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A "system dynamics-based Balanced Scorecard" to support strategic decision making

Insights from a case study

Federico Barnabè
Department of Social and Business Studies, Faculty of Economics, University of Siena, Siena, Italy

Abstract

Purpose – This paper aims to focus on the development of a "dynamic Balanced Scorecard" and to demonstrate that matching the traditional Balanced Scorecard (BSC) architecture with system dynamics principles offers better support for strategic management decisions.

Design/methodology/approach – The paper is based on a case study related to a service-based business. The maps, the mathematical model and the BSC developed according to system dynamics modelling principles are discussed.

Findings – A system dynamics-based BSC, particularly if embedded into a management flight simulator, would allow exploration and understanding of features of complexity and dynamics, consideration of feedback loops rather than unidirectional causality, the use of mapping tools for a more comprehensive design of the strategy maps, the facilitation of a process of organisational learning; and support for policy design and strategic analysis performed by managers.

Originality/value – The value of this paper is two-fold: first, it shows that by using system dynamics modelling principles it is possible to overcome positively some limitations of the original BSC framework; second, the paper provides information and suggestions that are helpful for companies that are interested in developing strategic management systems based on both BSC architecture and on system dynamics principles and simulation tools (e.g. the management flight simulator).

Keywords Balanced Scorecard, System dynamics, Feedback loop, Strategic management, Performance management (quality), Decision making

Paper type Research paper

1. Introduction

Over the last few decades the necessity to develop, implement and use adequate performance measurement systems (PMSs) and strategic management systems (SMSs) has become evident in management science. In particular, the complexity of the surrounding environment and the need for a holistic approach to management have pushed towards the adoption of more structured and comprehensive PMSs and SMSs. However, it is still debatable how to develop and design these systems and which measures and parameters should be included.

As a consequence, many management tools and approaches have been theorised and studied over the last few years, such as (Chartered Institute of Management Accountants, 2002; ten Have *et al.*, 2003):

- total quality management (TQM);
- business process re-engineering (BPR);

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- business process management (BPM);
- enterprise resource planning (ERP);
- customer relationship management (CRM); and
- value based management (VBM), etc.

One of the most successful tools has been the Balanced Scorecard (BSC), as originally created in 1992 and later developed by Robert Kaplan and David Norton.

However, the BSC is not exempt from limitations. In particular, it basically considers unidirectional cause and effect linkages; it does not consider time delays and suffers from relevant limitations both in the design phase and in its implementation and use.

Consequently, there has been a growing interest in the use of mixed research tools and, in particular, in the development of a "dynamic scorecard". Starting from these considerations, this study suggests that the system dynamics methodology could help in overcoming some of the limitations of the BSC, facilitating the development of a strategic management system centred on a "system dynamics-based Balanced Scorecard".

The paper is structured as follows. Section 2 presents the main characteristics and strengths of the BSC approach, then Section 3 discusses its main limitations. Section 4 highlights some key features of the system dynamics methodology, and Section 5 presents the case study of a service-based business. Finally, the paper concludes with a discussion of final remarks.

2. A brief overview of the Balanced Scorecard framework

During the last two decades the necessity for developing and implementing multidimensional performance measurement systems and strategic management systems has become clear in management science (Neely, 1998; Dyson and O'Brien, 1998; Epstein and Manzoni, 2004; Kaplan and Norton, 2008; Micheli and Manzoni, 2010). In particular, the Balanced Scorecard has increasingly acquired a well-recognised relevance both in real world business organisations and in tertiary and management education (Akkermans and van Oorschot, 2005, p. 931).

The Balanced Scorecard is a performance measurement system theorised by Kaplan and Norton at the beginning of the 1990s (Kaplan and Norton, 1992). First created as a performance measurement tool, it has subsequently evolved into a PMS, later becoming a comprehensive SMS.

This system provides a holistic approach to performance measurement, being able to link an organisation's performance metrics in four main perspectives, as described by its authors (Kaplan and Norton, 1996), "the Balanced Scorecard is a concept for motivating and measuring business unit performance. The Scorecard, with four perspectives – financial, customer, internal business processes, and learning and growth – provides a balanced picture of current operating performance as well as the drivers of future performance".

The origin of the BSC is linked to the famous book *Relevance Lost: The Rise and Fall of Management Accounting* (Johnson and Kaplan, 1987), in which the authors acknowledge that the traditional performance measurement systems, relying heavily on financial data, had become inadequate. Therefore, it has become necessary to design and develop something new, which would be able to convey a broader view of the company. In search of a more holistic approach to performance measurement Kaplan and Norton developed the Balanced Scorecard, which is able to demonstrate the relationship between an organisation's performance metrics in four main perspectives:

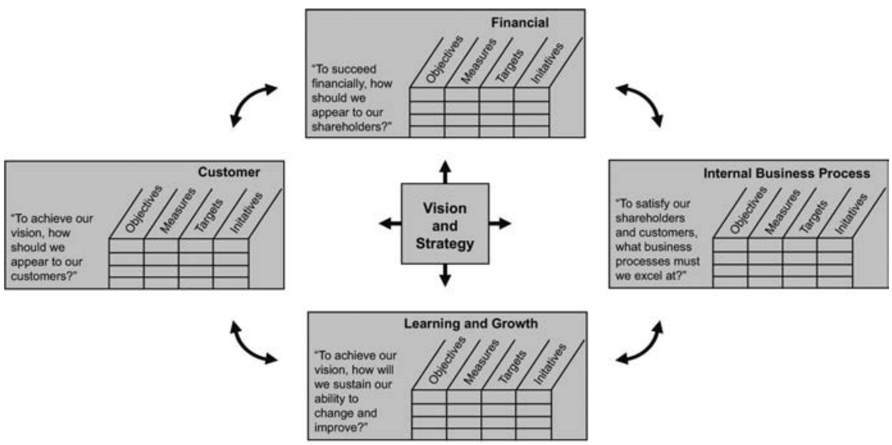
(1) customer;
(2) financial;
(3) internal business process; and
(4) learning and growth (see Figure 1).

Each perspective is based on lagging and leading indicators and contains a prevision of actions to be taken in order to reach the pre-set targets. The lag indicators are outcome measurements and indicate the results of a strategy; the lead indicators are driver measures, able to illustrate incremental changes that ultimately will affect the outcomes. Overall, the four perspectives can be represented as an interlinked hierarchy and "objectives should be linked in cause-and-effect relationships" (Kaplan and Norton, 2004, p. xii). The firm's strategy underlies the whole scorecard, as the measures for each of the four perspectives are drawn from this strategy.

It is important to note that the "balance" sought by the authors could be identified in several situations and could involve numerous factors, i.e. a balance between four different perspectives related to the whole organization; short term and long term objectives; performance drivers (leading indicators) and outcomes (lagging indicators); external and internal measures; the traditional rigid and financial based measurement approach and a more flexible/holistic approach to performance measurement, including non-financial parameters and soft indicators (e.g. customer satisfaction, company image, product quality, customer loyalty, etc.).

In brief, the model enables the simultaneous control of several key performance areas, through specific key performance indicators linked by cause and effect relationships.

The introduction of the BSC certainly opened the way for a different method of managing modern companies, conveying a sense of holism, stimulating top decision-makers, managers and employees to consider several perspectives and their mutual inter-relationships at the same time. Note that initially (Kaplan and Norton,



Source: Kaplan and Norton (1996, p. 9)

Figure 1.
Simplified representation of a BSC template

1992, 1996) the Balanced Scorecard was primarily a tool meant for performance measurement, aimed at integrating financial/non-financial, internal/external and leading/lagging information in a coherent fashion.

Later, the authors realised that the Balanced Scorecard had the potential to play a crucial role in the strategic management process of modern companies, helping managers to clarify and obtain consensus on strategic objectives, assisting them in the communication of a chosen strategy, and consequently aligning the efforts of both individuals and departments (Kaplan and Norton, 1996, 2001, 2006).

In this regard, the authors added new tools to the original BSC step by step, such as strategy maps and the decision statements, creating so-called "second" and "third generation" Balanced Scorecards (Lawrie and Cobbold, 2004).

In particular, strategy maps were introduced for the first time in an article in the September 2000 *Harvard Business Review* (Kaplan and Norton, 2000) and later refined in 2001 in the book *The Strategy-focused Organization* and in the 2004 publication *Strategy Maps*. This introduction finally witnessed the development of the BSC into an entire strategic management system, due, in particular, to a deeper causal analysis between the leading and lagging indicators included in any BSC.

