# Building "dynamic" balanced scorecards to enhance strategy design and planning in public utilities: key-findings from a project in a city water company

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# Building "dynamic" balanced scorecards to enhance strategy design and planning in public utilities: key-findings from a project in a city water company

Carmine Bianchi y Giovan Battista Montemaggiore *

*Resumen / Abstract*
Increasing complexity and uncertainty of both business internal and external variables determines a growing need for prompt and accurate information. On this concern, in the last decade, there has been an increasing effort to provide public utilities with tools aimed to support decision makers in planning and control, by taking into account not only operational but also strategic issues. Among them, for instance, customer satisfaction, internal business process efficiency, business image, and bargaining power against other counterparts (e.g. the municipal administration). Often, however, such an effort has been oriented to generate a large volume of data, only focused on financial indicators and on a static view of the relevant system. This article shows how the use of Balanced Scorecards based on System Dynamics models can significantly improve the planning process in a strategic learning perspective. Empirical findings from a research project conducted in a municipal water company are analysed and discussed

Key-words: System Dynamics simulation models – Performance measurement – Strategic Resource analysis – Public Administration Management – 'Dynamic' Balanced Scorecards

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## The rising dynamic complexity in public utility management and the need of innovation in planning & control systems

In order to improve efficiency in public utility management, in the past decade Governments have been undertaking privatization policies. Higher competition and decentralized decision making were expected to result into greater accountability and performance.

However, this transformation of the public utility sector has sensibly increased managerial complexity. In fact, since local governments tend to maintain control over company equity, they have to run competitive firms by simultaneously playing the roles of owner, ruler, budget designer and social service provider (Horváth and Gábor, 2001).

In particular, because of the regulations required by the social relevance of public utility services, management is subject to several limitations in the use of policy levers. Dynamic complexity of management tasks has also been dramatically increased by the fast technological evolution and the rising concern on environmental and social issues, which have led to rapid changes in regulations.

Another important complexity factor in such a peculiar environment is related to the wide range of stakeholders who play an active role in the legislative and policy making process. Regulatory agencies, local government associations, representatives of the professional and business community, and consumer protection agencies may take part in the formulation of company policies. This increases the effort the management has to make in order to balance the different interests that public utilities have to satisfy.

Therefore, to pursue competitiveness, financial stability, and to meet different social needs at the same time, public utility managers need proper strategy design and planning tools that allow them to take into consideration both stakeholders' expectations and the sustainability of company policies.

To this end, traditional planning and control systems exclusively based on financial indicators are insufficient to communicate to shareholders and other stakeholders the value creation process the management wants to foster through the designed strategy (Neely et al., 2003). As a matter of fact, if not accompanied by other indicators, financial measures do not provide an accurate picture of the company's direction and, hence, can lead the management to seek short-term goals rather than long-term growth.

For instance, managers may be reluctant to invest in intangible assets in order to avoid reductions of current financial results (Norreklit, 2000). In the long term, however, such a policy may imply lower efficiency and effectiveness, as well as customers and other stakeholders' dissatisfaction.

Another drawback in the use of only financial indicators is associated to the difficulty to measure non-monetary goals. This may hinder communication of companies' strategy to managers and employees at different levels of the organization hierarchy, and generate incongruence between strategic decisions and daily operations.

For the above reasons, there has been a growing effort to provide public utilities with tools aimed to support decision makers in planning and control, by taking into account not only financial indicators but also intangible variables (e.g., such as customer satisfaction, business image, and bargaining power against other counterparts), and their dynamic interdependencies. Therefore, more relevant, selective and systemic reporting systems are needed.

Although the availability of such information might appear as an easy task today, in the information age, planning & control tools are often characterized by an access to a great volume of analytic data, which actually overload the decision making process (Todd and Palmer, 2001).

A proper planning and control system design implies, on the contrary, a focus on the key-indicators of companies' efficiency and effectiveness, and on their dynamic interdependencies.

This article aims to offer an empirical evidence of the greater benefits public utility management can obtain by integrating the Balanced Scorecard (BSC) approach to performance measurement with the System

Dynamics (SD) methodology in the analysis of cause-and-effect relationships between key-variables of the company system.

With this purpose, a case study, based on a research project with a city water company, will be analyzed and commented.

## Formulating public utilities' strategy through a balanced scorecard approach

Since its introduction in 1992 (Kaplan and Norton, 1992), the use of BSC has been widely spreading among private and public companies, as a performance measurement system enabling managers to translate strategy into a correlated set of performance indicators from different business perspectives.

Differently from traditional performance measurement systems, the BSC considers both financial and non financial performance, through a balanced set of lead and lag indicators (Kaplan and Norton, 1996a) so that companies can simultaneously evaluate the achieved results and their progresses towards the implementation of a strategy in core business areas.

According to Kaplan and Norton, the BSC enables companies to measure financial results while simultaneously monitoring progress in building capabilities and acquiring the intangible assets they need for future growth (Kaplan and Norton, 1996b). Therefore, they explicitly recognize the BSC as a strategic tool for the control of both lag and lead indicators (Norton, 2001).

The increasing popularity of the BSC is due to the support it gives to the management in avoiding disconnections between strategy and implementation.

The BSC also stresses the idea of cause and effect relationships between measures in order to avoid that performance improvement in one area may be at the expense of performance in other areas. Kaplan and Norton, indeed, explicitly stated the systemic inter-relationships within and between four key-perspectives (financial, customer, internal processes, learning and growth), incorporating both lead and lag indicators, which impact on organizational performance. The alignment of the strategy throughout the

company, in fact, is the result of the causal linkages between the objectives in all the four perspectives.

Precisely, this approach is aimed to offer a systematic and comprehensive road map for organizations to follow in translating their mission statements into a coherent set of performance measures. These measures are not only intended to control company performances, but also to articulate and communicate the organization's strategy and to help align actions from different levels of management for the achievement of a common goal.

Furthermore, the BSC enhances managers' understanding of strategies and stimulates the creation of a common company vision. The BSC, indeed, forces managers to elicit, compare and discuss their implicit assumptions and beliefs and to articulate them for the formulation of company's strategy. Managers, in fact, are requested to contribute to the implementation of the BSC by identifying a set of objectives that are connected by causal relationships, which are consistent with the vision and mission of the company.

