objectives of the modeller and (5) designing and evaluating policies for improvement. The iterative steps for modelling are defined by Sterman (2000).

1. Problem articulation: This is the most relevant step and identifies the issue of concern, time frame, boundary and scope of factors involved. During this phase reference modes and time horizon should be defined.

-Reference Modes definition: A set of graphs and other descriptive data showing the development of the problem over time.

-Time horizon definition: The period of time to be analysed. It should start as far back in history as necessary to show how the problem emerged and describe its symptoms.

2. Dynamic Hypothesis: This is the hypothesis the modeller defines to represent the problem and focuses on specific structures. This hypothesis characterises the problem in terms of the underlying feedback loops and stock and flow structure of the system. It is not static, it is temporary and prone to revision. It is related to discussion of the problem and theories associated with causes of the problem (Morecroft, 2015).

3. Formulation: In most cases it is very difficult or almost impossible to conduct real world experiments that show the faults in a dynamic hypothesis. For this reason accurate and detailed simulation is vital. In this stage it is understood that causal loops, stock and flow diagrams and general policy structure are already defined. Causal loops are defined as the maps showing causal links among variables and contain arrows linking causes, effects, and stock and flow tracks.

4. Testing: Every equation defined in the previous stages must be reviewed for dimensional consistency. In this step sensitivity of model behaviour and policy recommendations need to be evaluated in order to reduce uncertainty. During this stage a comparison of the simulated behaviour of the model to the real behaviour should be done. Policy instructions must be checked and models should be tested under extreme conditions.

5. Policy formulation and validation: Policy design is much more than changing the values of parameters involved in the model. Rather it is based on the creation of entirely new strategies, structures and decision rules. Policy design not only is based on value change of parameters, but it also combines the creation of entirely new strategies, structures and decision rules (e.g. changing feedback loops, eliminating time delays, defining new decision processes). According to Morecroft (2015), the principal interest of policy formulation is improving organisational activity. This question is directly linked to what-ifs. Policies can be tested through simulation (Morecroft, 2015). Yao *et al.* (2018)

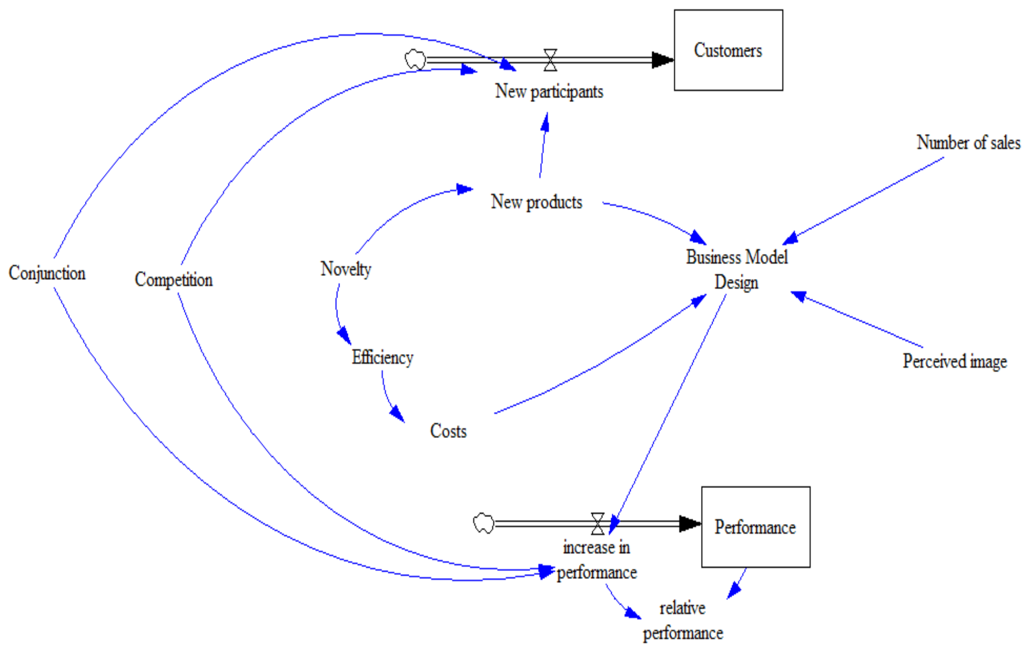

Figure 3. Computational model (own source).