Basically, a strategy map is a diagram that describes how an organization creates value by connecting strategic objectives that are in explicit cause-and-effect relationships with each other into the four BSC perspectives (see Figure 2). It also represents a qualitative way of providing a macro view of an organisation's strategy, prior to constructing metrics for the evaluation of performance against strategic targets.

It is worth underlining that strategy maps operate as add-on tools to the BSC, actually being a strategic part of the Balanced Scorecard framework aimed at describing strategies for value creation. Having the strategy maps combined with the traditional BSC, Kaplan and Norton pursued the following goal (Kaplan and Norton, 2004, p. xiii):

$$\text{Breakthrough results} = \text{Describe the strategy} + \text{Measure the strategy} + \text{Manage the strategy}.$$

Regarding the so-called "third generation" BSC, the more recent novelty is the addition of a destination statement, typically a one- or two-page description of the organisation at a defined point in the future (typically three to five years away), assuming the current strategy has been successfully implemented.

Overall, the Balanced Scorecard has attracted considerable interest and favour. This is demonstrated by the large number of articles highlighting its strengths and advantages (Hepworth, 1998), a variety of books containing case studies of companies or public administrations that have adopted the BSC (e.g. Olve *et al.*, 1999; Kaplan and Norton, 2004; Niven, 2003), articles focusing on the diffusion of the BSC in specific geographic areas (e.g. Malmi, 2001; Speckbacher *et al.*, 2003; Ax and Biørnenak, 2005), and a number of software houses that provide tools for BSCs (see Marr and Neely, 2003), as well as reports and case studies presented on the web[1]. Furthermore, in the analysis of management and accounting literature, many authors support the relevance, positive role and usefulness of this strategic management tool (Hoque and James, 2000; Rigby, 2001; Malmi, 2001; Niven, 2003; Davis and Albright, 2004; Akkermans and van Oorschot, 2005; Busco *et al.*, 2007), underlining its key strengths and advantages as follows.

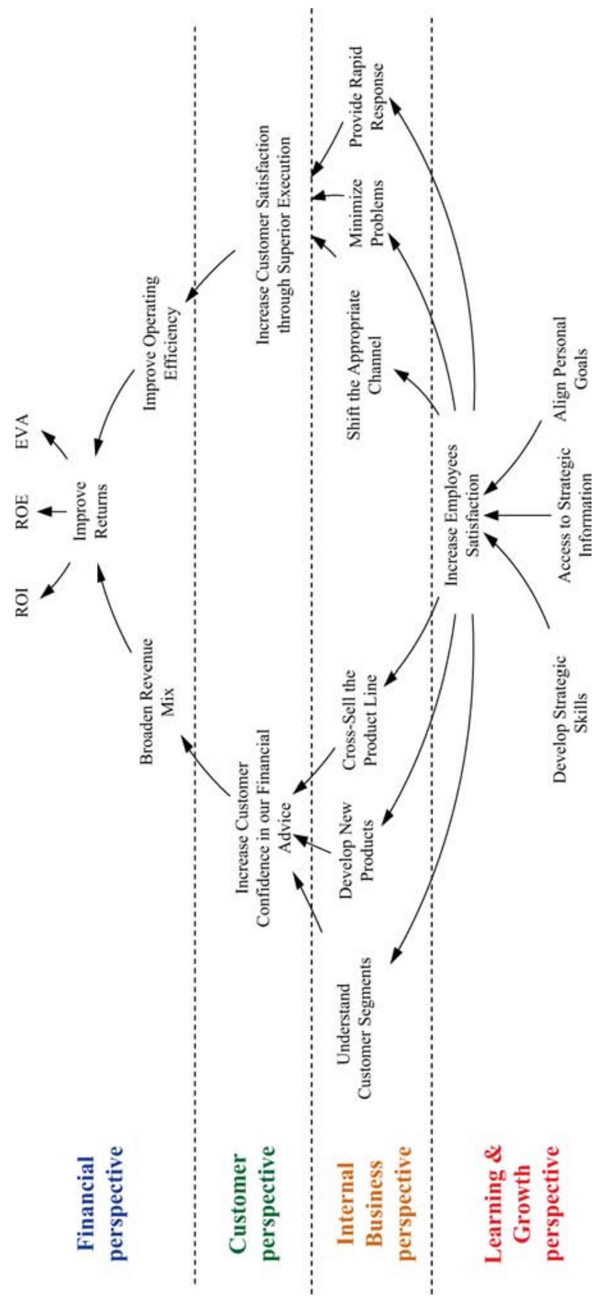


Figure 2.
An example of a strategy map

- The BSC is simple, giving managers the chance to focus on just ten to 25 key indicators, balanced across four (or more) different perspectives.
- The BSC is developed in an interdisciplinary way, merging into one single framework all the different activities and performance metrics that characterise an organisation, its personnel and functions.
- The BSC has the potential to enhance management capabilities, increasing management's understanding of the business and of the causal relationships between non-financial and financial measures. Therefore, the Balanced Scorecard can act as a learning device for determining whether the fundamental assumptions made by management in formulating the firm's strategy are accurate and reliable and can be used to support management accounting change programmes.
- The BSC conveys a systemic view of the organization, since it explores and identifies the cause and effect linkages among four (or more) different perspectives representing both the internal and the external environment, merged into a systemic view of the firm's operational domain.
- The BSC has the ability to align intangible assets, especially human resources and information technology, with the company's strategy. By setting both short- and long-term targets for driver and outcome measures in the customer, internal business process and growth/learning perspectives and by comparing actual attainment against the target, feedback is obtained on how well the strategy is being implemented and on whether the strategy is working.
- The BSC supports corporate restructuring. In recent years, many firms have moved from a traditional hierarchical structure to a flatter, team-based organisational structure. The Balanced Scorecard can support such organisational change, helping to clarify the objectives and the critical success factors.
- Overall, the BSC is a powerful strategic management system that can be used for goal setting, compensation, resource allocation, planning and budgeting, performance improvement, strategic feedback and learning.

This said, it is useful to note that if on one hand the "new generation" BSCs have built on previous strengths and critical features of the original BSC approach, on the other hand, those changes have emerged because of limitations that had clearly characterised this architecture.

Further details are presented below.

3. Key drawbacks of the BSC approach

All the considerations and characteristics we mentioned in the previous paragraph lie heavily at the center of the enormous success that the BSC has gained over the last ten to 15 years, being consequently adopted and implemented in many private and public organisations. Moreover, the BSC has been also introduced as a fundamental topic in management education, and BSC-based case studies are frequently presented and taught in higher education.

However, we have to emphasise that the BSC has its own drawbacks; therefore, moving from the enthusiastic literature that characterised the years immediately following its creation, more recently several authors highlight that many BSC implementation processes fail and therefore, they have begun to focus on the limitations, consequently suggesting alternative or complementary approaches able to overcome such flaws. For instance, Mooraj *et al.* (1999, p. 481) state that "although surrounded by much publicity in both professional and academic circles, few organisations are yet in position to quantify its benefits, therefore investing time and money for unquantifiable results". Furthermore, Neely and Bourne (2000, p. 3) point out that "70 per cent of balanced scorecard implementations fail" and provide two main reasons:

(1) inappropriate design; and

(2) implementation failure.

Schneiderman (1999, pp. 6-7) states that "the vast majority of so-called Balanced Scorecards fail over time to meet the expectations of their creators", subsequently providing six main reasons for such failures. Newing (1994) argues that one of the main weaknesses of the BSC is the complexity and time involved in its development. Dinesh and Palmer (1998, p. 367) suggest that two key causes for failure are related to partial implementation of the system and non-recognition of the need for adopting a human relations view. Further drawbacks of the BSC may be mentioned. For example, Butler *et al.* (1997) consider Kaplan and Norton's model too general. Epstein and Manzoni (1997) question the ability of companies to agree on a strategy in such clear terms that would enable construction of a BSC. Some authors (Bourguignon *et al.*, 2004; Bessire and Baker, 2005) question the novelty of the idea, mentioning the French *Tableau de Bord* as its precursor.

Furthermore, addressing the research question raised in this article and aiming to highlight some critical elements of BSC design and implementation process to be later addressed in this study, we identify some specific shortcomings cited in the literature that need to be further discussed (Nørreklit, 2000; Neely and Bourne, 2000; Nørreklit, 2003; Akkermans and van Oorschot, 2005; Bessire and Baker, 2005):

- The concept of causality in the BSC is not extensively explained and is often unclear. As Akkermans and van Oorschot (2005, p. 933) highlight, a specific concern related to BSCs is that "the concept of causality is not in all implementations of BSCs equally well developed". In particular, in emphasising that improvements in one area of the BSC lead to improvements in others, Kaplan and Norton basically identify unidirectional causal relationships, subsequently connecting many variables across four different perspectives into a linear bottom-up sequence.