The BSC has been adopted by various public utilities in different sectors, such as electricity provision (Kaplan and Norton, 1996b), (Morisawa, 2002), (Niven, 1999), telecommunication (Zingales and Hokerts, 2002) and transportation (Olve et al., 2004). Also in the water management sector there are a few applications of BSCs. For example, the City of Eugene's Wastewater Division (a section of the Oregon Public Works Department responsible for the wastewater treatment service) and the Charleston CPW (a municipal corporation that provides both water and wastewater treatment services to the City of Charleston) developed a BSC to include in their performance measurement system other management areas that were not covered by their environmental management system, such as the financial perspective [1]. The BSC approach helped these companies to set objectives and performance measures that, while not important from an environmental point of view, were relevant from the corporate management perspective. As a result, these companies could utilize this holistic approach to balance

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[1]  Continual improvement in utility management: a framework for integration - http://asp1.walkontheweb.com/ctwater/ctwater_news_more.asp?id=9131.

the costs of new capital investments with the benefits of meeting environmental goals. Another example of application of the BSC to the water management sector is provided by Metrowater (the Auckland City's water and wastewater utility), which used the BSC as a platform to measure the company's progress towards company objectives [2]. This approach helped Metrowater to implement a comprehensive benchmarking against other utility companies in order to identify opportunities to become more efficient. Finally, the Water Utility Enterprise (Santa Clara Valley Water District) [3] and the Sydney Water Corporation [4] (a water utility that runs drinking water and wastewater treatment services in the Sydney Region) used the BSC approach to design their business plan including key objectives and targets from different managerial perspectives for all division levels.

In particular, the adoption of such a strategic performance measurement system supports public utilities in (Bracegirdle, 2003):

− providing both public accountability to local governments and citizens and internal accountability between the different levels of management;

− improving performance in terms of quality, quantity, and costs of the services through better strategic planning;

− determining expenditure, by allocating budget resources to measurable results that reflect agreed priorities.

The translation of the company strategy into a causal map of financial and non-financial indicators required by the BSC makes this approach particularly valuable for public utilities to align the often conflicting objectives of the relevant number of shareholders and other stakeholders involved in public utilities' policy making processes. In fact, more than other private companies, public utilities need a high level of consensus from local authorities and citizens before implementing a designed strategy. With this regard, the causal tree including the objectives in all the business

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[2]   Metrowater's Water Asset Management Plan 2004 -
http://www.metrowater.co.nz/pdfs/amp_water(2004).pdf.
[3]   Water Utility Enterprise's Annual Business Plan Fiscal Year 2005 -
http://www.valleywater.org/media/pdf/FY05%20WUE%20ABP%20Final.pdf.
[4]   Continual improvement in utility management: a framework for integration -
http://asp1.walkontheweb.com/ctwater/ctwater_news_more.asp?id=9131.

perspectives is a powerful communication tool for the management to clarify to different key-actors how the company intends to achieve higher performance. A clear statement of the company strategy through the BSC map may enhance cohesion among shareholders and other stakeholders and help management to explain them how some of their goals may conflict with the company overall strategy.

Moreover, BSC can help public utilities in simultaneously evaluating the achieved results and their progresses towards long-term value creation. Indeed, public utilities generally cannot use the service tariff as a policy lever. Most of the service contracts between the local government and the public utility contain a quite detailed description of the required service quality. Consequently, the search for higher financial results usually leads to cost-cutting activity.

However, the cost reduction activity may affect long-term investment, such as personnel training, equipment maintenance, information system implementation. Such a policy can improve short-term financial indicators at the expense of long-term performance drivers. Therefore, the balance between lag and lead indicators required by the BSC approach can help public utilities to avoid that cost-cutting activities hinder future growth.

The BSC is also a valid tool to foster a cultural change in the management of the company at different levels of the organization. Despite the privatization process, most of the public utilities are still experiencing relevant difficulties in shifting their culture from state company to private company. Aligning the reward system to the objectives included in the BSC helps employees to address their efforts towards company success, generating greater commitment and consensus around business strategies.

## "Dynamic" balanced scorecards to enhance strategy design and planning

In spite of its widely recognized advantages, the BSC presents some conceptual and structural shortcomings.

First of all, different scholars have remarked that the BSC is a static approach (Sloper et al., 1999). The links among the parameters inside the

four perspectives do not express their dynamic relationships. As a result, in the analysis of the strategy, delays between actions and their effects on the system are ignored.

Moreover, these relationships follow an open-loop logic and, hence, they do not consider feedbacks (Linard and Dvorsky, 2001). Although Norton and Kaplan stress the importance of feedback relationships between scorecard variables to describe the trajectory of the strategy, the cause and effect chain is always conceived as a bottom-up causality, which totally ignores feedbacks, where only the variables in the lower perspectives affect the variables in the upper perspectives.

In addition, the BSC approach does not help policy makers in understanding whether a given performance measure ought to be considered as an outcome (or lag) indicator or as a driver (or lead) indicator. Furthermore, it does not support organizations in understanding how to affect performance drivers, which in turn will influence the outcome indicators.

In particular, the BSC approach does not provide any methodology to understand:

1. how performance drivers affect outcome indicators;
2. how performance drivers' dynamics derive from strategic assets' accumulation and depletion processes triggered by the use of different policy levers;
3. how results measured by outcome indicators will provide business decision makers new resources to reinvest in building a consistent set of strategic assets.

The validity of BSC's assumptions about causal relationships between the included performance measures has been also questioned by the literature. In particular, it has been demonstrated that the hypothesized links between quality and financial indicators may be not confirmed in reality. For instance, it has been remarked that the commonly assumed causal relationship according to which a higher customer satisfaction leads to higher financial results may not have any empirical evidence (Norreklit, 2000). On the contrary, it may happen that the costs of policies aimed to

increase customer satisfaction are higher than the related benefits, both in the short and long term. For such reason, the lack of rigorous validation of the BSC's assumptions may lead the management to the selection of faulty performance indicators, which imply dysfunctional organizational behavior and sub-optimize results.

In addition, the BSC does not contain an exhaustive description of the system where managers operate. In fact, often in strategy design some important factors (e.g. competitors' reactions, technological innovations, shipping delays, labor shortages, rising material prices) are not considered. Managers can better handle their occurrences if they determine in advance which risks can undermine their plans, what should be monitored to provide early warning of each risk, and the best response to such latent circumstances.

Furthermore, the analysis of company strategy based on the BSC approach considers the causal relationships between performance variables only in qualitative terms. This implies that managers should rely on mental simulations and heuristics in order to quantify the results of their strategy and, hence, evaluate its efficiency and effectiveness. This task is even tougher when the company system is characterized by a high degree of complexity, non-linear relationships among variables, and delays between causes and effects. Indeed, Linard and Dvorsky (2001) report that many studies in SD, as well as in economics and psychology, suggest that managers have great difficulty in dealing with dynamically complex tasks. Even a detailed causal loop analysis of the links between performance variables provides little help in predicting the complex interaction between multiple feedback loops. This often requires the use of simulation models.

