Developing a Sound Operations Strategy’s Balanced Scorecard Using System Dynamics: A Case Study

by

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Abstract
Nowadays, companies face a diversity of operational challenges and decisions in accomplishing their operations strategies and their corresponding competitive priorities. Significant evidence suggests that successful companies have devised operation strategies internally consistent with their business strategy. Different classifications of operations decisions and metrics are used to characterize a particular operations strategy (OS) based on the proposed capacities, supply network, organizational structure, and processes technologies. In general, once the OS has been implemented, companies use performance measurement systems that measure the gap between actual operational performances and key benchmarked performance indicators (KPIs). In early 1990s, Norton and Kaplan introduced the Balanced Scorecard (BSC), a performance measurement framework that addresses the limitation of traditional performance measurement framework that relied exclusively on financial performances or measures. Through the BSC framework, the company's strategy is translated into strategic objectives and measured around four perspectives: financial, customer, internal process, and learning and growth. Although originally designed as a business wide strategy framework, the method quickly became popular in the development of functional strategies (operations management, marketing, finance, etc.) However, traditional BSC practices have serious shortcomings rooted in their inadequacies of dealing with dynamic, systemic, complex and unpredictable competitive and operational aspects in the internal and external company’s environments.

This study describes a system dynamics (SD) simulation approach useful in the evaluation of operations strategies based on the BSC framework. The approach has five phases: (1) plan and decide on the initial BSC constructs, (2) develop the corresponding OS, (3) translate the OS into operational terms, (4) develop a system dynamic model based on BSC metrics and the feedback structure of operational terms (making the OS dynamically actionable), and (5) examine and compare the operational performances of the simulation to the BSC metrics throughout time. The approach relates the company’s operational strategic capabilities in a dynamic manner and overcome the limitations of traditional BSC practices. The simulation model was based on the causal loop diagrams developed in the fourth phase of the project and reflected the OS process of the company. A case study from the pharmaceutical industry was used to describe the approach. Through model development and simulation experiments, dynamic implications of the BSC configuration were examined, shortcomings identified and the consequences of different operations strategies’ policies were tested. The results suggest that similar approaches are promising to overcome existing BSC framework limitations.

Key Words: Operations Strategy, System Dynamics, Balanced Scorecard
Introduction

In recent years, practitioners and scholars have given increasing attention to the importance of corporate, business and functional (marketing, finance, operations management, etc.) strategic measurement systems that includes both financial and non-financial measures. The field of operations management is no exception. At the corporate and business level, companies recognized that financial performances are derivative of other organizational functional performances. Originating in the field of Management Accounting, where organizational control on the basis of only financial criteria was found to be deficient, Kaplan and Norton (1992) proposed that performance management system should be based on BSC approach of interrelated metrics, instead of only financial performances. Since then, their version of the BSC has been popularized and characterized as a “…simple system that can monitor some key indicators, and has the strength of interdisciplinary” (Hafeez, Zhang, & Malak, 2002). The later is related to a proposition by Ackoff (1981) related to the interconnectedness in organizations: “…all different aspects and functions of the organizations are interrelated and that one cannot improve one area, or the whole for that matter, without influencing all other areas as well.” The BSC is more than an anthology of financial and non-financial measures established in other strategic measurement systems: Works as a strategic control system aligning functional goals to the overall strategy. Contains performance measures linked together in cause-and-effect relationships and aims to be a feed-forward control system.

Regardless of its popularity, during the last two decades, the BSC has been beleaguered based primarily on its dependency on subjective and unrigorous nonfinancial performance measures (Ittner & Larcker, 2003) that could decrease the precision and clarity, and increase the range of plausible interpretations of its performance results. For example, according to Kaplan and Norton measures in the learning-and-growth perspective drive
measures in the customer perspective, which drive measures in the financial perspective. Investigating the cause and effect relationship between these perspectives, Noerreklitt (2002) concluded that the weak definition of cause and effect undermines the model as a whole. Other studies concluded that similar performance measurement systems provide multiple forms of performance feedback (Arias-Aranda et al., 2009).