  In this regard, Nørreklit (2000, 2003) extensively criticizes the BSC model for providing poor guidance on causality, specifically underlining that "the relationship between measures on the balanced scorecard is ambiguously described" (Nørreklit, 2000, p. 72) and that very often such causal relationships are "assumed to be unidirectional" (Nørreklit, 2000, p. 77).

  On the contrary, real systems are characterised by complex patterns of interacting variables and even by the presence of a variety of bi-directional cause and effect relationships among those variables (and, consequently, among the four areas of the BSC; Nørreklit, 2000, p. 75), thus forming sub-structures, referred to as feedback loops (Forrester, 1968; Sterman, 2000). It is fundamental to stress not only that any "structure consists of the feedback loops, stocks and flows, and nonlinearities created by the interaction of the physical and institutional structure of the system with the decision-making processes of the agents acting within it" (Sterman, 2000, p. 107), but also that the behaviour of a system arises from its causal structure, as discussed in Section 4.

- The BSC lacks dynamics, since it does not properly consider the effect of the dynamics existing within a system, i.e. there is a lack of consideration of time-delays between causes and effects (Bianchi and Montemaggiore, 2008). Consequently, lagging and leading indicators are listed at the same time, cause and effect are not separated in time, there is no consideration or even awareness that policies could generate short term results that could be completely different from those of the long term, and long targets and actual values are often compared, obtaining discrepancies that are evaluated as failures. In other words, a key element in correctly specifying causal relationships is to consider their time dimension and magnitude. As Kaplan and Norton (1996, p. 67) admit, "specifying such relationships is much easier said than done. Initially, these impacts must be done subjectively and qualitatively. Eventually, however, as more data and evidence are accumulated, organizations may be able to provide more objectively grounded estimates of cause-and-effect relationships. At this point, the Balanced Scorecard can be captured in a System Dynamics model that provides a comprehensive, quantified model of a business's value creation process". In brief, a BSC offers a useful snapshot of the organization's performance but does not always allow managers to accurately address the temporal dimension of their actions, plans and strategies. This situation has several serious implications since delays are fundamental in order to strategically manage a complex environment; moreover, due to its static nature the BSC becomes useless in order to extensively answer questions such as "what will happen if . . .?".
- The BSC considers just a small number of indicators. We have previously stated that one of the factors at the basis for BSC success relies on its simplicity, largely ensured by the consideration of a limited number of parameters. Hence, this remark may seem anachronistic. However, a performance measurement system based on only a few indicators could be troublesome if the most relevant ones are not selected. As Neely and Bourne (2000, p. 6) suggest, "the trick is to measure as little as possible, but to ensure that you are measuring the things that matter". This situation is particularly relevant when considering that the BSC approach has no specific mechanism in order to select metrics and targets, or peculiar procedures/tools to test and validate such choices. In the initial stage, the problem mainly arises from the design phase of the BSC in which there may be a lack of rigorous mapping tools, the elicitation of mental models is often naïve and there may be a high degree of subjectivity in the selection of the key-indicators. In the second stage, when the measures have been identified and the BSC template created, there is a lack of mechanisms for strong validation and testing of such assumptions. In brief (Neely and Bourne, 2000, p. 4), the selection of the wrong indicators could provoke the development of an incoherent strategy and its consequent failure.

  On the contrary, another risk may consist in selecting too many indicators, trying to measure most of the activities carried out. This situation could obviously be problematic since a wide set of performance metrics may not reflect the organisation's strategy; produce an amount of data which will not be properly analysed; include some unrelated metrics; or help managers and employees to understand what the organisation's priorities are (Neely and Bourne, 2000).

- There is no strong development process for the BSC. Very often the BSC is not only missing a strong design approach, but it is for the most part developed by the top-management. In particular, when a firm designs its initial Balanced Scorecard (Neely and Bourne, 2000), the causal relationships between non-financial and financial measures, and among the four perspectives, mainly reflect management's subjective understanding of the critical success factors in their business and could not entirely reflect the organisation's strategy. It is subsequently communicated and implemented within the organisation, adopting a top-down process and may lead to partial implementation (Dinesh and Palmer, 1998). The final result could be a lack of alignment between strategic objectives, divisional performance and operational/individual actions (Akkermans and van Oorschot, 2005). In summary, it may reveal a missing link between strategy and operation, which is exactly the opposite of its objective.
- The systemic view advocated by its authors is somehow incomplete. The BSC based on the four original perspectives ignores relevant actors and aspects of the overall value chain, such as some stakeholders, the competitors' reactions and relevant technological innovations. If these factors are not well understood and taken into consideration, the success of business strategy could be seriously damaged and a company's BSC model may not be coherent with its stakeholders' approach to performance measurement (Atkinson *et al.*, 1997). Basically, the BSC may be too internally focused.

Beginning with these considerations, the key question that arises is: how can these limitations be overcome?

Kaplan and Norton, as previously mentioned, have been developing new ideas and devices in order to further develop the original BSC architecture, adding tools such as the strategy maps or integrating new perspectives in the BSC cockpit (such as the environmental perspective or the risk management perspective). Other authors have matched the BSC framework with specific management and engineering approaches and methodologies, such as data envelopment analysis, multi-criteria decision analysis and/or Six Sigma. Furthermore, some authors argue to fully integrate system dynamics modelling and simulation principles and tools within the BSC strategic architecture. In this regard, quite recently within the system dynamics community there has been an increasing interest in the development of a "dynamic scorecard", designed taking into consideration a feedback loop approach and tested against real world data (e.g. Akkermans and van Oorschot, 2005; Bianchi and Montemaggiore, 2008; Capelo and Ferreira Dias, 2009).

Hence, the following sections aim to show that the system dynamics methodology could help to overcome some key limitations of the BSC and define a comprehensive strategic management system, centred on a "system dynamics-based Balanced Scorecard".

4. Towards a system dynamics-based balanced scorecard

Originally theorised by Jay Forrester in the well-known book entitled *Industrial Dynamics* (Forrester, 1961), system dynamics (SD) models and tools have proved their validity over more than four decades of application in a variety of different fields. Based on the concept of feedback and on information-feedback control theory, system dynamics (Forrester, 1961, 1968; Richardson and Pugh, 1981; Sterman, 2000) can be considered as "a perspective and a set of conceptual tools that enable us to understand the structure and dynamics of complex systems. System Dynamics is also a rigorous modeling method that enables us to build formal computer simulations of complex systems and use them to design more effective policies and organizations. [. . .] Together, these tools allow us to create management flight simulators – microworlds where space and time can be compressed and slowed so we can experience the long-term side effects of decisions, speed learning, develop our understanding of complex systems, and design structures and strategies for greater success" (Sterman, 2000, p. vii).

It is particularly relevant to highlight that the role of a system dynamics model and, even more important, of the whole modelling process is to gain insight into a complex problem and influence thinking and actions in management teams (Forrester, 1961, p. 49). In this regard, we have to stress that system dynamics is to be preferred to other planning and control/simulation techniques in order to face dynamic and complex issues[2].

System dynamics uses a number of different tools to reach its goals and to support decision-making processes, which are both qualitative (such as diagramming tools, "causal loop diagrams" (CLDs) and "stock and flow maps") and quantitative (formal models based on a rigorous mathematical language). In particular, computer models, formally combining maps and knowledge, theory and practice, are a key element of the system dynamics methodology.

In the first stage of building the maps, the modeller filters and organises knowledge from mental models and from real data. In this way gaining and formalising knowledge about complex systems and identifying interlinked sub-structures (referred to as "feedback loops") becomes possible. This is fundamental as Richardson and Pugh (1981, p. 15) state, "the System Dynamics approach to complex problems focuses on feedback processes. It takes the philosophical position that feedback structures are responsible for the changes we experience over time. The premise is that *dynamic behaviour is a consequence of system structure*"[3].

However, it is clear that mapping tools such as CLDs, even in the form of system archetypes (Senge, 1990; Wolstenholme, 2004), while on the one hand are able to contribute to the investigation and understanding of the dynamics of complex systems, on the other hand they are not sufficient to infer precisely all the possible dynamics arising from the interaction of those sub-structures.

Subsequently, building and using the computer model in a second stage, it becomes possible to learn about complex dynamics and develop managerial understanding and skills[4]. That is to say, simulation is essential, probably being the only practical way to test mental models; as Sterman (2000, p. 37) argues: "formalizing qualitative models and testing them via simulation often leads to radical changes in the way we understand reality. Simulation speeds and strengthens the learning feedbacks. Discrepancies between formal and mental models stimulate improvements in both, including changes in basic assumptions such as model boundary, time horizon, and dynamic hypotheses".