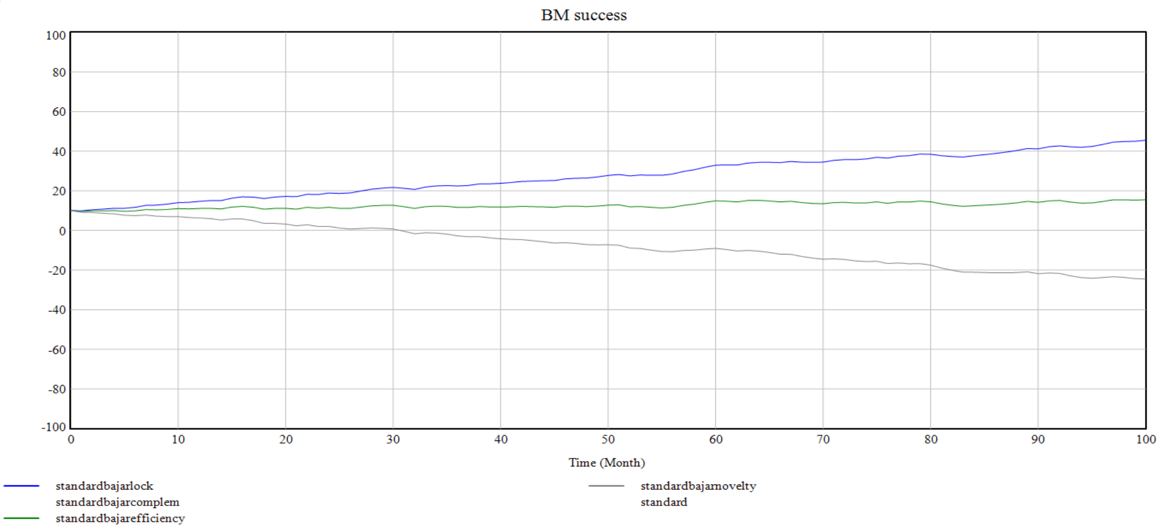

Figure 4. Scenario simulation (own source).

used System Dynamics to explore the influences of different recycling scenarios in China.

The simulation is composed of 2 stocks, 2 flows and 10 variables. The key variables as mentioned before are “Business Model Design”, “Novelty”, “Efficiency”, and “Performance”. The rest of the factors are variables defined for each of the constructs. The main aim of this model is to measure performance and understand the influence of “Novelty” and “Efficiency” on the system. Performance is measured, whereas the rest of the variables are direct influencers on BDM. These directly affect performance levels of the firm.

4.4. Validation

The aim of system dynamics model validation is to verify the validity of the structure of the model. Once the structure is validated, behaviour accuracy (of the model) and reproduction of real behaviour through the model is guaranteed. Direct Structure tests were applied for the validation of the model (Barlas, 1996).

Table 2. Variables and their values

Variable	Value
Value Creation	1000
BM Success	10
Performance	increase in success/BM success
Business plan arquitecture	(Complementarities*v2)+(Novelty*v1)
Novelty	"Lock-in"
Lock-in	0.8/2
Efficiency	1-"Lock-in"
Complementaries	Efficiency
V1	0.5
V2	1
V3	RANDOM NORMAL(-1, 0 , -0.5 , 0.5 , 777)
V4	RANDOM NORMAL(-1, 1 , 0, 0.5 , 777)

Direct Structure tests can be divided into empirical or theoretical. Empirical tests involve comparing the model structure with information (quantitative or qualitative) extracted from the real system being modelled. On the other hand, theoretical tests are focused on comparing the model structure with generalised knowledge about the system that exists in the literature. In this project two hypotheses were defined according to the literature (theoretical tests), and then these hypotheses were compared to real situations (empirical tests).

H1: The higher the novelty level, the higher performance level.

H2: The higher the efficiency level, the higher performance level.

The objective was to compare in the same screen the impact of novelty and efficiency, on performance. The value of novelty was reduced in order to visualise its influence. As it was expected, performance lever was lowered.

Blue oscillation represents the standard model and green represents the scenario in which novelty was reduced. Novelty directly influences BMD, and BMD has a direct impact on Performance of the firm. Brown oscillation represents the scenario in which efficiency was reduced. As expected, an efficiency reduce implies a performance decrease.

5. Conclusions

This research was useful to test the effect of novelty and efficiency, considered key variables, for firm performance. Their direct and positive impact on competitiveness has been demonstrated. Such an empirical tool can thus be beneficial for decision makers, enabling the acquisition of knowledge, leading to more effective decisions.

This research has contributed to the definition of a standard process that could be followed for the successful design of a business model. The steps to be followed are: i) define the strategical goal, ii). identify the key variables that will compose the constructs of the business model. ii) draw a conceptual map with systemic view of the whole business model must be defined, iv) simulate the conceptual model, v) Test the hypotheses (understood as the levers and goals to be implemented in the firm), vi) design policies in order to make more effective decisions and define a specific plan for the subsequent decision makers.

One of the principal future lines is the aim of testing the tool with a real database.