This study presents a SD approach useful in the development and evaluation of operations strategies based on the BSC framework. This methodology overcomes some of the BSC weaknesses. Moreover, describes the application of this methodology in a case study done in a pharmaceutical company. At that time, the company needed to formulate an OS as a requirement to attain the Good Manufacturing Practices (GMP) Certificate.

**Literature Review**

**Balance Scorecard**

According to Kaplan and Norton, the BSC enhance long-established financial measures with criteria that measure performances from three added non-financial perspectives: customers, internal business processes, and innovation and learning (i.e., learning and growth.) Since companies create value through customers, understanding how customers view performance becomes a major aspect of a performance measurement and its financial derivatives. The internal-business-process perspective deals with how well the business is running, and whether its products and services conform to customer requirements, based on the corresponding mission (Othman, 2006). According to Kaplan and Norton, the innovation-and-learning perspective identifies the actions that the organization must build on to create a long-term growth and improvement environment. It includes employee training and corporate cultural attitudes related to both individual and corporate self-improvement. In a knowledge-worker organization, people - the only “storehouse of knowledge” - are the
Nonetheless, within the BSC, financial measures remain an important dimension, since they specify whether a company's strategy implementation and execution are contributing to end-result outcomes (Luft, 2009). Therefore, altogether, the four BSC perspectives enable organizations to trail the developments and necessary resources for acquiring the desired financial and operational performances (Sim & Koh, 2001). This first-generation BSC may employ 10-25 performance measures. Since BSC requires limited number of metrics for each dimension, it helps organizations to focus on their key strategic vision and operational actions. Figure 1 shows key elements of all perspectives.

![Balanced Scorecard Diagram](image)

**Figure 1. The Balanced Scorecard**

Limited participation of key stakeholders in the BSC formulation process is a latent ambiguity and weakness of first and second generation BSC approaches. Senge (1990) and Kotter (1995) stated that both generation approaches disregarded wide participation in the formulation process, hampering the understanding of a shared vision in the organization.

In the late 1990s, Cobbold & Lawrie (2002) proposed that new approaches were emerging based on management and key stakeholders participation. They referred to these approaches as third-generation BSC. Empirical research demonstrated how this new generation BSC has been applied successfully as a strategic control tool in both private and public organizations (Shulver & Antarkar, 2001; Lawrie, Cobbold, & Marshall, 2004). At the same time various practitioners and scholars emphasize that, the goal of performance
measurement is to modify business strategic processes and that one should be careful when selecting the performance metrics Robson (2004).

**Operations Strategy**

Until late 1960s, business and corporate strategies were primarily based on marketing and financial priorities. The task of the operations management function was to develop and implement all necessary systems and processes to meet these priorities and to restraint production costs. Operations management - particularly in manufacturing - was thought in terms of a century old paradigm that emphasized mass markets, stable productions lines, standard designs, and mass production (Hayes & Pisano, 1994).

In his seminal work, Skinner (1987) pointed out the missing link between operations management and corporate strategy in manufacturing organizations in the United States. He criticizes the absence of manufacturing elements and concerns in the strategic planning process of most manufacturing organizations. He supported (1) the need for a manufacturing strategy to exploit precise actions and distinctiveness of the manufacturing function and (2) the need to converge all functional efforts to support a single competitive priority (cost, dependability, quality, flexibility, speed or product differentiation) to achieve a competitive advantage.

Early in the 1980s, the fast development of worldwide competition and technology improvements increases the pressure on organizations to be more responsive to their markets and foster others. OS became imperative as these changes and requirements evolved in most sectors of the economy and researchers begin to warn about other counterproductive organizational behaviors (e.g. “Manufacturing Myopia” and the “Bullwhip Effect”), triggered by numerous manufacturing actions ((Berry & Hill, 1992; Skinner, 2007). Since then, continual request have been made to better integrate operations management with other organizational functions (Adam and Swamidass 1989; Miller and Roth 1994). In
retrospective, the early 1980s is considered the beginning of manufacturing strategy as a field of study.

