PERFORMANCE AND DATA ENVELOPMENT ANALYSIS

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Abstract. *Performance indicators have been introduced to evaluate a firm in various aspects like profitability, market share and satisfaction of the clients. However, a relevant question is how to combine these measures to obtain, in a balanced way, a global evaluation of the situation of a firm and compare it with other organizations. It is also necessary to compare these measures, to avoid giving an excessive weight to certain aspects at the expense of the others. In a previous work, we proposed a Balanced Scorecard (BSC) methodology for the definition the strategy of a firm and the set of performance indicators, in terms of the expectations of the customers and firm owners, the internal and external processes and the available and necessary resources. The Data Envelopment Analysis (DEA) is a tool that can be used to complement this methodology, allowing us to calculate the global performance of a firm by means of a weighted sum of the set of performance indicators. Here, we propose an approach that relates the strategic objectives and the strategic map obtained by our model with these weights. Each indicator is related to a link in the strategic map, and the cause and consequence relations of the map give the relative importance (and weights) of these links (and indicators). On the other hand, these cause and consequence relations give rise to restrictions on the measures of the performance. So we consider the application of Causal Loop Diagrams during the construction of the strategic map in order to identify these restrictions.*

Keywords*: Strategic planning, Balanced scorecard, Data envelopment analysis.*

1. INTRODUCTION

As a direct consequence of the globalization process of economy, the firms need to develop a strategic vision of the business and the balanced scorecard models (Maisel, 1992; Kaplan and Norton, 1992; Boivin, 1996; Edvinsson and Malone, 1997; Olve, Roy and Wetter, 1999 and Simmons, 2000) supply an answer to this necessity, balancing the usual financial measures with an additional focus on non-financial ones. In this sense, we proposed (Pureza and Dalla Valentina, 2006) a balanced scorecard (BSC) methodology in terms of the expectations of the customers and firm owners, the internal and external processes and the available and necessary resources, the four perspectives for the model, shown in Fig. 1.

The first one, called powerholders perspective, represents the point of view of the group that is the responsible for the strategic decisions. The second perspective, present in any BSC model, is the customers' perspective and identifies the expectations and tendencies of the market. These perspectives represent the motivation for the strategy.

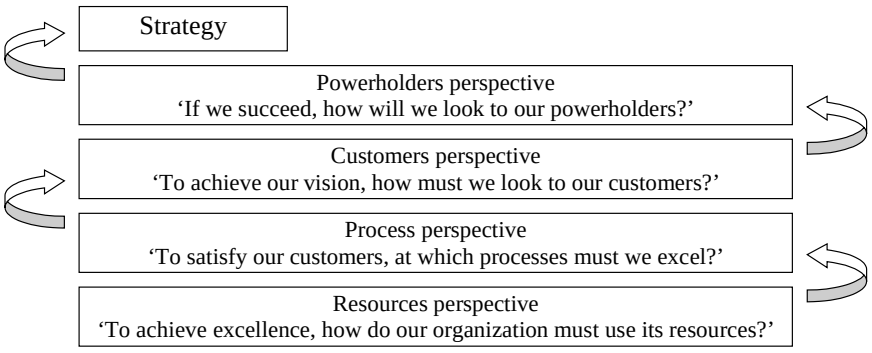


Figure 1. Four perspectives.

The third perspective focus internal and external processes that aggregate value for the clients. Finally, the resources' perspective considers tangible and intangible assets, such as the physical and financial resources, the market share, the organizational culture, the information system, the employees' capabilities and the image of the firm. These two perspectives, in opposition to the others represent the restrictions to the strategy, since it depends on the present structure of the firm and the environment and on the resources availability for the actions to be performed in order to adequate the firm to the strategy.

Our model pretends to answer a couple of problems that were indicated in some papers (Normann and Ramirez, 1993; Kaplan and Norton, 1996; Maltz, 2003; Yee-Chin, 2004 and Flak and Dertz, 2005). It can be used without changes by non-profitable and public organizations and during the formulation of a new strategy. It highlights the role of the community and the employees in the decision process as well as the social responsibility action. Moreover, its structure avoids any misunderstanding between means (resources perspective) and ends (powerholders perspective) that arises when both aspects are described according to the same financial perspective.

In order to deal with the absence of reliable information about the organization and its environment, one of the basic elements of our model is the existence of three specific teams to manage the stages of the cyclic process shown in Fig. 2. The conduction team represent the point of view of the direction of the firm, being responsible for all decisions to be made at all stages of the process. The other two teams give the technical support to the conduction team: the execution team is a small group that will work at the formulation of the strategy while the continuous improvement team is a larger group, with people from all areas of the firm, that will implement, evaluate and update the strategy, following a PDCA cycle (Ishikawa, 1985).