Nevertheless, building a model is not an easy task. It implies an iterative process in which the model could be rebuilt several times. There is no best recipe for developing a successful model and no optimal procedure that could guarantee a useful model, although a few main steps should be included in any modelling process, such as the following[5]:

(1) articulate the problem that needs to be addressed;

(2) formulate a dynamic hypothesis or theory about the causes of the problem;

(3) build a simulation model to test the dynamic hypothesis;

(4) test the model; and
(5) design and evaluate policies.

Overall, by taking into account the information we have previously highlighted and integrating system dynamics modelling principles into the BSC framework, it is possible to argue that the use of a system dynamics-based Balanced Scorecard may be recommended to:

- Provide a better representation of the causal structure of the analysed system, thanks to the concept of feedback loops and the use of mapping tools such as causal loop diagrams (Senge, 1990). In such a way it would also be possible to combine the use of key performance indicators and factors (KPIs and KPFs) with key success loops (KSLs (Kim, 1997)).
- Separate causes and effects in time, through the notion of time-delays and their mathematical representation in formal models (Sterman, 2000).
- Identify, formalise and analyse the systemic structure of the business environment under observation, in terms of the relationships between structure and behaviour (Davidsen, 2000).
- Make use of mechanisms for rigorous testing and validation (such as structure validity and behaviour validity tests; Barlas, 1996) of assumptions, relationships, parameter choices and strategy development.
- Filter performance measures and parameters in order to select the most relevant ones for each of the perspectives included in the BSC architecture (Akkermans and van Oorschot, 2005).
- Elicit mental models and share knowledge (Ford and Sterman, 1998) among all the people (working at different levels and having different responsibilities) involved in the SD modelling process.
- Expand at will the boundaries of the analysis, also allowing the consideration of a wider range of stakeholders and stakeholders' and their rivals' policies (Warren, 2002; Bianchi and Montemaggiore, 2008).
- Better link strategy at the operational level, since a SD modelling intervention begins by identifying the main operational flows and the basic resources in a system and concludes with a comprehensive analyses of policies developed by managers and their effects through quantification in the model, hypothesising "what if" and policy analyses or scenario testing (Morecroft, 2007; Warren, 2008).
- Assess a company's vision and strategy, make substantial improvements in corporate performance (Warren, 2008) and identify potential side-effects of management policies (Forrester, 1971).
- Sustain individual and organisational learning and support improvements in mental models thanks to the use of hypothetical scenarios (Capelo and Ferreira Dias, 2009).

Subsequently, the following section focuses on a case study in which the integration between the BSC approach and system dynamics was successfully realised in order to demonstrate how, and to what extent, a "dynamic scorecard" could be used to support decision-making and strategic thinking in complex and dynamic domains.

5. The case study

In order to provide evidence of the potential applications of a system dynamics-based Balanced Scorecard, a case study related to a start-up service-based business is subsequently described. The case study, presenting insights and ideas from the pilot project organised at the company, plays out key features similar to many service-based businesses, which are reliant on trained staff and adopters, and for which it is fundamental to simultaneously manage and balance internal and external variables and levers as well as tangible and intangible factors. Further details on the case study are subsequently provided through the presentation of the causal loop diagrams portraying the company's business environment. Afterwards, the main features of the system dynamics-based Balanced Scorecard and the main characteristics of the management flight simulator developed during the project are reported.

The system dynamics-based BSC portrays the business environment of a firm (called "Alpha") providing commercial services for its clients[6].

Alpha operates within a market made up of potential customers. When persuaded, these clients become "adopters" and Alpha assists them by offering support services (e.g. through the call centre, by answering queries, etc.).

In order to attract customers, Alpha manages three main variables[7]:

(1) The unit price is a fundamental variable. The discrepancy between Alpha's price and the market price produces an attraction or a repulsion towards the services offered by the company (both for potential customers and, at a lesser degree, for old adopters)[8]. Adoption may also come through word of mouth, which is considered as social exposure and imitation.

(2) Adoption may come from advertising, since commercials and ads on various media create awareness of the services offered by the firm, thus attracting potential clients[9].

(3) Intangible resources, such as reputation, can play a fundamental role. If Alpha develops a good reputation, this will benefit sales, attracting more potential customers. If the reputation becomes negative, Alpha will drive away potential customers and could also lose old adopters. Similar considerations apply to service quality.

All the variables considered within a system and their cause-effect relationships can be represented using a specific map called a "causal loop diagram" (CLD): a causal loop diagram consists of variables connected by arrows denoting the causal influences among such variables. Each causal link is assigned a polarity, either positive (+) or negative (−) in order to clarify how the dependent variable changes when the independent variable changes. 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. 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.

Note that the polarities describe the structure of the system and not the behaviour of such variables. When two or more variables are circularly connected they create a feedback loop.

All dynamics arise from the interaction of just two types of feedback loops:

(1) positive (or reinforcing) loops; and

(2) negative (or balancing) loops.

A positive loop tends to reinforce or amplify whatever is happening in the system, generating exponential growth (or exponential decay) as its dynamic behaviour, while a negative loop tends to counteract the tendencies within a system, opposing change and seeking for balance, equilibrium and stasis. This feedback operates to bring the state of the system in line with a goal or a desired state, counteracting any disturbance moving the system away from its goal. It generates goal-seeking as its dynamic behaviour, describing processes that tend to be self-limiting.

A variety of other dynamic behaviours arise from the nonlinear interaction of the above-mentioned structures with one another, such as oscillations, S-shaped growths and even chaotic behaviours.

The first CLD built during the project is shown in Figure 3.

Expanding the analysis, it is relevant to stress how service quality and reputation are affected by other variables.

Service quality dheavily epends on the comparison between staff capacity and workload required to assist customers.

The index named "workload" identifies the effort that should be provided by Alpha's staff in order to meet customers' needs and requirements. In each moment the actual staff can provide a total amount of capacity, measured as the sum of productive hours that can be provided by the employees, weighing their experience and productivity[10]. Low-quality service arises when there is a negative discrepancy between workload required and available capacity. Therefore, a main objective of the top decision-makers is to manage their staff properly, continuously balancing the workload with actual capacity and taking into account the delays that are active in the system (e.g. the time required to hire a new employee or the time required to train him/her in order to get more experienced personnel). Note that trainees need time to acquire new skills and become experienced, while experienced employees are asked to put effort and time into training new employees. Subsequently, a delicate trade-off emerges: if on the one hand this situation makes it possible to increase new employees'

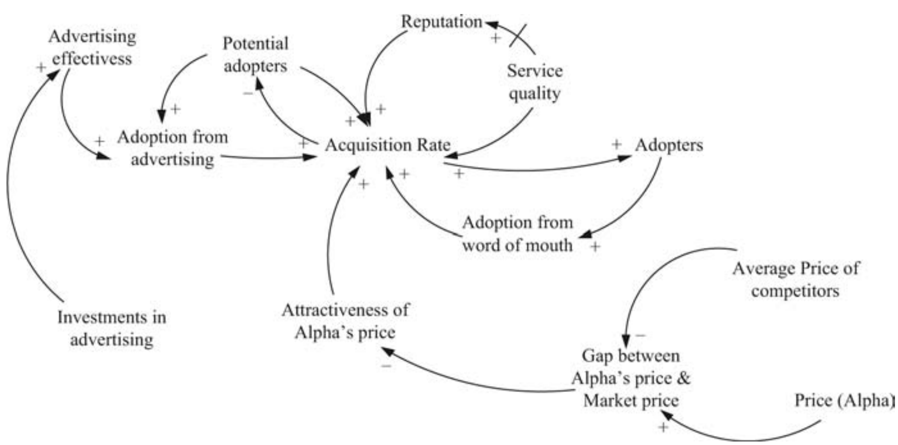


Figure 3.
Simplified CLD focused on clients and service

skills and productivity, on the other hand it reduces the available time and actual productivity of experienced staff.

High-quality service positively influences the company's image and its reputation. Note that reputation is an intangible asset that is quickly lost, whilst it can be increased very slowly over long periods of time.

In this regard, as additional information, we underline that CLDs allow the explicit identification of time delays affecting some variables. In particular, within the CLDs shown here, the presence of a delay characterising a cause-effect link is indicated by a short line crossing such link[11].

All the above-mentioned variables and their cause-effect relationships are shown in Figure 4.

Taking into account the financial perspective, revenues basically come from the price multiplied by the number of operations carried out. Therefore, the number of adopters and their transactions with the company are key figures to control. Some other variables/situations need to be verified continuously, such as the spread between Alpha's price and its competitors' prices and the effectiveness of key marketing elements (e.g., word of mouth, advertising and reputation).