For these reasons, the BSC offers little help in understanding and solving problematic behaviors of the key-variables. Also Kaplan and Norton warn managers that the BSC, though correctly implemented in terms of balance between lead and lag indicators and causal relationships, does not point out whether (Kaplan and Norton, 1996b):

- the vision is wrong;
- the model is not a valid description of the strategy;

- the performance indicators are incorrect.

Linard et al. (2002) also assert that, in practice, BSC fails in translating companies' strategy into a coherent set of measures and objectives because of the "lack of a rigorous methodology for selecting the metrics and for establishing the relationship between the metrics and the corporate strategy".

In consideration of the above mentioned flaws in the BSC approach, it is evident the need of managers for a strategic decision support tool that enables them to cope with dynamically complex systems. Kaplan and Norton explicitly recognized that embodying BSC into SD models might satisfy such a need. In fact, they remarked:

"The BSC can be captured in a SD model that provides a comprehensive, quantified model of a business's creation value process" (Kaplan and Norton, 1996a);

"Dynamic Systems Simulation would be the ultimate expression of an organization's strategy and the perfect foundation for a Balanced Scorecard" (Norton, 2000).

The SD approach enables the creation of interactive learning environments (ILEs) which can help managers to understand the dynamic relationships between performance variables included in the BSC.

The elicitation of the causal chain between performance drivers and outcomes enhances the managers learning process and, thus, their ability to comprehend how different strategies might affect organization performance.

SD models offer managers a virtual world where they can test their hypotheses and evaluate the possible effects of their strategies without bearing the costs and risks of experimenting with them in the real world. They provide low-cost laboratories for learning (Sterman, 2000), where:

− time and space can be compressed or dilated;

− actions can be repeated under the same or different conditions;

− dangerous, infeasible or unethical strategies can be experimented in safe conditions;

- the information delays of feedbacks from the adopted decision are extremely reduced.

Through simulations the story of the strategy can be experienced rather than just passively absorbed (Richmond, 2001).

The advantages related to the use of SD modeling to implement the BSC approach have been particularly emphasized by Loomis Ritchie-Dunham (Ritchie-Dunham, 2001). Based on a field research conducted on two telecommunication firms, a SD model was developed by the author to portray BSC indicators. The model was used to conduct a simulation experiment with 118 MBA students, who virtually run the firm for seven simulated years. The scorecard and the enterprise system were varied between subjects in the experiment in order to test the following research hypotheses:

- the number of stakeholders in the scorecard positively influences the number of stakeholders in decision makers' mental models;

- scorecard similarity positively influences mental model similarity;

- information consistency positively influences mental model similarity;

- the number of stakeholders in decision makers' mental model negatively influences total value created;

- mental model similarity positively influences total value created.

Simulation experiments allowed the project team to validate the above hypotheses.

We believe that public utilities can successfully apply the SD approach in the formulation of BSCs for:

- assessing company's strategy and vision and their coherences in order to detect potential side effects;

- validating the causal map representing company's strategy against reality;

- filtering performance measures in order to select the smallest number of proper indicators of company's progress towards strategic goals;

- simulating the effect of performance drivers on financial and non-financial outcomes in order to detect the most opportune policy levers;

- implementing what if analysis to learn about potential future scenarios and threats.

The use of simulation results increases the communication power of the BSC, further supporting public utilities in clarifying the strategy to different counterparts, enhancing social actors' cohesion and balancing conflicting goals coherently with company growth sustainability.

In order to demonstrate the above assumptions, the next sections of this article will show results form an applied research project, which was focused on the creation and use of a SD model supporting a BSC to foster strategic decisions in a public utility company.

## An application of dynamic balanced scorecard to public utilities: the case of AMAP

In the last section benefits related to the adoption of the Dynamic Balanced Scorecard (DBSC) have been shown. In order to provide empirical evidence of this concept, an analysis of a DBSC application to a municipal water company (AMAP) will be developed in the next sections of this article.

AMAP has been running the municipal water provisioning and distribution service for the area of Palermo since 1950.

With the intent to foster public utility efficiency and effectiveness, in the last decade the Italian Government implemented a set of reforms. In particular, in 1994 the management of water resources was reorganized in order to avoid waste and to improve the quality of the service provided to citizens–customers.

Government regulations have been merging the sewer and wastewater treatment management with city water provisioning and distribution management, making all the municipal water service companies handling the so called integrated water cycle. In addition to this business re-engineering process, the regulator introduced competition for the management of the water service that led to a privatization process, which implied the transformation of all the Italian city water companies from public agencies to joint stock companies. In this new scenario, the regulator

assigns the water management service for a specific area to the company with the highest effectiveness, in terms of service quality, and with the best efficiency, in terms of service costs.

With the aim to increase AMAP's competitiveness and to foster a deep cultural change, a research project was started by the authors with AMAP managers. A SD simulation model was built in order to support performance measurement and improvement, according to a BSC approach. By a deep involvement of AMAP's key-managers in the modeling process, the research team identified main performance variables and policy levers, and the system structure describing their causal relationships.

In the following sections we will describe the DBSC model building process carried out at AMAP, and the related benefits on the strategic decision making process.

## Implementing the dynamic balanced scorecard at AMAP

The changes in the water provision service above illustrated made AMAP perceive the need to improve its performance in terms of both financial outcomes and quality of the service supplied to customers. However, it was lacking a shared vision of the company's mission as well as a coherent strategy for its accomplishment. Furthermore, the communication between the different levels of the organization was almost absent and just a few of the middle managers and line workers were aware of the company's overall performance.

In particular, AMAP presented some of the dysfunctional behaviors reported by Linard (1996):

- negative operating incomes were balanced by public contributions, whose volume was depending on the political power of the Board of Directors;
- managers focused on specific tasks and most of them were unaware of how their activity was contributing to company's results;

- the management information system was characterized by the production of a number of reports that were mainly responding to bureaucratic routines, instead of strategic information needs;
- evaluation programs were perceived as a "weapon", by which managers could be blamed for bad performance, rather than as a tool to enhance managers' efficiency.

In order to create a shared vision of business strategy, to stimulate communication among managers, and to avoid strategy disconnections among the different levels of the organizations, the project team proposed to the Board of Directors the implementation of a DBSC. The Board organized a number of meetings with top and middle managers with the purpose to design an information system that could be used to monitor business units' performance. The final result was a long list of activity indicators, included in an about 40-pages long report. Neither a common strategy was designed nor causal linkages were connecting these activity measures.

In order to translate the produced list of indicators into a BSC map, the project team conducted several interviews with AMAP's key-managers at different levels of the organization. These interviews allowed the project team to elicit managers' tacit knowledge about internal business processes and causal relationships between available policy levers, performance drivers (lead indicators) and financial and qualitative outcomes (lag indicators).