Wheelwright & Hayes (1984) defined manufacturing strategy as “…the deployment and development of manufacturing capabilities in total alignment with the firm's goals and strategies.” Most definitions agree on the content or process driven rationale of the relatively new field. At this stage, most of the work ponders on (1) the trade-off of competitive priorities, (2) delineation of order-winner and qualifiers, and (3) core competencies identification and development (Hill & Hill, 2009). At the beginning of the 90’s, a new breed of practitioners and researchers started to integrate an array of new theories, methodologies and concepts into the field of manufacturing strategy, and the service sector started to mandate specialized tools and frameworks to deal with the operational aspects of organizations in this sector. This gave birth to OS as a distinct and idiosyncratic professional and academic discipline (Slack, Lewis, & Bates, 2004).

Nowadays, some competitive priorities are now being considered as synergistic and simultaneously attainable, i.e., improving the performance in one enhances the performance in another. Also, there seems to be a general agreement that the main concern of OS is the reconciliation of key market requirements with operations strategic decisions (capacity, supply network, process technology, and structure). Therefore, OS has to do with the whole transformation process, philosophy, long-term, and aggregate capabilities of the organizations (Meredith, 1994; Jayanthi et al., 2009). Accounts show that departing from this perspective could intensify appalling consequences, as has been the cases of Hewlett-Packard and Procter & Gamble. Figure 2 provides an illustrative representation of such constructs. The figure identifies four major dynamic interacting collections that drives strategic operational considerations and defines the general reconciliation model.
System Dynamics

System thinking and dynamics plays an important role in understanding the relationship between strategic choices and its outcomes. Five decades ago, Jay Forrester, regarded as the father of SD, started to advocate for the application of systems and feedback theory to the formulation of organizational and social policies (Forrester, 1961). Peter Senge’s *The Fifth Discipline* (1990) has been an important source for understanding system thinking and dynamics to a wide audience. SD importance is rooted on the decision-makers limitations to fully understand their environment and business system realities due to three main conditions: complexity, uncertainty, and cognition limitations (Folke, 2006). Rather than try to optimize for a solution, the decision-maker choose for satisfying explanations. This is the groundwork of Simon’s “theory of bounded rationality”, the type of rationality that a decision-maker draws on when the situation is too complex relative to their limited rational abilities (Simon, 1979). He reasons that decision-making in practice challenge existing assumptions that “…decision-makers pursuit optimal choices in all conditions.” For the operational strategist this discussion implies that he/she will be only somewhat capable of retaining and manipulating sufficiently representative information and structural relations.
during the process of strategy formulation due to the steering of intermediaries, which may be particularly difficult to anticipate and control (Nobs, Minkus, & Rummert, 2007).

In SD, a system is a way of understanding any dynamic process and many complex relations in the organizations. SD creates a representation of the operations choices and studies their dynamics, facilitating the understanding of the relation between the behavior of a system over time and its underlying structure and decision rules. Better performing organizations attempted to gain an understanding of the system structure before they proceeded to develop strategies and take action. Concisely, SD is based on a structural theory that offers a panorama on operations strategy issues.

**Objective**

The purpose of this study is to explain BSC performance measurement from a systems perspective, and show how the systems thinking and dynamics can improve OS initiatives. Mainly, this study focuses on the use of a concomitant approach to formulate and implement an OS in a pharmaceutical company using SD and BSC. This approach reduces several limitations encountered in the development of OS initiatives: (1) feedback loops rather than unidirectional causality, (2) explicit separation of cause and effect in time, (3) linking strategy with operations, and (4) broadening focus by challenging system boundaries. A case study of a pharmaceutical company is used. The company is a part of a conglomerate of a larger pharmaceutical company. Recently, the organization had undergone a major restructuring, shifting from a regional structure to structuring along different areas of sensible expertise. With the SD/BSC model, both strategic measures and operational measures were developed, tested and studied.
Research Method

This study describes a system dynamics (SD) simulation approach useful in the evaluation of operations strategies based on the BSC framework. The approach has five phases: (1) plan and decide on the initial BSC constructs, (2) develop the corresponding OS, (3) translate the OS into operational terms, (4) develop a system dynamic model based on BSC metrics and the feedback structure of operational terms (making the OS dynamically actionable), and (5) examine and compare the operational performances of the simulation to the BSC metrics throughout time. During the first stage, preparatory interviews were conducted with key members of the company. Several exercises on causal loop diagramming and BSC were discussed, and a correspondence OS and BSC dimension matrix was created and agreed on. Table 1 shows key results based on such matrix.