Costs are generated by a variety of activities being performed by the company. First, most are related to salaries and operating costs (included recruiting and training costs), with particular relevance assumed by costs arising from customer activities. Second, some costs are overhead costs. Third, customer service requires some costs as well, primarily administrative expenses.

Operating profit (or loss) emerges as the difference between revenues and costs, and cash balance is calculated subsequently.

As a final stage it is possible to identify some other feedback loops, taking into consideration the actual levels of the operating profit. For instance, positive results will lead to further increases in the effort devoted to specific policies, such as new investments in advertising or in recruiting or likely changes in the level of the price applied on the market. In addition, a high operating profit would positively influence

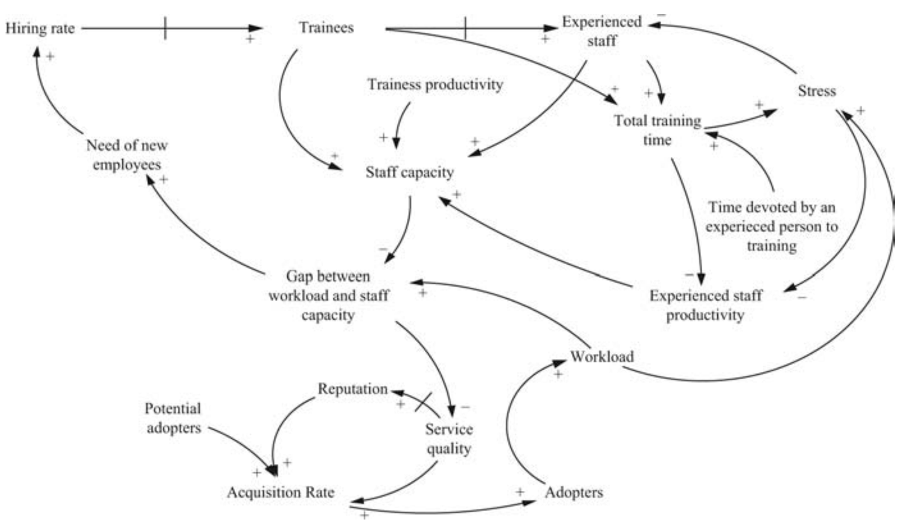


Figure 4.
Simplified CLD focused on staff

the reputation of the company, thus attracting new potential customers or investors. All these loops, if well identified and strengthened, can guarantee to sustain the processes of growth. All these relationships are portrayed in Figure 5.

Three additional steps are required in order to develop a System Dynamics-based BSC: transform the CLDs into a "dynamic strategy map"; formalize the dynamic strategy map into a quantified simulation model; and embed the model and the maps into a management flight simulator displaying a BSC-like architecture.

First, the map shown in Figure 5 was modified in order to develop the "dynamic strategy map" shown in Figure 6.

As shown in Figure 6, this map allows for the clear identification of the main causal links and their polarities, the most relevant time-delays active within the system and a variety of feedback loops through four main perspectives:

(1) learning and growth;

(2) internal processes;

(3) customer; and

(4) financial.

Analysing Figure 6, it is useful to note that there is no sharp division between the four perspectives. On the contrary, curved lines are used to make clear that some variables are "boundaries", i.e. they could be included in more than one perspective. In this regard, the boundaries of the model can be easily modified when necessary or when there is a need to include more variables into the BSC.

Most importantly, this dynamic strategy map is not built by adopting a bottom-up approach. Rather, it links the four perspectives into a comprehensive and inter-hierarchical view of the business domain under analysis. For example, the financial perspective is not traditionally positioned at the top of the strategy map, which instead shows mutual and circular causal links among all the four perspectives, thus generating a variety of feedback loops. It is relevant to stress again that a fundamental principle of system dynamics is that the structure of the system gives rise to its behaviour (Sterman, 2000, p. 28). Consequently, identifying key feedback loops is the first step towards inferring the probable dynamics that will characterise this system over time.

In this regard, starting from the dynamic strategy map, it was possible for managers to identify and isolate a few feedback loops that were considered critical for the company's success. Those loops, according to Daniel Kim's (1997) definition, are key success loops (KSLs) that need to be monitored and managed alongside the well-known key performance indicators (KPIs). Figure 7 summarises some of the most relevant key success loops identified in the project.

Figure 7 shows four main feedback loops: three of them are reinforcing loops (R1, R2 and R3), while the fourth is a balancing loop (B1)[12]. As previously stated, reinforcing (or positive) loops are responsible for growth (having exponential growth as their dynamic behaviour), whilst balancing (or negative) loops are responsible for equilibrium and stasis. The task of managers and the goal of a successful strategy would be that of strengthening the positive feedback loops, at the same time removing or properly managing the negative ones.

In this particular case, the hypothesis is to start from the variable "hiring rate" on the top-right of the loop. By investing in human resources (through new hires that result in a higher number of trainees and, later, of experienced employees), it is possible to increase the company's staff capacity. When compared to the workload required by