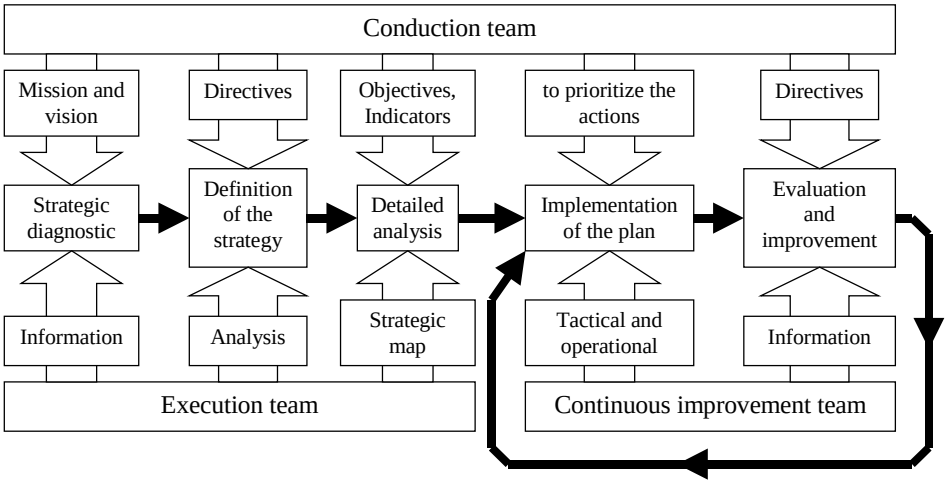


Figure 2. Stages and teams.

The formulation of the strategy is divided in three actions: performing the strategic diagnostic, defining of the strategic plan and detailing the plan. The strategic diagnostic allows the identification of alternative strategies to be considered and chosen by the conduction team. The execution team details the strategy from a rigorous evaluation of the demands, not only physical, but in terms of the capabilities to be dominated by the employees, the functional structure and the management of information. It allows the construction of the strategic map of the firm (see Fig. 3), a set of performance indicators (Edvinsson and Malone, 1997 and Kaplan and Norton, 2004) and targets for the evaluation of the strategy.

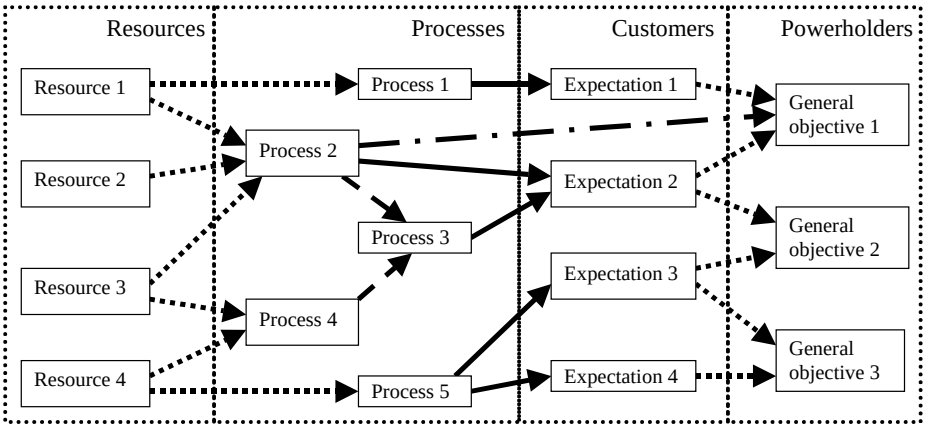


Figure 3. Strategic map.

The aim of this paper is how to deal with the strategic map and performance indicators (Kaplan and Norton, 2004). In fact, the easy part of the strategic planning is to elaborate the diagnostic and to define the objectives of the strategy, the great task is how to detail the strategy and implement it. As a consequence, the great majority of the firms fail in performing this stage of the process. On the other hand, some authors criticize BSC model for the multiplicity of performance indicators that can lead a lack of focus (Banker *et al*, 2004).

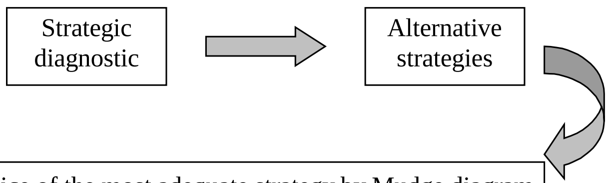
These same authors say that these problems come from the difficulty in identifying priorities and the cause and consequence relations that are present in the strategic map. In this paper, we complement our model (Pureza and Dalla Valentina, 2006) with a procedure for the construction of the strategic map, the choice of performance indicators and targets for the strategy.