Based on this initial analysis and on the list of indicators produced by company's managers, a SD model was built to study the effect of planned strategies on company's performance and to select proper measures to be monitored in order to assess company's progress towards the designed strategic goals. After validating the SD model capability to replicate the company's past performances, we built a BSC including the selected performance indicators in four key-perspectives according to their causal linkages.

The project lasted 12 months, four of which were devoted to qualitative modeling; six months were needed to build the SD simulation model

embodying a BSC, and the remaining two months were allocated to apply the DBSC to the company's planning & control processes.

As it can be read from Figure 1, AMAP's proposed strategy mainly consisted in improving the company image by higher efficiency and effectiveness in the provision of the water in order to increase its competitiveness for the management of the integrated water service in the area of Palermo. According to managers' mental models, such goal could have been achieved by increasing the availability of the water sources and, hence, the volume of water distributed to households. In fact, an increase in the volume of distributed water would have both improved customer satisfaction and financial results, through higher revenues and lower unit costs (since the overhead costs would have been spread on a larger volume of supplied water). The improvement of customer satisfaction, by a better service, and of shareholder satisfaction, by higher financial results, would have led to enhanced company image.
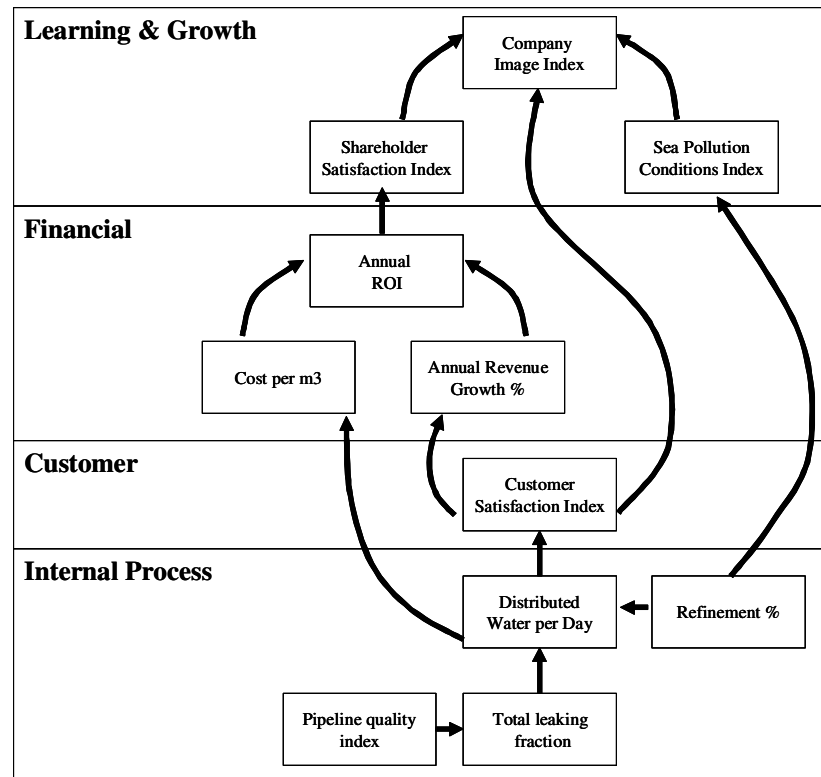


Figure 1. AMAP's Traditional Performance Measures BSC Chart

For this reason, a great deal of efforts was devoted to the search for new sources and to the acquisition of the right to exploit a larger percentage of the existing sources (all the lakes are shared among AMAP and other water management companies or hydroelectric companies). With this purpose, AMAP was evaluating the opportunity to invest in the construction of a refinement plant for the treatment of wastewater. Basically, in the refinement plant, the sewage collected is subjected to a specific purification process so that it can be used for agricultural purposes. Because of this investment, AMAP could have distributed the refined wastewater to farmers, thereby increasing the volume of drinkable water distributed to households.

Furthermore, according to the company management, the refinement of the wastewater would have improved sea pollution conditions. The planned investment, therefore, would have given evidence of the company's commitment for the cleanness of the seashore and, hence, for the improvement of the life quality of the served community. This, in turn, would have further enhanced the company image and, hence, its advantage on other potential competitors in the management of the integrated water service in the area of Palermo.

However, a relevant problem AMAP also had to face was the high leaking rate of its pipelines. In fact, it was necessary to improve the quality of pipelines by replacing the quite old existing distribution network. The obsolescence of AMAP's pipelines determined a high rate of leakage, which sensibly reduced the volume of water distributed to households. This phenomenon on the one hand contributed to customer dissatisfaction, and on the other hand further worsened the efficiency of the distribution process and, hence, company financial results.

Figure 1 shows AMAP's main objectives included in a BSC chart. As the reader can notice, differently from Kaplan and Norton's proposed scheme, the "learning and growth" perspective is at the top of AMAP's BSC diagram. Indeed, the company image index can be considered as an indicator of AMAP's capacity to learn how to combine conflicting shareholders, customers and local community's objectives in order to create

synergies that are necessary for the company' growth. Notwithstanding, AMAP's performance indicators are linked according to the bottom-up approach generally adopted in the implementation of the BSC.

However, as already discussed, such an approach is not sufficient to figure out neither the strategic resources to build, nor the processes through which they will interact to affect company performance.

In AMAP, for example, it was clear that the refinement policy would have led to a greater volume of distributed water and to lower sea pollution and, hence, to higher customers and community's satisfaction and, eventually, company image. Nevertheless, the management was still evaluating the adoption of this policy because of the high investment and production costs, which would have had a negative impact on company financial results, reducing shareholders' satisfaction and, consequently, the image of the company as an efficient administrator of the municipal water service. Therefore, the BSC chart portrayed in Figure 1 only suggested what policy levers the management should use, but not how and when the company should act on these policy levers to balance the conflicting objectives of both shareholders and customers and community.