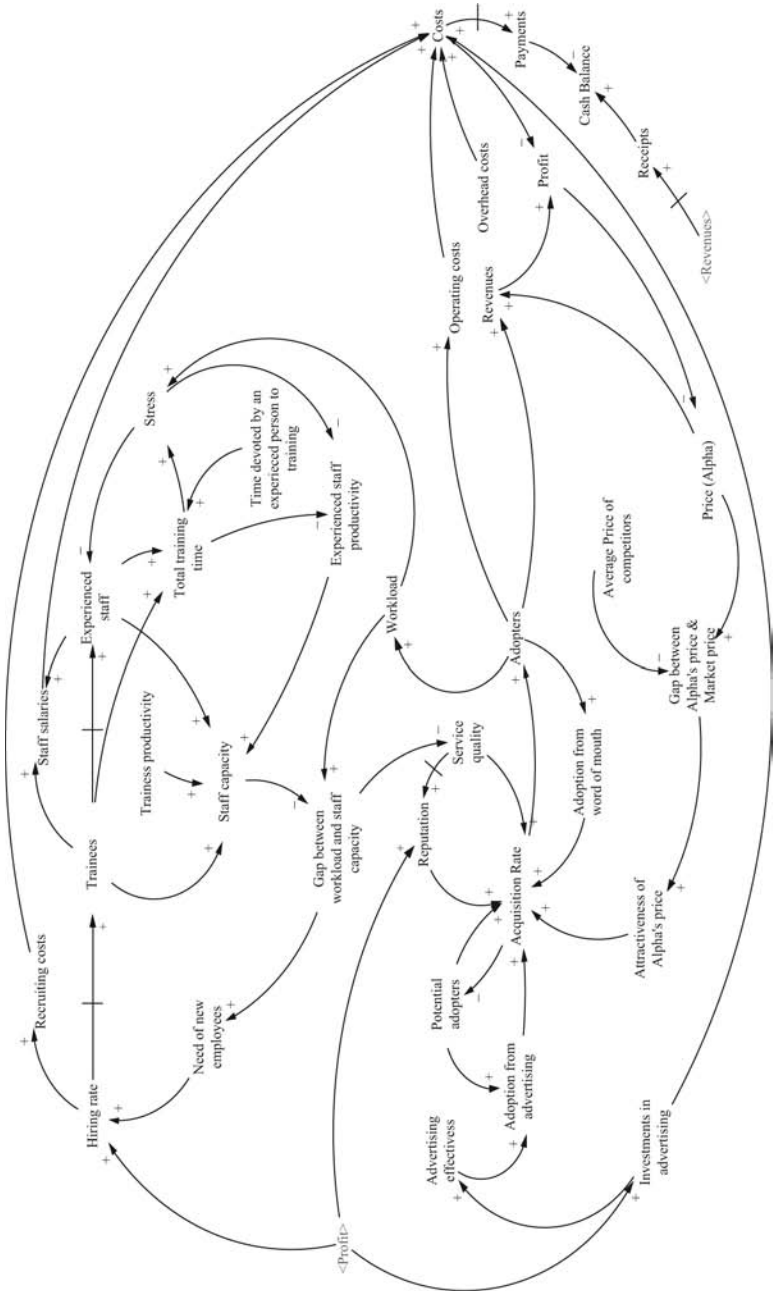


Figure 5.
Simplified CLD reporting costs and revenues

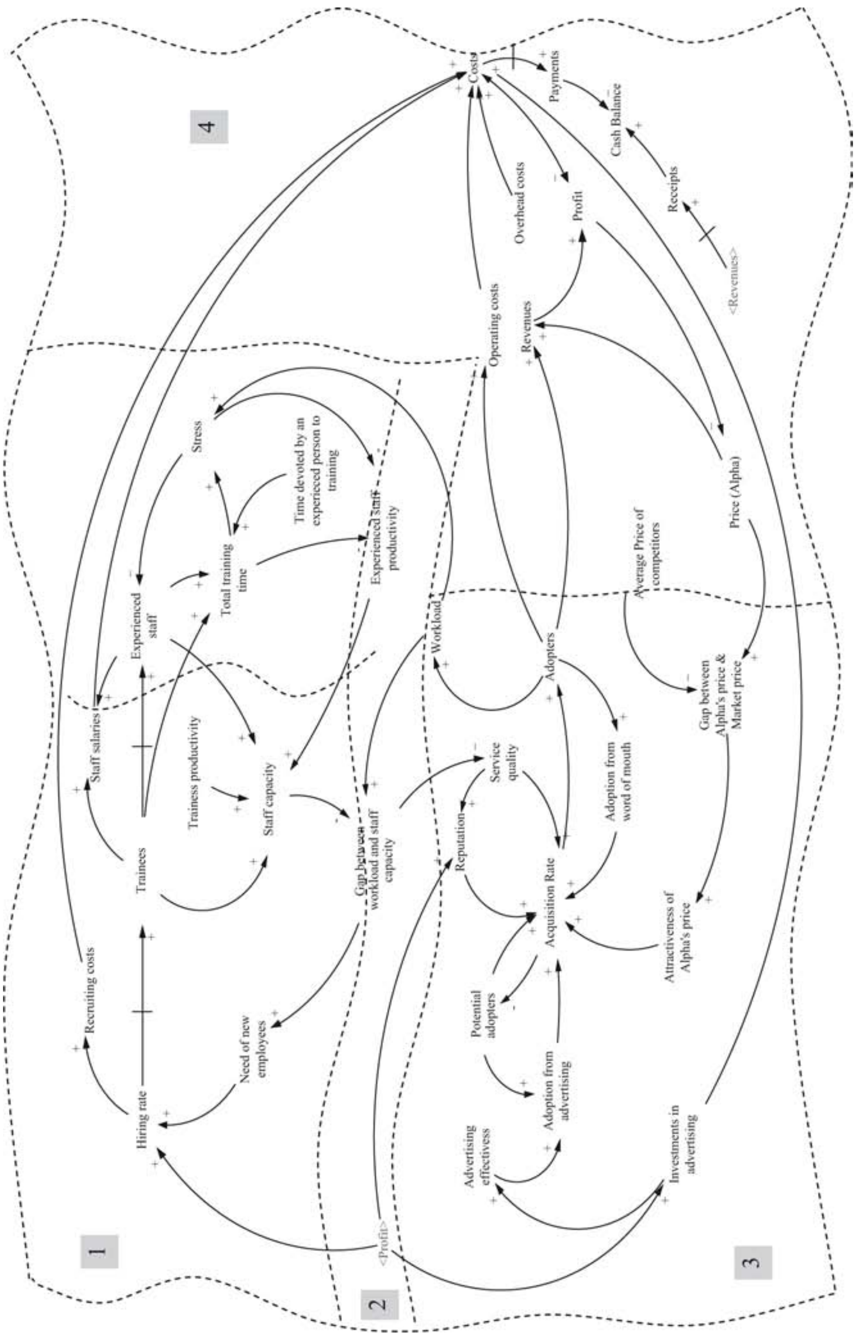


Figure 6.
The four BSC perspectives within the "dynamic strategy map"

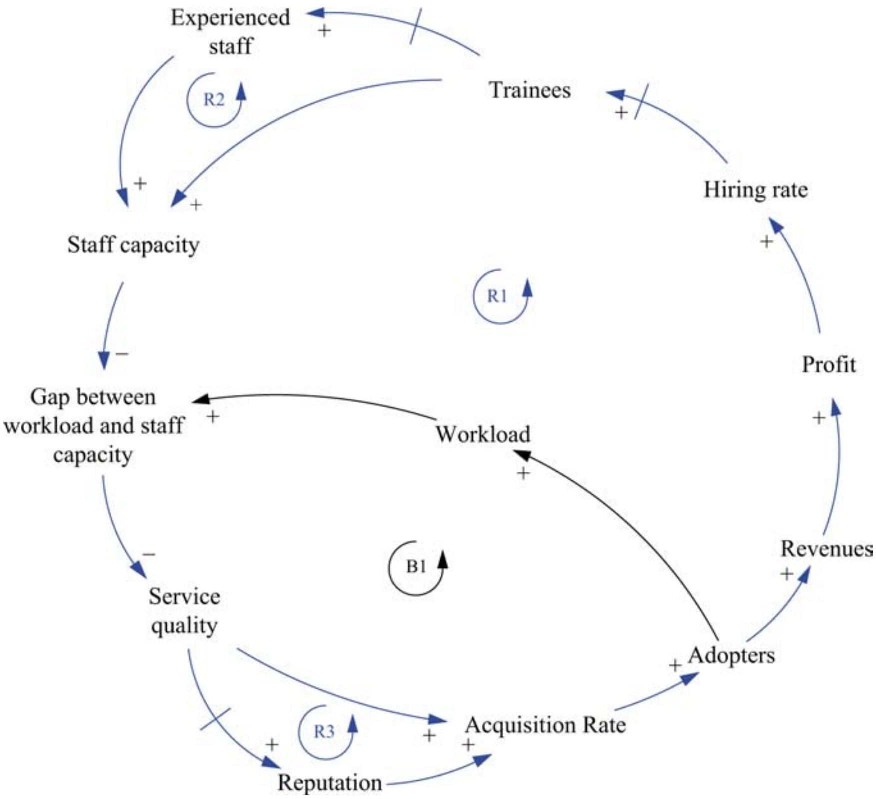


Figure 7.
A selection of the key success loops identified during the project

the actual number of customers, this surplus of staff capacity would help provide a higher quality service to clients, also boosting the company's reputation (although with a delay). Both situations would eventually lead to an increase in the total number of customers (basically due to a high level of customer satisfaction and to favourable word of mouth). Having an increased (and loyal) base of customers will subsequently lead to more revenues, higher profit and new investments in human resources. All the positive loops are consequently closed and active within the system.

In brief, if identified and managed correctly, these positive loops are the key to sustainable growth and the continued success of the company. Furthermore, all these KSLs display relevant information on hard and soft variables, polarities of causal links and time delays active in the system.

In the last stages, the dynamic strategy map was formalised into a mathematical model and then the model was embedded into the BSC architecture. This is particularly, relevant since building the mathematical model bridges the gap between a qualitative analysis (based on the use of CLDs) and a quantitative approach aimed at supporting strategy formulation and implementation (based on the use of the mathematical model).

In this way, the whole modelling process finally led to the development of a comprehensive "management flight simulator" (MFS (Spector and Davidsen, 1998;

Sterman, 2000)). Also named "microworlds" (Papert, 1980), "virtual worlds" (Schön, 1983), "learning laboratories" (Senge and Sterman, 2000), "computer-based learning environments" (CBLEs (Isaacs and Senge, 2000)) and "interactive learning environments" (ILEs (Spector and Davidsen, 1998; Spector, 2000)), management flight simulators are computer-model based laboratories that are useful as tools to support strategic thinking, group discussion and learning in management teams, since they offer learning conditions that could not be allowed in the real world or with other educational and training tools (Sterman, 2000, pp. 88-9): as Isaacs and Senge (2000, p. 270) point out, the central purpose of MFSs "is to provide decision makers with new opportunities for learning through conceptualization, experimentation and reflection that are not easily achieved in everyday management activities".

Basically, a MFS consists of two main components:

(1) the underlying system dynamics model; and

(2) a graphical interface.

While the simulation model is at the heart of the simulator, the interface is the place where the interaction between the player and the model takes place. The users take on the role of decision-makers within the system and are called on to face complex problems in different scenarios. Usually, an interface contains a control panel plus some graphs and tables reporting data and figures. Additional elements can be included as well, such as information for the users, multimedia objects and pop-up windows giving the player cognitive feedbacks when specific critical values of key variables are reached.

Considering the case study, the MFS was developed in order to display the CLDs, embed the mathematical model into the system dynamics-based BSC architecture and provide all the controls, figures and tables needed to interact with the model and test policies and strategies over a four-year time horizon.

More specifically, Figure 8 presents the interface of the MFS, which contains:

- the control panel;
- a simplified causal loop diagram portraying the main variables of the model; and
- some graphs, tables and reports showing details on the behaviour and actual values of the main variables of the model.