2. STRATEGIC MAP AND PERFORMANCE INDICATORS

The definition of the strategy comes from the analysis of the strategic diagnostic, with the identification of alternative strategies for the firm. At this moment start the analysis that will be completed with the strategic map. In fact, this decision must be based in a rational and detailed evaluation of the firm and the environment, at the present and in the future. Some firms tend to overestimate the powerholders expectations and underestimate the restrictions related to the processes and resources perspectives. Other firms do not take into account the dynamics of their specific market and overestimate the return to the investments. There are many other situations where the problems come from the lack of consistency in the analysis to be done at the definition of the strategy.

This choice can be done through the application of the Mudge technique (Mudge, 1989). The execution team identifies for each alternative strategy the objectives to be reached and actions to be performed. Then, each member of the conduction team compares these possibilities by filling a table like the one in Fig. 4 in terms of (Ansoff, 1977):

- Attractiveness versus competition in target markets;
- Short term and long term results;
- Risk analysis;
- Necessity versus availability of resources;
- Synergy with the present situation.



Choice of the most adequate strategy by Mudge diagram

Actions / objetives	Market attractiveness	Competition	Time for results	Human resources	....	Total
	ω_1 = ...	ω_2 = ...	ω_3 = ...	ω_4 = ...	....	
....	P_1 = ...	P_2 = ...	P_3 = ...	P_4 = ...	....	$\Sigma P_i\omega_i$
....	P_1 = ...	P_2 = ...	P_3 = ...	P_4 = ...	....	$\Sigma P_i\omega_i$
....	P_1 = ...	P_2 = ...	P_3 = ...	P_4 = ...	....	$\Sigma P_i\omega_i$
....	P_1 = ...	P_2 = ...	P_3 = ...	P_4 = ...	....	$\Sigma P_i\omega_i$
....	P_1 = ...	P_2 = ...	P_3 = ...	P_4 = ...	....	$\Sigma P_i\omega_i$

Figure 4. Definition of the strategy.

The next step is to adjust the objectives to the resources and the environment, with the definition of priorities, the actions to be performed and its chronogram. The main product of this work is the strategic map (Edvinsson and Malone, 1997 and Kaplan and Norton, 2004) that indicates, for each perspective, the elements that characterize the strategy and the cause and consequence relations that link them (see Fig. 3).

The construction of the strategic map begins with the indication of the main objectives of the strategy at the powerholders perspective level. Probably, some of these objectives are linked by cause and consequence relationships that are identified in the map by arrows (see Fig. 3). Following the usual BSC approach, the next perspective indicates the expectations of the clients, which must be satisfied to achieve the objectives of the strategy, and the links that exist

among these expectations and the objectives. The process continues with the other two perspectives, identifying the critical processes and necessary resources, as well as the links (cause and consequence relations) that exist among the elements of the map.

The perspectives, its elements and links constitute the structure of steps of the strategic plan that gives dynamics to the process and the targets to be pursued at each level of the map. For example, be an objective of the strategic plan to increase the market share of the firm (powerholders perspective), to be achieved after reducing the prices of some products (customers perspective). It is the consequence of improvement in productivity (processes perspective) after some investments in equipment and qualification of the employees (resources perspective). It is straightforward the identification of some targets (performance indicators) like market share, relative price reduction, global productivity, capacity of production and productivity per employee.

The definition of a small but representative set of performance indicators can be done through the application of the Mudge technique (Mudge, 1989). The execution team identifies a large set of indicators and compares them in terms of the following criteria:

- Impact on the others indicators;
- Relevance for the final objectives;
- Difficulty in the evaluation;
- Possibility of benchmarking.

The diagram is shown in Tab. 1: the capital letters at the rows 'i' and columns 'j' represent the indicators under analysis and the symbols of the intersections 'ij' indicate which indicator is more relevant.

Table 1. Mudge diagram.

A	**B**	**C**	**D**	**E**	**F**	**G**	**Total**
A	A_2	0	D_1	A_2	F_4	A_3	7
	B	C_2	D_3	C_2	F_2	0	0
		C	D_1	E_1	0	C_2	4
			D	D_2	D_1	D_4	12
				E	F_3	0	1
					F	F_3	8
						G	0

For example, considering that all criteria have the same status and, if the indicator D dominates B by three criteria and they are equivalent according to the last one, the result would be represented by the symbol D_3 (see Tab. 1) placed at the BD-intersection. At last, the last column indicates the sum of the symbols' indexes. These values indicate the importance of each indicator according to these criteria.