## Turning the BSC chart into a causal loop diagram

Since the bottom-up causality depicted in Figure 1 does not take into consideration feedback loops between and within the four perspectives, the project team moved to a more detailed causal loop analysis, which evolved to the diagrams depicted in Figure 2-a and b.
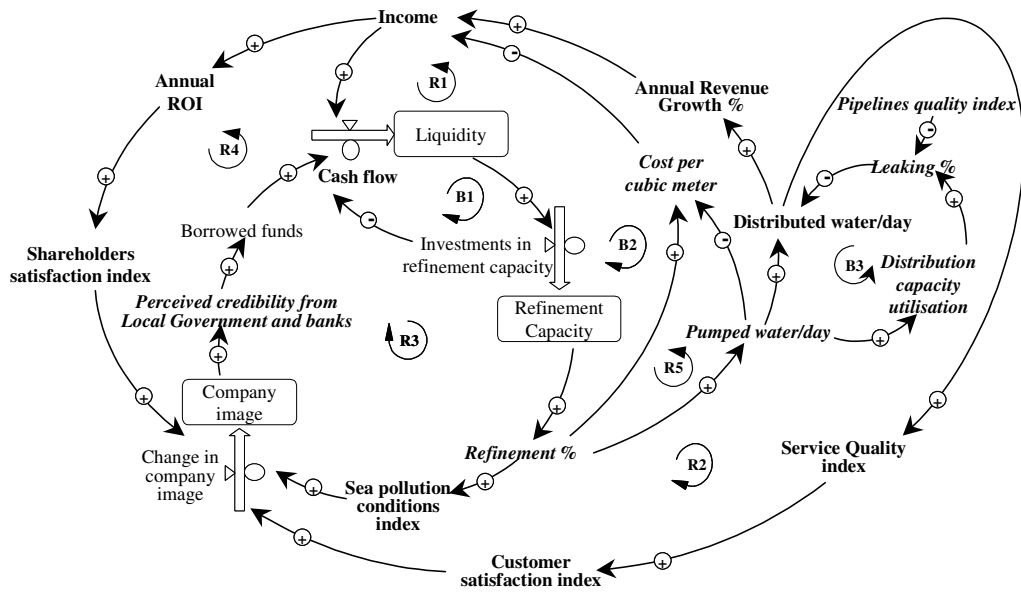
Figure 2-a. Refinement Capacity Policies

Figure 2-b. Distribution Capacity And Accounts Receivable Collection Policies

**LEGENDA:**

| | |
|---|---|
| (R) | = Reinforcing loop, whose dominance generates an exponential behaviour in affected variables |
| (B) | = Balancing loop, whose dominance generates a stabilising behaviour towards an equilibrium in affected variables |
| ▭ | = Strategic asset stock, available at a given time period |
| ⟹ | = Change (in-*or*-outflow) in strategic asset stock, occurring from a given time period to another |
| *Italic Bold Variables* | = Performance drivers, or *lead* indicators |
| **Bold Variables** | = Outcome, or *lag* indicators |

Figures 2-a and b. Main Causal Loop Diagrams From Group Model Building Sessions with AMAP Managers

The causal loop diagrams in Figure 2- a and b describe main cause-and-effect relationships between the key-variables of the business system. They show a number of reinforcing and balancing loops, whose dominance over

time, according to different scenarios, is likely to originate different effects in both company lead and lag indicators.

Such feedback loops depict the effects of policies affecting the dynamics of strategic resources, such as: refinement capacity, corporate image, liquidity, accounts receivable, workers.

The above strategic assets are modeled as stocks (or levels) of available tangible or intangible factors in a given time. Their dynamics depends on the value of corresponding in-and-outflows.

Such flows are modeled as 'valves' on which decision makers can act through their policies, in order to influence the dynamics of each strategic asset, and therefore – through them – business performance drivers and outcome indicators.

In particular, Figure 2-a shows a number of feedback loops associated to refinement capacity policies, while Figure 2-b depicts feedback loops related to distribution capacity and accounts receivable collection policies.

According to the loop R1 in Figure 2-a, investments in refinement capacity would enable the company to pump (performance driver) and distribute more water to households (outcome indicator). This would result in higher revenues (outcome indicator). An increase in the revenue growth percentage would lead to a higher income and – other conditions being equal – cash flows (outcome indicators). A higher cash flow will lead to a rise of available financial resources to reinvest in the acquisition of more refinement capacity.

Furthermore, the more water distributed to households, the higher the service quality and customer satisfaction (outcome indicators) will be. This will improve company image, which in turn will increase the perceived credibility of the firm in the financial market and towards the local Government (performance driver). A higher company credibility will allow business decision makers to better negotiate funds to borrow from different stakeholders, and therefore to increase cash flows to reinvest in refinement capacity (loop R2). Another effect of a higher refinement % (performance driver) associated to a refining investment policy is an improvement of sea

pollution conditions index [5] , leading to higher company image, a better credibility towards funders and higher cash flows available for more investments in refinement capacity, implying a further increase in the water refinement % (loop R3).

A higher volume of water distributed to households also implies – other things being equal – an increase in income and in the annual ROI, resulting in an improvement in shareholders satisfaction [6]. A higher shareholders satisfaction would increase company image and, again, the funds the firm can attain to finance its refinement policy (loop R4)

According to the loop R5, the larger the volume of distributed water, the bigger the basis upon which to spread overheads costs and, all other things being equal, the lower the water unit cost will be. The reduction of the cost per cubic meter of distributed water should increase the company's income and liquidity to reinvest for the refinement policy.

Figure 2-a also shows a number of balancing loops, whose dominance could undermine business growth and, if not promptly detected and properly counteracted, evolve into crisis.

Loop B1 shows how higher investments in refinement capacity imply a reduction in total company cash flows. This provides a possible limit to growth in the investment policy, if its returns from higher income and borrowed funds will not be able to provide higher cash flows.

The loop B2 describes how the increase of the wastewater refinement percentage would determine a rise of the cost per cubic meter of water (because of the additional variable costs of the refinement process).  A boost in water unit costs would negatively affect income. This could cause a reduction of the financial resources and, hence, would prevent the company from acquiring new refinement capacity.

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[5]   The sea pollution conditions were modeled as an index, i.e. as a function of a ratio between treated and refined wastewater (numerator) and total collected wastewater (denominator). Such an index represents another important outcome indicator portrayed in the model.
[6]   Shareholders satisfaction was modeled as an index, i.e. as a function of a ratio between the difference between the actual and desired dividends (numerator) and the desired dividends (denominator). Such an index represents another important outcome indicator portrayed in the model.

Furthermore, as shown in loop B3,  if the volume of pumped water grows faster than the distribution capacity, an increase in distribution capacity utilization would occur and, consequently, the leaking rate would be higher, negatively impacting on the quantity of water distributed to customers. In fact, the more water AMAP pumps through the pipelines, the higher is the pressure, and hence the greater is the volume of leaking through the holes, conjunctions, etc. As a consequence, the cost per cubic meter of water would be higher, reducing the financial results that could be invested in refinement capacity acquisition.