As shown, in order to simulate the behaviour of the model, assist policy design, support strategic thinking and perform scenario analysis, a few key variables (unit price, new employees to hire per unit of time, investments in training, investments in marketing) were put under the direct control of management[13].

Above all, this final step of the project facilitated the quantitative analysis of the business domain, eventually making it possible to support the company's policy design process with numerical data, information and graphs and therefore allowing for the prediction of the magnitude of the expected dynamics over the given time-horizon.

As an example, another screenshot from the MFS is shown in Figure 9.

6. Discussion and final remarks

This study has focused on the development of a system dynamics-based Balanced Scorecard, i.e. a Balanced Scorecard developed on the basis of the principles and tools of system dynamics methodology. The article aims to show that the combined use of

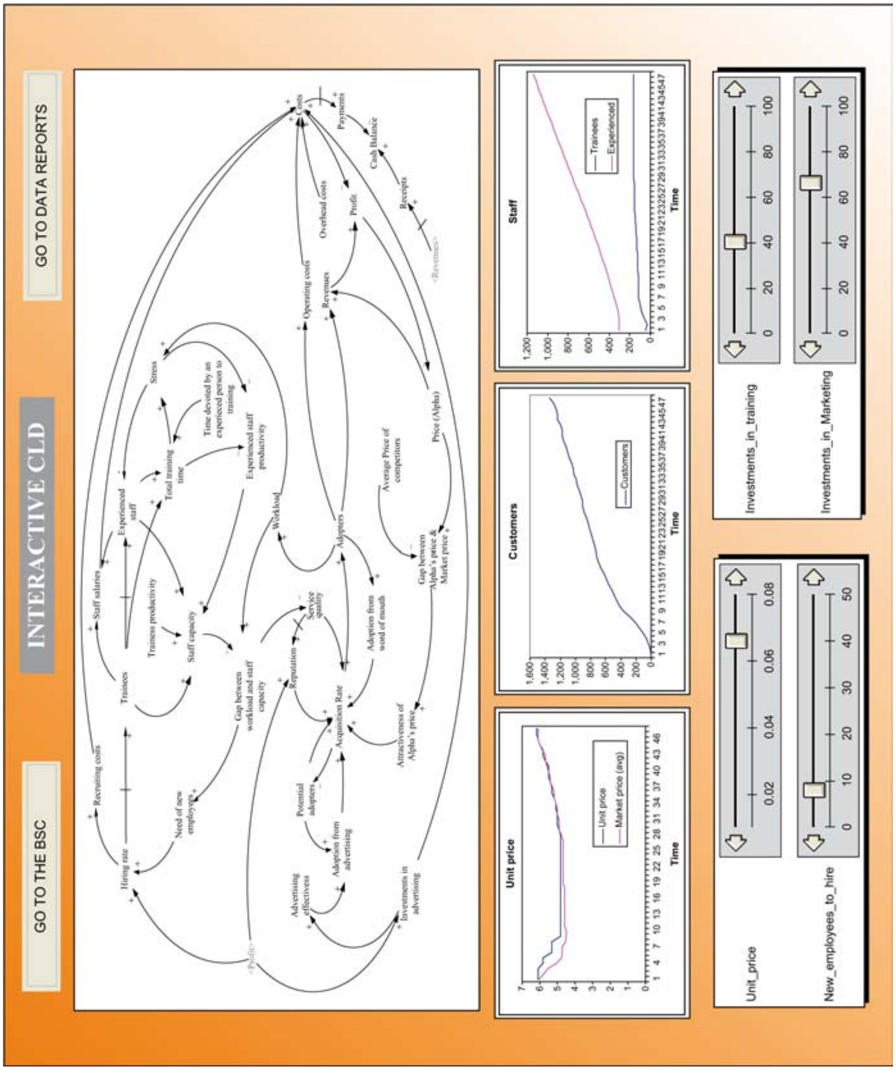


Figure 8.
Interactive CLD and graphical interface of the management flight simulator

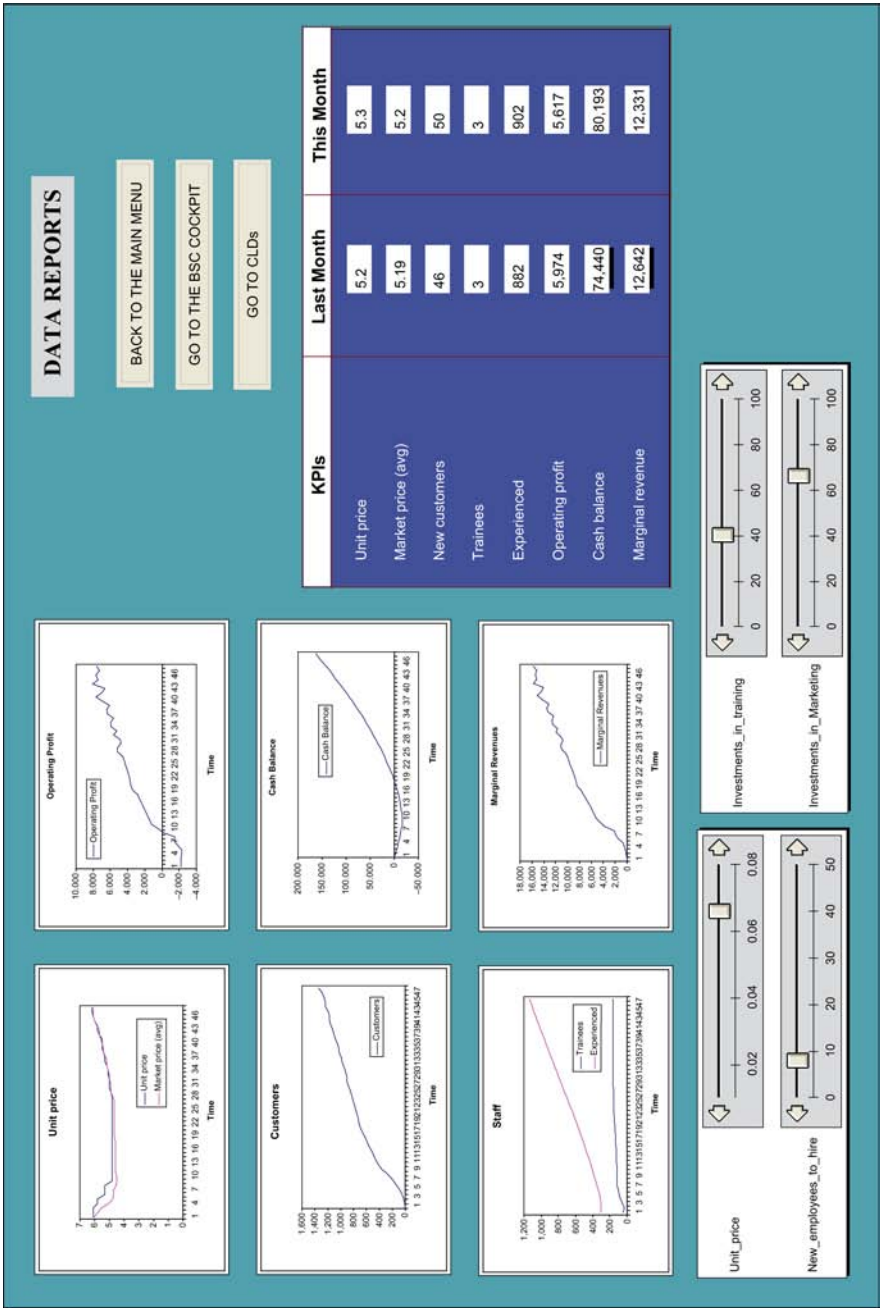


Figure 9.
Screenshot related to the Data Reports

the Balanced Scorecard approach and system dynamics principles and modelling techniques has the potential to be developed into a comprehensive management flight simulator to be used as a strategic management tool.

This section summarises some considerations and information presented earlier, providing some further final remarks.

The Balanced Scorecard does exactly what its name suggests. It offers a more balanced view of a firm's or manager's performance by integrating both financial and non-financial information in a coherent fashion and framework. This overcomes one of the obvious flaws of traditional performance measurement systems: undue emphasis on historical financial information.

Therefore, the Balanced Scorecard can play a useful role in strategy formulation and strategy implementation, especially when developed by relying on a rigorous strategy map, or within change management programmes. It can also assist in communicating the strategy to both managers and staff. Finally, by creating a better connection between the performance measurement system and the firm's strategy, the Balanced Scorecard can align employee efforts with those required for successful strategic implementation.

However, successful implementation of a Balanced Scorecard is not a trivial matter as many firms have failed in this process or have ended up with partial implementations (Dinesh and Palmer, 1998). Moreover, if on one hand the concept of a Balanced Scorecard is simple, on the other hand the related design and formulation process can be a time consuming and costly task. Even more relevant, as previously stated, some critical deficiencies could severely hamper its efficiency and success.