<table>
<thead>
<tr>
<th>Balanced Scorecard Dimension</th>
<th>Corresponding Operational Strategy Dimension</th>
<th>Key Performance Indicators</th>
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<tbody>
<tr>
<td>Financial</td>
<td>Supply Network</td>
<td>Output per employee</td>
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<tr>
<td></td>
<td></td>
<td>Percentage outsourcing</td>
</tr>
<tr>
<td>Customer</td>
<td>Supply Network</td>
<td>Customer satisfaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Throughput time per case</td>
</tr>
<tr>
<td>Internal Business</td>
<td>Process Technology, Organizational Structure &amp;</td>
<td>Throughput time per case % of small and easy cases</td>
</tr>
<tr>
<td></td>
<td>Capacity</td>
<td>Number of successful projects</td>
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<tr>
<td>Innovation and Learning</td>
<td>Organizational Structure &amp; Supply Network</td>
<td>Employee satisfaction</td>
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<td>Training on the job/coaching</td>
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<td>Hiring of new staff through referral by colleagues</td>
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<td>Employee Turnover Rate</td>
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The other phases are related to the development, use and analysis of a SD simulation model. Strategic and operational level matters were included in the model, and the loops that have been drawn are feedback loops that connect both levels. The causal feedback loops structure for the capacity dimension is shown in Figure 3. Similar feedback loops where
developed for the other three operational strategies dimensions (supply network, process technology and organizational structure.)

Figure 3. Causal Loop Diagram of Key Interdependencies of Capacity

These diagrams were transformed to stock-and-flow constructs. For example, Figure 4 shows the representation of stocks-and-flows of the feedback loop labeled B1. In the final inclusive model, different loops connect different stocks-and-flows of the BSC performance measures.

Figure 4. Partial Stocks-and-Flows View of Feedback B1
Discussion

After quantification key structural relations, based on the BSC and key structural relations of operations’ activities, and “running” the SD model, an initial conclusion was that the performance measures selected fairly represent the expected state. They behaved in a similar manner as reference models developed in an early stage. Therefore, aspects such as employee productivity, throughput time, customer and employee productivity, and employee turnover rates were indeed confirmed to be key drivers of performance, as well as in the quantitative version of the model. Figure 5 shows the behavior over time for key KPIs. Again, this graph partly replicates history and reasonably foresees plausible future behavior. The gradual build-up of work pressure over time and the increases in throughput time that are the logical consequence are clearly discernible. Also, as there had been a considerable increase of new and inexperienced staff, there is a gradual decrease of employee productivity.

![Figure 5: Development of performance under different effort policies (Time Period)](image)

The improvement based on the interaction process between OS and BSC is shown in Figure 6. For explanation purpose, a brief account of the process: Initial BSC’s KPIs were incorporated in the SD model, the model was run, based on the results changes in the
structure (BSC decisions) were made in the SD model, the SD was run again, etc. The process stops when it was decided that the performance measures were within tolerable limits. The basic model structure follows the conceptual model outlined and key operational KPIs used in the BSC (quality, delivery, cost and flexibility.) As shown, capabilities are increased by the effort. Every effort put into a capability depends on the connection between the capability stocks and one or more variables (functions) that change this comparison into a supporting or an inhibiting factor. For example, delivery supports the development of cost, meaning that whenever delivery is greater than cost, any effort put on cost is effective and augmented by the preferred relationship between the two. Delivery is affected by cost only, when the level of the cost capability is greater than that of delivery.

**Conclusions**

The use of SD has proved to be very beneficial in this process. The use of feedback structure was instrumental during the first stage of model building in identifying BSC’s KPIs, key variables and their causal interrelations. The use of SD simulation modeling was essential in arriving at a proper appreciation of the importance of behavior in the KPIs (e.g., attracting and retaining employees.) Surely, strategic models that integrate BSC and SD will be more appropriate in some cases than the use of only traditional BSC approaches. Therefore, SD remains a good choice to test for relevance in a wide variety of BSC development settings, as the case of formulating operations strategies.
Bibliography