As referred in the last section of the paper, the high leaking rate was a major problem experienced by the firm. Figure 3 shows how leakages had been increasing from 1998 to 1999, though in this period the volume of counted water had been decreasing. The main reason of such an unintended phenomenon was identified, through the modeling sessions, into the bad pipeline quality, due to the high average age of the AMAP's water conducts: the older is a pipeline, the higher leaking will be.
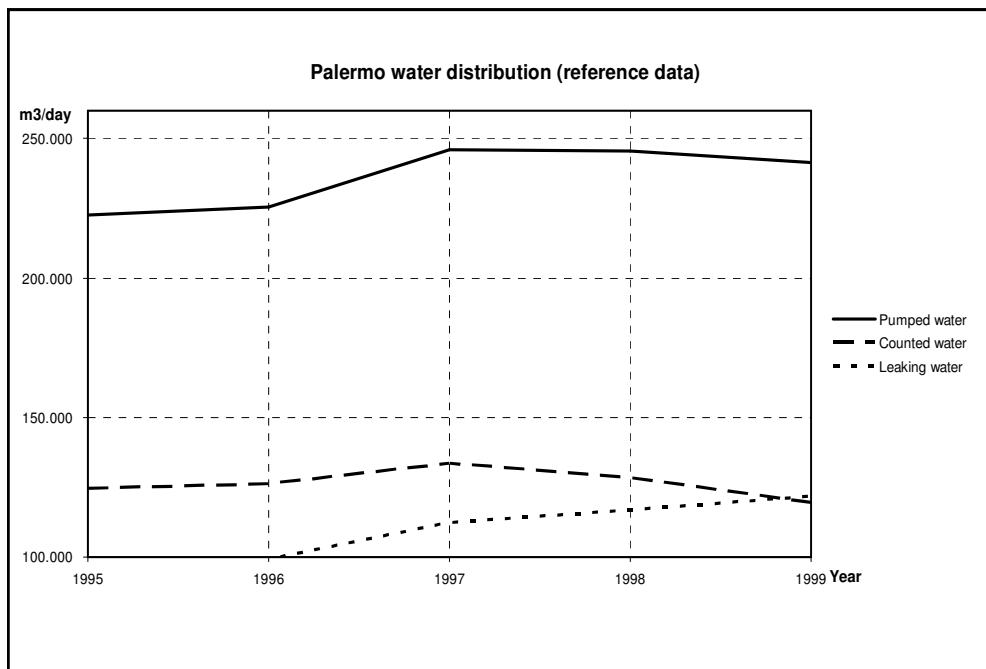


Figure 3. AMAP's Water Distribution Reference Behavior

While discussing the above problem in group model building sessions (Vennix, 1996), during which the causal maps reported in Figure 2 were sketched and shared with participants, the company management remarked that – in order to reduce the leaking rate and increase the volume of distributed water – AMAP had been undertaking a policy aimed to offset distribution capacity obsolescence outflows (see Figure 2-b). Such a policy would have increased the pipeline quality [7] , which would have implied a lower leaking rate. This would have lead to higher distributed water, increased revenues, income and – other things being equal – cash flows and liquidity to sustain further investments in distribution capacity (loop R6 in Figure 2-b).

Another reinforcing loop (R7) associated to distribution capacity investment policy is related to the allocation of more auxiliary workers to the repair of breakdowns in the distribution capacity system, caused by its obsolescence rate. As shown in Figure 2-b, the higher the number of auxiliary workers allocated to repairing tasks, the shorter the time to fix breakdowns will be. This will increase service and customer satisfaction, leading to higher company image and capability to negotiate funds to boost cash flows. Higher liquidity resulting from increased cash flows could be reinvested in hiring more auxiliary workers. A larger auxiliary workers staff will allow the firm to further reduce the time to fix breakdowns.

However, a trade-off problem may concern the allocation of auxiliary workers here. In fact, they could be also alternatively employed to suspend the service to those clients who delay the payment of their bills. As the company already experienced, after the suspension of the water provision, a large percentage of tardy customers are more inclined to be punctual in paying their debts, which on a side decreases the average days of sales outstanding (performance driver), and – on another side – has a positive influence on cash flows and liquidity available for further investments (loop R8).

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[7]  Pipeline quality was modeled as an index, i.e. as the complement to 1 of the weighted wear levels related to differently aged  pipelines. Each wear level could have a range value comprised between zero and 1. Such an index represents another important outcome indicator portrayed in the model.

Likewise commented about investments in refinement capacity, also in this case higher distribution capacity investments and auxiliary workers hiring rate imply a reduction in total company cash flows. This provides a possible limit to growth in the above investment policies, if their returns from higher income and borrowed funds will not be able to provide higher cash flows.

The analysis of the above feedback loops with company managers in a group model building context allowed the project team to obtain more insights compared to the traditional bottom-up approach of the BSC. Other lead and lag indicators were identified and, then, monitored – see the final BSC chart in Figure 4.  Such a BSC chart was linked to the SD model that was built, based on the causal loop analysis above illustrated. Simulation results from the SD model were also depicted through the above chart.

| Perspectives | Objectives | Measures | Targets | Current Situation | Initiatives |
|---|---|---|---|---|---|
| Learning & Growth | Improve Company Image through a higher satisfaction of shareholders and local government, and through a better life quality of the served community. | Company Image Index | 1,00 | 0,61 | - Keep a satisfying flow of dividends to shareholders. - Invest in wastewater refinement plants. |
| | | Shareholder Satisfaction | 1,00 | 0,96 | |
| | | Service Quality Index | 1,00 | 0,59 | |
| | | Sea Pollution Conditions Index | 1,00 | 0,30 | |
| Financial | Improve profitability through cost reduction and revenue growth. | DSO | 60 | 194 | - Intensify controls on tardy customers. - Intensify exploitation of internal financial opportunities (dividends and credits collection). |
| | | Tardy Customers % | 0,00 | 0,36 | |
| | | Annual ROI | 0,07 | 0,00 | |
| | | Cost per m3 | 0,70 | 0,79 | |
| | | Annual Revenue Growth % | 0,10 | 0,00 | |
| Customer | - Increase customer punctuality. - Increase customer satisfaction through service level, response time to | Customer Satisfaction Index | 1,00 | 0,59 | - Intensify controls on service quality features. |
| | | Demand Fulfilment % | 1,00 | 0,51 | |
| | | Service Reduction % | 0,00 | 0,00 | |
| | | Days to Fix Breakdowns | 1,00 | 1,00 | |
| Internal Process | - Improve suspension process efficacy. - Increase water provision through refinement. - Reduce leakage. - Reduction of pipeline breakdowns through better auxiliary workers allocation and wear conditions | Days to Suspend Service | 60 | 1302 | - Shorten pipeline replacement period. - Invest in wastewater refinement plants. - Allocate effectively auxiliary human resources. |
| | | Leaking % | 0,20 | 0,44 | |
| | | Pumped Water per Day | 245.000 | 223.381 | |
| | | Refinement % | 1,00 | 0,00 | |
| | | Pipeline Repair Percentage | 1,00 | 1,00 | |
| | | Pipeline Quality Index | 1,00 | 0,50 | |

Figure 4: The DBSC charts to input objectives (targets) and simulated results (current situation).