In order to address some of these issues, during the 18 years since its advent, many changes have been made to the BSC architecture and its design process. Furthermore, many authors suggest matching the BSC framework with specific management and engineering approaches and methodologies, such as data envelopment analysis and multi-criteria analysis. In this regard, the system dynamics community has increasingly explored the possibility of designing and implementing "dynamic Balanced Scorecards".

This is particularly relevant since developing a system dynamics-based BSC and eventually embedding it into a computer-based management flight simulator would consent to retain all the advantages of the original architecture created by Kaplan and Norton, while at the same time benefiting from some specific strengths of system dynamics methodology. In particular, if fully integrated into a BSC architecture, the "dynamic scorecard" would allow us to explore and understand the features of complexity and dynamics that characterise business domains.

Consequently, a system dynamics-based Balanced Scorecard – when compared with a traditional BSC – would specifically improve the strategic architecture, allowing:

- the use of mapping tools (such as CLDs) for a more comprehensive and detailed development and analysis of the strategy maps (e.g. through the definition of link polarities or the identification of key success loops);
- the provision of a better representation of the causal structure of the system under analysis, thanks to the concept of feedback loops (rather than the identification of mere unidirectional causality);
- identification, formalisation and analysis of the systemic structure of the business environment under observation, in terms of the relationships between structure and behaviour;

- the building of quantitative models (and the use of rigorous validation tests to ensure their validity) in order to perform and test policy analysis;
- the development and use of specific Balanced Scorecard-oriented management flight simulators, in order to support strategy formulation, assist strategy implementation, perform scenario analysis and facilitate organisational communication and learning; and
- better linking of strategy at the operational level, since for an effective SD modelling intervention it is necessary to elicit mental models and share knowledge among all the people involved in the project and belonging to different levels and having different responsibilities within the company.

In brief, the system dynamics methodology is suitable for developing a sound performance measurement system and for supporting strategy formulation; as Warren (2002, p. 278) states "integrating a sound strategic architecture with BSC principles leads to a scorecard that is not only balanced but compact, joined up, and dynamically sound".

Furthermore, considering the case study and the system dynamics-based BSC that has been presented and reporting some additional elements that provide evidence of the correct and useful implementation of this tool within the company, some key elements should be subsequently highlighted. In particular, interviews with managers and operators at the company permitted us to gather some interesting feedback on the usefulness of the pilot study, allowing us to:

- reach a general common agreement about the dynamics ruling the system under analysis;
- obtain a better understanding of the system and the activities being run in that specific service-based business environment;
- create a common understanding about a business domain characterised by the presence of feedback loops and complexity;
- identify the key success loops to reinforce within that specific business domain;
- develop a specific "dynamic" strategy map, showing polarities, delays and clear interdependencies among four different perspectives, tangible (or hard) and intangible (soft) resources, demand side and supply side variables;
- share knowledge among all the employees and managers involved in the project, thus better aligning the operational and the strategic decision levels within the company; and
- use the management flight simulator to test feasible policies before their implementation and develop a synthetic scenario analysis.

On the whole, system dynamics-based BSCs such as the one used in this case study may help managers and decision-makers to increase their knowledge about their specific business environment and become more aware and conscious of both generic and specific dynamic issues. Finally, we believe that the system dynamics methodology (both in the form of qualitative causal maps and quantitative simulation models) combined with the traditional BSC architecture is useful in the development of "dynamic scorecards" that can offer fundamental support for decision-makers facing complex and dynamic domains.

Notes

1. In addition to the references provided in the text, the books and articles by Kaplan and Norton (e.g. Kaplan and Norton, 1996, 2001, 2004) contain and discuss a large number of case studies related to both the private and the public sector, as well as to profit and non-profit organisations. As to internet sources, one example is related to the website www.balancedscorecard.org, where examples and success stories focus on companies that have adopted the BSC.
2. Regarding the concept of complexity, Sterman (2000, p. 21) argues that "most people think of complexity in terms of the number of components in a system or the number of combinations one must consider in making a decision. [. . .] *Dynamic* complexity, in contrast, can arise even in simple systems with low combinatorial complexity". More specifically, complexity arises because social and economic systems are dynamic, tightly coupled, governed by feedback, non-linear, history-dependent, self-organising, adaptive, counterintuitive, policy resistant, characterised by trade-offs. Thus, it is a natural consequence of management that intended objectives for actions carried out could not be reached or could provoke unanticipated effects (Forrester, 1971). In particular, this frequently happens because real system are characterised by the presence of feedback loops and unfortunately human beings are ineffective in analysing and taking into account complex feedback structures.
3. Davidsen (2000, p. 172) provides more insights underlining that "the relationship between structure and behaviour is at the very heart of system dynamics. That relationship can be portrayed as follows: behavior is created by the structure that characterizes the system. This behavior, on the other hand, can influence the structure of the system and cause the relative significance of the various component structures of the system to change. [. . .] Typically, these substructures constitute feedback loops, and we talk of shifts in feedback loop dominance. Note that these structural modifications take place endogenously as a consequence of the internal behavior of the system originating from the structure of the system itself". In addition, Sterman (2000, p. 28) clarifies that "a fundamental principle of system dynamics states that the structure of the system gives rise to its behavior. However, people have a strong tendency to attribute the behavior of others to dispositional rather than situational factors, that is, to character and especially character flaws rather than the system in which these people are acting. The tendency to blame the person rather than the system is so strong psychologists call it the 'fundamental attribution error'".
4. A simulation model is a mathematical computer model that can be used for different purposes, as policy analysis, scenario analysis or education. Basically, each model has two main components: it includes a representation of the physical world relevant to the problem under study without adding too many details; and it has to portray the behaviours of the actors in the system, and consequently it must include decision-making rules. Note that there are no difficulties in including in the model both hard and soft variables, as there are no difficulties in expanding or narrowing the boundaries of the model – that is, the number of variables and feedback loops portrayed in it. In particular, a broad model boundary including relevant feedback loops could be more important than a great amount of details on individual components.
5. These steps allow the development of the simulation model but they are no guarantee of its usefulness to the user or client. Indeed, to be effective, the modelling process must focus on clients' needs, must be designed to solve problems and gain insights, and should help managers in piloting their organisations better, supporting organisational redesign and sustaining processes of individual and organisational learning.
6. The name of the company has been omitted for reasons of privacy.
7. It is useful to note that all cause-effect relationships related to these variables are usually non-linear.

8. The negative polarity (" – ") associated with the causal link between the variables "Gap between Alpha's price & Market price" and "Attractiveness of Alpha's price" means that: if Alpha's price is higher than the market price and this gap is going to increase, the final effect will be a decrease in the attractiveness of Alpha's price; and if Alpha's price is lower than the market price and this gap is increased (to the advantage of Alpha), the final effect will be an increase in the attractiveness of Alpha's price.
9. It is necessary to emphasise that the magnitude and the pervasiveness of advertising is very seldom constant over long periods of time.
10. The productivity of a senior is usually higher than that of juniors and rookies. However, in order to be trained, new employees need to be assisted by more experienced staff, thus absorbing part of their time and energy.
11. As Sterman (2000, p. 411) states, "a delay is a process whose output lags behind its input in some fashion". There are two main typologies of time delays: a material delay captures the physical flow of material through a delay process; while an information delay represents the gradual adjustment of perceptions or beliefs. For example, the delay characterising the causal link between service quality and reputation belongs to the latter typology. In general, to correctly define and model any time delay it is necessary to know and specify the average length of the delay and the distribution of the output around the average time delay. For further details on time delays, see Sterman (2000, chapter 11).
12. On correctly determining whether a feedback loop is positive or negative, we refer to Sterman (2000, p. 144): "The right way to determine the polarity of a loop is to trace the effect of a small change in one of the variables as it propagates around the loop. If the feedback effect reinforces the original change, it is a positive loop; if it opposes the original change, it is a negative loop. You can start with any variable in the loop; the result must be the same".
13. The time horizon used for the simulation was four years (48 months, with monthly decisions for the users of the MFS), as shown in Figures 8 and 9.

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About the author

Federico Barnabè is Associate Professor in Business Administration in the Department of Business and Social Studies, Faculty of Economics "Richard Goodwin", University of Siena, Italy. His research interests as well as his publications focus on simulation modelling techniques (such as system dynamics) and management control. On these topics he has published in international journals such as *Journal of Management and Governance* and *Simulation & Gaming*. Federico Barnabè can be contacted at: barnabe@unisi.it