In this way, firms will acquire knowledge about successful business models, as well as key variables for innovation and measurement of outcomes.

Finally, the authors plan to combine different hypotheses to obtain more real world scenarios. This would take the form of an interactive application that could be used by non experts in simulation, and thus facilitate the use of the tool by managers.

References

Aldrich, H.E. (1999). *Organizations Evolving Sage*, C.A., Thousand Oaks.

Amit, R., Zott, C. (2001). Value creation in e-business. *Strategic Management Journal, 22*(6-7), 493-520. https://doi.org/10.1002/smj.187

Andreini, D., and Bettinelli, C. (2007). *Business Model Innovation: From Systematic Literature Review to Future Research Directions*, Springer.

Antunes, L., Respicio, A., Balsa, J., and Coelho, H. (2011). *Gaming and Simulations: Concepts, Methodologies, Tools and Applications*, IGI Global.

DeGregorio, G. (1999). Enterprise-wide Requirements & Decision Management. *INCOSE International Symposium, 9,* 644-650. https://doi.org/10.1002/j.2334-5837.1999.tb00221.x

Demil, B., and Lecocq, X. (2010). Business model evolution: In search of dynamic consistency. *Long Range Planning, 43*, 227-246. https://doi.org/10.1016/j.lrp.2010.02.004

Forrester, J. W. (1997). Industrial dynamics. *Journal of the Operational Research Society, 48*(10), 1037-1041. https://doi.org/10.1057/palgrave.jors.2600946

García, J. M. (2017). *Teoría y ejercicios prácticos de Dinámica de Sistemas para Vensim PLE*, Spain, Juan Martin García.

Giesen, E., Berman, S.J., Bell, R., and Blitz, A. 2007. Paths to success: Three ways to innovate your business model. *IBM Institute for Business Value, 23*, 436-438.

Kirkwood, C. C. (1998). *System dynamics methods*. (College of Business Arizona State University USA, Ed.), System Dynamics Methods.

Magretta, J. (2002). Why business models matter. *Harvard Business Review, 80*, 86-87.

Milgrom, P. R. (1992). *Economics, organization and management*, NJ, Prentice-Hall.

Miller, D. (1996). Configurations revisited. *Strategic Management J., 17,* 505-512. https://doi.org/10.1002/(SICI)1097-0266(199607)17:7%3C505::AID-SMJ852%3E3.0.CO;2-I

Morecroft, J. (2015). *Strategic modelling and business dynamics: a feedback systems approach*, John Wiley & Sons., Ed. https://doi.org/10.1002/9781119176831

Nair, S., Paulose, H., Palacios, M., and Tafur, J. (2013). Service orientation: Effectuating business model innovation. *The Service Industries Journal*, *33*, 958-975. https://doi.org/10.1080/02642069.2013.746670

Richardson, G. P., and Pugh III, A. I. (1981). *Introduction To System Dynamics Modeling With DYNAMO*. OR: Productivity Press.

Schalk, R., Timmerman, V., and Van den heuvel, S. (2013). How strategic considerations influence decision making on e-HRM applications. *Human Resource Management Review*, *23*(1), 84-92. https://doi.org/10.1016/j.hrmr.2012.06.008

Sterman, J.D. (2000). Business Dynamics: systems thinking and modeling for a complex world. Irwin-McGraw-Hill.

Sterman, J.D. (2002). System Dynamics: Systems Thinking and Modeling for a Complex World. In *Proceedings of the ESD Internal Symposium.*

Teece, D.J. 2010. Business models, business strategy and innovation. *Long Range Planning, 43*, 172-194. https://doi.org/10.1016/j.lrp.2009.07.003

Warren, K. (2002). *Competitive Strategy Dynamics*. Wiley.

Weill, P.M., Malone, W.T., d'urso, V.T., Herman, G., and Woerner, S. (2005). *Do Some Business Models Perform Better than Others?, A Study of the 1000 Largest US Firms*. Sloan School of Management, Massachusetts Institute of Technology, MIT Sloan School of Management , MIT Centre for Coordination Science .

Yao, L., Liu, T., Chen, X., Mahdi, M., and Ni, J. (2018). An integrated method of life-cycle assessment and system dynamics for waste mobile phone management and recycling in China. *Journal of Cleaner Production, 187*, 852-862. https://doi.org/10.1016/j.jclepro.2018.03.195

Zott, C. 2003. Dynamic capabilities and the emergence of intra-industry differential firm performance: Insights from a simulation study. *Strategic Management Journal, 24*(2), 97-125. https://doi.org/10.1002/smj.288

Zott, C., and Amit, R. 2007. Business model design and the performance of entrepreneurial firms. *Organization Science, 18*(2), 181-199. https://doi.org/10.1287/orsc.1060.0232