The robustness of the proposed policies here summarized was then evaluated through a SD simulation model, based on a BSC, which was

developed as a second step of the project, focused on the feedback loop analysis previously depicted in Figure 2.

## The dynamic balanced scorecard

As remarked, such an approach allowed us to identify as stocks the main strategic resources for the achievement of the company objectives over time, referred to the four different BSC perspectives. The dynamics of the system provided by such resources impacts, on the net of lead indicators, which in turn affect the outcome measures that were originally depicted in Figure 1.

As previously underlined, among relevant strategic resources were identified:

- capacity, in terms of both volume water and wastewater that can be processed , and of pipeline network quality;
- auxiliary workers, who can be involved in maintenance and service suspension tasks;
- financial resources, in terms of company liquidity, local government's funds and bank debts AMAP can invest to implement the designed strategies.

Corresponding in-and-outflows were then identified in more detail than in the qualitative analysis, to detect and simulate the process through which such resources are subject to change over time, either according to adopted policies or due to external factors (e.g. obsolescence, human resource attrition).

With this purpose, material delays (i.e. the time to replace pipelines, to fix breakdowns, etc.) and information delays (i.e. the time to detect tardy customers and to start the credit collection process) affecting in-and-outflows were calculated based on past data, when existing, or on managers' estimation, when formal data were not available.

As showed in Figure 5, the stock-and-flow model was developed around four sectors [8]:

a)  the distribution sector, which analyses the adduction and distribution process of the water and the aging process of pipelines;

b)  the sewer sector, which refers to the collection and refinement of wastewater;

c)  the human resources sector, which describes the allocation of the auxiliary workers between the maintenance activity and the activity of service suspension to tardy clients;

d)  the financial sector, where the dynamics of the net income, cash flows and financial resources are analyzed.

An ILE, embodying both the SD and the accounting models portraying balance sheets, was built on the basis of the above mentioned sectors, in order to facilitate the use of the simulator. Through the ILE the management can easily:

−  input the initial model parameters according to company data;

−  insert the company objectives in the different perspectives through a BSC chart;

−  experiment different policies under various scenarios through a control panel including the modeled policy-levers and a scenario-setting board;

−  evaluate company strategy through several tables and graphs, reporting the simulated impact of the inter-related set of policies according to the selected performance indicators.

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[8]  Figure 5 is a simplified representation of the SD model. Equations are available on request from the authors.
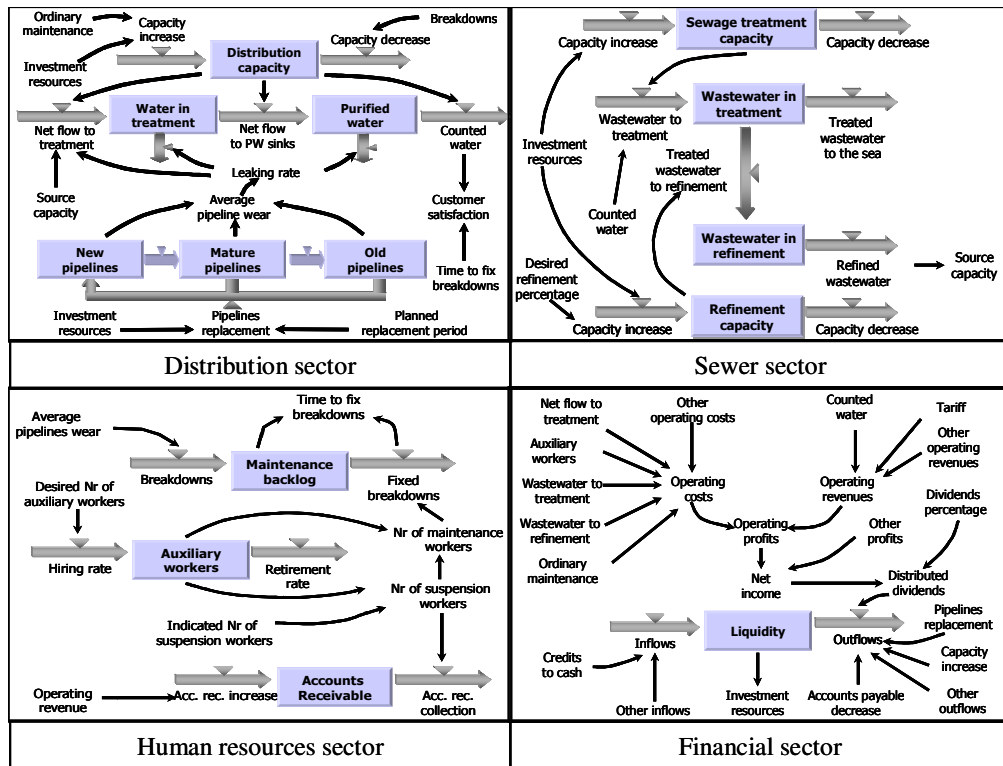
Figure 5: The four sectors of AMAP's simulation model

Figure 6 show the ILE control panel through which managers can make decisions and have access to other sections of the simulator to appreciate the effects of their policies over a four years' period.
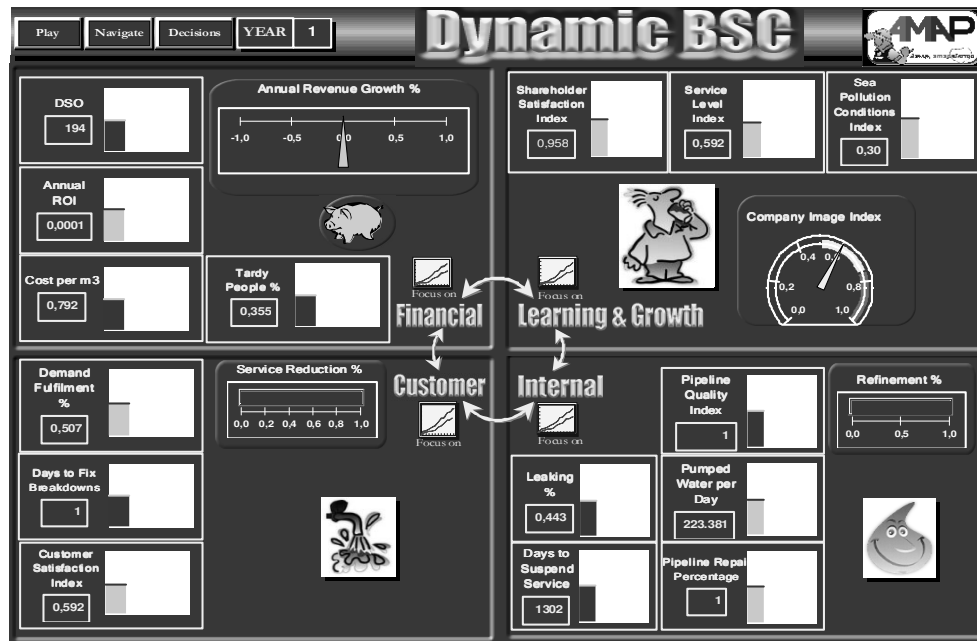
Figure 6. The DBSC Control Panel to Test Strategy