This analysis may include other decision techniques for the comparison between performance indicators. Causal diagrams (Maruyama, 1963) may generate an interesting procedure to measure the extension of the cause and effect relationships among the elements of the strategy and the indicators. As an example, Fig. 5 exposes these relations for a set of public health services indicators.

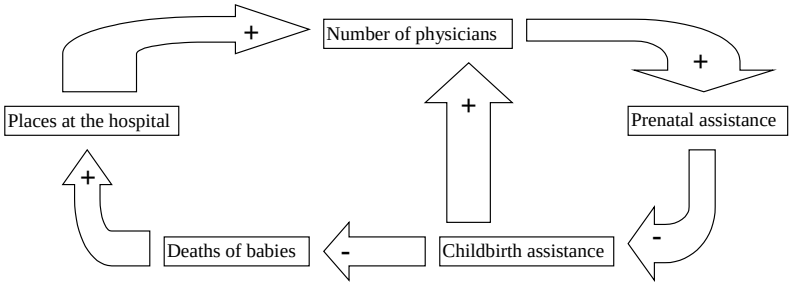


Figure 5. Example of causal diagram in health services (Bortolanza, 2005).

There, the arrows indicate if there is a causality relation between two indicators while the indexes '+' and '-' indicate if it is a reinforcement or an opposition relation. The analysis of the causal diagram may provide a measure of the degree of relevance of the indicators.

However, at the end of the process, there will be a relative importance weight for each indicator. Moreover, the conduction team will reduce the set by eliminating the less relevant indicators. In the example shown in Tab. 1, the indicators D, F and A should be maintained at the expense of the others.

3. STRATEGIC PLANNING AND DATA ENVELOPMENT ANALYSIS (DEA)

Now, once it is necessary to indicate reasonable targets, taking into account the relationships among the indicators and the present numbers achieved by the firm and the competence.

The data envelopment analysis (DEA) is a non-parametric technique that makes use of linear programming to construct efficiency frontiers for a set of production units with similar technological processes (Coelli *et al*, 1998). These frontiers allow the evaluation of the relative efficiency of the units and determine efficiency goals. The measures of total productivity for a unit with outputs P_i and inputs R_j is given by:

$$PT = \frac{\sum_i \rho_i P_i}{\sum_j \rho_j R_j} \tag{1}$$

where ρ_m is the weight of the output P_m or input R_m and represents its utility relative to the others outputs or inputs. Now, for a set of production units with similar technological processes, these values allow the identification of efficient units that are placed at the frontier of production and a measure of inefficiency for the others.

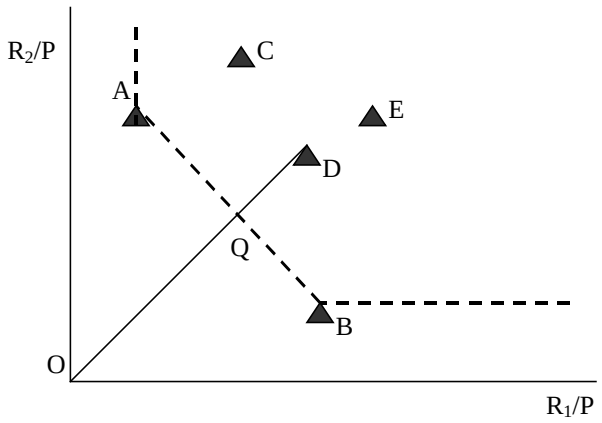


Figure 6. Efficiency map.

A simplified situation is shown in Fig. 6 and considers five firms (A, B, C, D and E) that use only two inputs (R_1 and R_2) to produce a single output (P) under the assumption of constant returns of scale (Coelli *et al*, 1998). The dotted line is the frontier of production with the efficient units (firms A and B) while the others are placed in the region above and to the right of the line. On the other hand, the relative inefficiency of the firm D under consideration is given in terms of the distances OD and OQ,

$$TE_P = \frac{OQ}{OD} \tag{2}$$

In the case of several inputs and outputs, one deals with an n-dimensional space and the data envelopment analysis allows the identification of the frontier of production, relative inefficiencies, as well as efficient targets for the firm under consideration.

This approach can be used to evaluate the global performance of the firm in comparison with the competence. Then, there is only one set, $\{\eta_k, k=1,\ldots m\}$, of the measures that identify each individual performance indicator and the global performance can be obtained, by using a set of relative importance weights $\{\rho_k, k=1,\ldots m\}$ with the data obtained by the Mudge technique,

$$\eta_g = \sum_k \rho_k \eta_k \tag{3}$$

It must be emphasized that the indicators are not independent. Their metrics are not contemporaneously congruent, so actions to improve an indicator may imply a corresponding decline to other ones (Banker *et al*, 2004). In this sense, DEA is a convenient tool to deal with this problem, exposing the tradeoffs among the indicators and identifying the frontier of performance. For instance, be a set of N firms and R performance indicators η_{rj} (r = 1, 2,…R and j = 1,2,…N), the BCC model of DEA (Banker, 1993) allows one to obtain the position of the firm j under consideration relative to the frontier of performance.

The solution of this linear programming problem is the optimal weights that characterize the situation of the firm j relative to the frontier of performance (the coefficient θ_j) in terms of the convenient set of the firms placed on the frontier (the coefficients λ_k).

$$
\begin{aligned}
&\hat{\theta}_j = Max(\theta) \\
&\sum_{k=1}^{N} \lambda_k \eta_{rk} \geq \theta \eta_{rj} \qquad \forall r = 1..., R \\
&\sum_{k=1}^{N} \lambda_k = 1 \\
&\theta, \lambda_k \geq 0 \qquad \forall r = 1,....., R \\
&\lambda_k \Big/ \lambda_{\min} \geq C_k \Big/ C_{\min} \qquad C_{\min} = \min(C_k) \qquad k = 1,....., N
\end{aligned}
\tag{4}
$$

where Ck is the relative importance weight of the indicator k obtained by Mudge technique. With this information it is possible to choose the targets for the firm under consideration, which will be placed at the performance frontier, taking into account the objectives of the specific strategy of the firm under consideration.

Figure 7 clarifies this point with a simplified situation with only two indicators. For the firm 'P' under consideration, the indicator 1 summed twelve in the Mudge diagram analysis and the indicator 2, only four and the target to be chosen will reflect it. Now, considering three possible strategies with corresponding goals, represented in the map by the letters 'X', 'Y' and 'Z', it is evident that target 'Y' is a more convenient than targets 'X' and 'Z'.

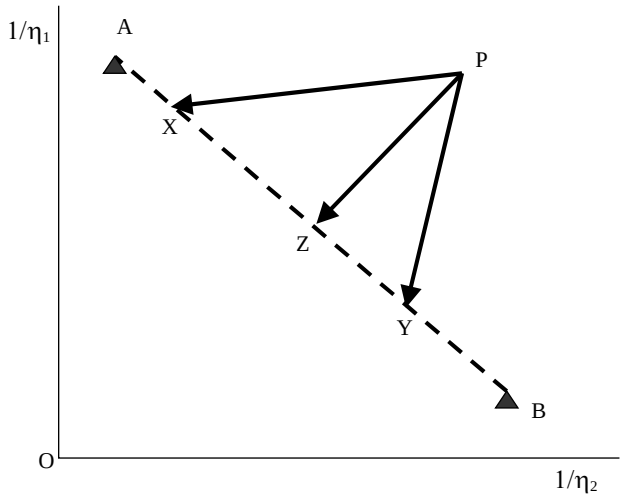


Figure 7. Choice of the target.

The execution team is responsible for all this technical analysis that includes the following items:

- Construction of the strategic map (after the formulation of the strategy and its objectives);
- Identification of the larger set of performance indicators;
- Construction of the Mudge diagram and valuation of the indicators;
- Evaluation of performance measures for the firm under consideration and the others firms;
- Construction of the performance map using data envelopment analysis;
- Identification of the possible targets for the firm.

On the other hand, the conduction team is responsible for the strategic decisions:

- Choice of the final set of performance indicators;
- Choice of the targets for the firm.

3. FINAL CONSIDERATIONS

In this work, we detail some fundamental aspects of the balanced scorecard model proposed in a previous work and analyzed some essential aspects of the implementation of a strategic planning. It is emphasized the importance of a detailed strategic disgnostic in such a way to perform a careful and responsible choice of the strategy and to identify the importance of each aspect of the plan in terms of the objectives of the strategy.

We complement our BSC model by proposing some procedures for the choice of the strategy among some alternatives, the identification of the set of performance indicators and the targets to be pursued by the firm. Moreover, the DEA approach allows the evaluation of the global performance of the firm, in comparison with the competence.

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