Several tests were implemented to validate the DBSC, such as the replication of AMAP's water distribution reference behavior with regard to the period from 1994 to 1999. A second set of interviews was conducted in order to verify whether the model structure and the simulation results were adequately representing real management processes. With this purpose, a couple of meetings were organized with the Board of Directors and the key-managers involved in the model building process in order to stimulate a debate over the issues covered by the model and build a common shared view of AMAP's system and strategy.

## Scenario analysis

Once enough confidence was built in the SD model, the ILE was used for what-if analysis and strategy testing under different potential scenarios. The differences between expected and actual results of the simulations stimulated a deep learning process.

An example of simulated scenarios is depicted in Figure 7. Two alternative scenarios are shown: a) refinement policy (line 1); b) combined refinement

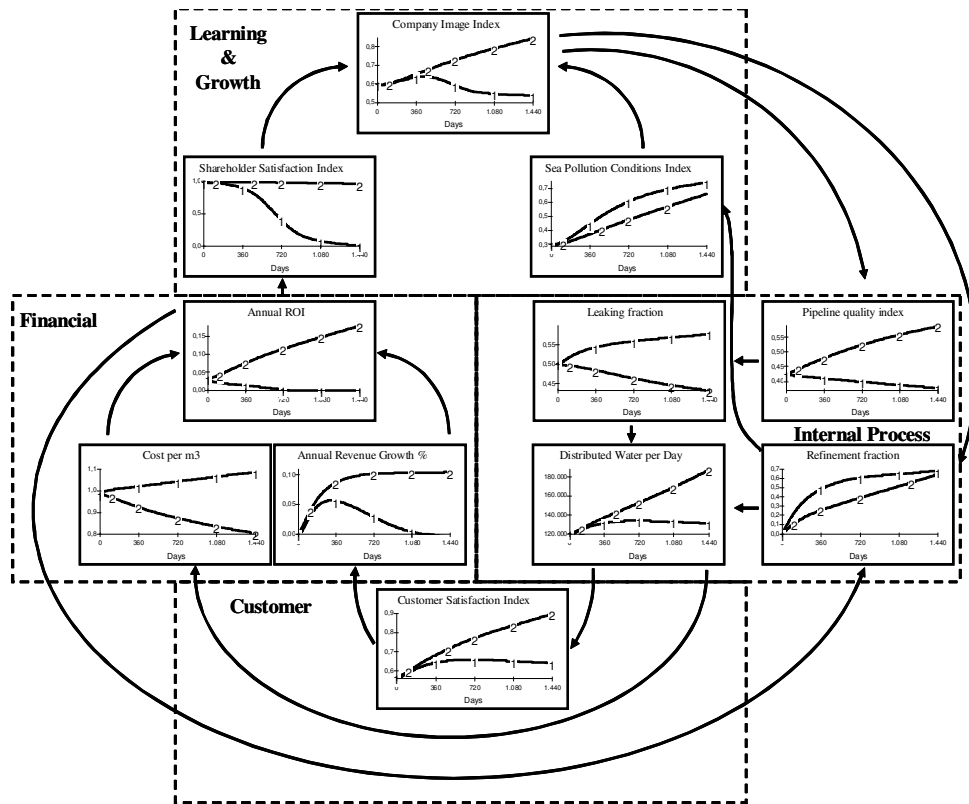and replacement policy (line 2), which implies a shorter pipeline replacement time.



Figure 7. AMAP's Strategy Simulation Results Included in the DBSC Casual Loop Diagram

Figure 7 allows decision makers to understand the circular relationships between performance indicators pertaining to the four traditional BSC perspectives. In fact, it matches the static BSC view, previously reported in Figure 1, with the feedback perspective of the system structure underlying experienced results, which was analyzed in Figure 2.

In particular, if we refer to the first scenario, from the behaviors reported in Figure 7 we can detect short and long term effects on company image related to a strong refinement policy. Short term effects can be referred to the loop R3 previously shown in Figure 2 (refinement fraction → sea pollution conditions index → company image index → local government's funds → refinement fraction).

In the long run, however, the effects produced by the above reinforcing loop are counterbalanced by the loop B2, which is followed by the loop R6, previously shown in Figure 2. In fact, provided that scenario 1 only implies an investment of available funds in the improvement of refining infrastructures, although a higher refinement fraction could increase the pumped water per day, a lack of investments in pipeline renewal gradually reduces its quality index, which drops the volume of distributed water. This determines a reduction in the customer satisfaction index, which also decreases revenues, ROI, and liquidity. A lower liquidity makes further investments in the refining infrastructure more difficult, which weakens the loop R1 and make the loop B2 dominant.

Furthermore, a lower ROI undermines shareholders satisfaction in the long run, and reduces company image. A lower company image is also likely to make more difficult raising funds to be invested in the replacement of pipelines, which further reduces its quality index and increases the leaking fraction. This reinforces the death spiral synthesized in the above said loop R6.

The above simulation results are quite counterintuitive. Although the refining policy gives better outcomes in terms of sea pollution conditions, it is less profitable, if compared to the combined policy. In fact, even if a combined refining and replacement policy is likely to generate lower results in terms of sea pollution conditions improvements, it can give rise to a higher company image. This is because image depends on both environmental and financial performance.

Pursuing a sustainable strategy in the long run, in terms of strong company image, is a major prerequisite for AMAP to gain stakeholders' confidence and be competitive in water service management.

## Conclusions

This article has tried to demonstrate the usefulness of an approach aimed to match the SD methodology with the BSC framework. The development of ILEs portraying DBSCs can successfully enable managers to better

understand cause-and-effect relationships between variables pertaining to the four traditional BSC perspectives.

In particular, the article has advocated the opportunity to adopt such an approach to strategy design and planning in public utilities, where a deep cultural change and major performance improvement are strongly required. The case study here described has demonstrated some benefits obtained by an Italian city water company in using a DBSC to enhance strategy design and planning. In the AMAP case, strategic mapping and simulation through the SD methodology has proved to successfully enhance managers learning and capability to identify causal relationships between policy levers and company performance, and better communicate strategy with stakeholders.

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