PERFORMANCE MEASUREMENT AND MANAGEMENT IN A SUPPLY CHAIN: AN INTEGRATED APPROACH BASED ON THE SCOR MODEL

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ABSTRACT

This article addresses the issue of assessing the best known systems of Supply Chain Management (SCM) with the aim of proposing an integrated and general approach to SCM able to be applied in a wide range of industrial contexts. The article begins with a literature analysis of the best known methods for SCM and performance measurement, pointing out their possible weaknesses and possibilities of applications. Then, an approach is defined, based on the SCOR model, that is able to guide the potential user to the management of a supply chain with specific workflows. The proposed approach could be defined as embedding into the development of the SCOR model the best known existing methods, proposing in some cases some specific modifications to obtain an integrated methodology.

Keywords: Performance Measurement, Supply Chain Management, Key Performance Indicators

INTRODUCTION

Supply Chain Management (SCM) is a topic of great interest in the actual business environment, because it can enable firms to manage a new complexity involving the creation, connection and management of physical and information flows, from the suppliers of raw materials, until the final consumer. In the industrial context which has developed during the last few years, this ability is required also to interact with technological and Business Intelligence instruments, that allow a close coordination between the several actors of a Supply Chain. In this context, performances evaluation plays a central role in the SCM, because the complexity of the existing relationships in a Supply Chain has to be analysed by management, and measurement tools must be able to give useful information in order to indicate if the strategic choices have generated an effective advantage for the company. Moreover, information deriving from a measure-

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ment system can be used for resources allocation, evaluation of business, and identification of inefficiency conditions (Simons, 1995). In recent years, many systems and techniques have been developed, however the management methods still remain one of the weak points in Supply Chain analysis because these methods sometimes turn out not to be included in the definition of techniques for performance evaluation or strategic control. Moreover, some have some weakness that have to be addressed by other approaches (Laitinen, 2002).

Based on these considerations, the scope of this article is to define an integrated system for the performance analysis and management of a Supply Chain. The proposed method integrates some of the most diffused systems of performance management, such as SCOR Model, BSC, ABC, and CSF allowing us to estimate the different aspects of the Supply Chain and to characterize them with a set of synthetic and meaningful indicators. In the first part of this article we analyse the different methods of performances management and evaluation, and then a step by step description of the integrated system is given.

LITERATURE REVIEW

The most important systems for performance measurement in SCM can be divided into two fundamental groups (Otley, 1999):

- **Financial Control Systems** (*FCM*), where the performance measured is essentially a profit; these methods encourage the company to become more efficient and effective in the creation of economic value;
- **Strategic Management Systems** (*SMS*), that integrate financial and non-financial measures to produce a complete vision of the productive environment.

FCM are frequently used by managers because they deal with financial data that would seem to be those that better express whether the company is able to create economic added value. The most important economic control systems are the Economic Value Added and the Activity Based Costing.

Economic Value Added (EVA)

EVA is a management system finalized to increase the enterprise added value over a long period. This task derives from the management's ability to produce satisfactory economic profits, in a constant and long-lasting way, based on the condition that the future profit is related to the cost/opportunity of having invested in a specific activity, calculated as follows:

$$EVA = NOPAT - (WACC^* C)$$

Where:

- *NOPAT*: net operating profit after operating taxes
- *WACC*: weighted average cost
- *C*: net capital invested

For example, for a company quoted on a Stock Exchange, *EVA* can give an estimation of the value created by the top management for the stakeholders.

A strategic plan based on *EVA*, provides a guide for management to pursue a profitable increase, and offers a basis to estimate operating and strategic choices. In this way it is stretched to improve the operating efficiency (i.e. to increase the NOPAT), and not to undertake investments in which the return does not cover the cost of capital. This method also gives a complete outline of the relationships between operative decisions and enterprise value. However it remains centred on the appraisal of financial performance, and consequently it does not guarantee that the company will have profitability in the long term "*despite the existence of predictions based on stock market valuations, but it remain an historic income measure*" (Otley, 1999).

Activity Based Costing (ABC)

"*ABC regards the firm as a set of interlinked activities that creates and delivers value to customers*" (Atkinson et al., 1997). According to this vision, activities need resources and generate costs; i.e. there is a causal relationship between costs and activities. For the calculation of the product cost it is necessary to measure the employment of each activity and to quantify it with a suitable driver.

The cost of the activity for the product will be obtained by multiplying the unitary cost of the activity and the driver; the total cost will be obtained as the sum of the costs of all the activities. It is important to stress the importance of the inner processes and the analysis of how costs influence the operations. The main scope of the ABC is to make the company more efficient and effective in the existing processes, but it does not encourage investment in new opportunities, or reshape the existing processes (Winters e al., 1994). Therefore, this method of measurement should not have to be adopted as an analysis system but as a mean to provide useful information to other systems.

The mere economic measures given by FCM provide only indications for decisions in the short term, but are not suitable for strategic decisions in the long term. "*The pressure for short-term financial performance can also cause a company to reduce spending on new product development, process improvement, human resources development, information technology and customer and market development*" (Kaplan and Norton, 1996).

In order to support long term decisions it is necessary to design a set of information that considers more than financial factors. Based on these considerations, several management systems have been introduced that develop financial and non-financial measures, and the most used are: *Key Performance Indicators Model, Critical Success Factors, Balanced Scorecard, and SCOR Model.*

Key Performance Indicators Model (KPI)

The *KPI* method considers the whole range of competitive performances. It is oriented to measure processes that are seen as a set of activities made with technological resources and that produce some output to answer a demand for service. This method provides measures of efficiency and effectiveness, giving pointers regarding the key performances of the process (Cravens et al., 2000).

The principle on which the system is founded is essentially the analysis of the customer and the market, with the subsequent adaptation of the Supply Chain in terms of logistic net, strategy and product, with the task of satisfying demand. The criteria for the determination and analysis of the pointers are well defined, moreover attention is directed to the entire Supply Chain, from the first input to the last output. However, the vision of the SC complexity, such as block input-output, limits the analysis, not allowing the creation of a real model and consequently the localization of possible weak links of the chain.

Critical Success Factors (CSF)

Wijn et al. (1996) define the CSF as: "*The factors on which a company can distinguish itself from competitors, and thus build a stable, positive relation with the market*".

So the CSF consists in the definition of certain parameters (such as Quality of Service or of Product, Costs, Timelines, etc.) that are able to create customer loyalty. In other words CFS create conditions for profit in the long term. The objectives, in this case, are derived from the market trends. To establish the strategy, the Critical Success Factors are identified; then the Critical Business Processes and the Critical Control Variables with the respective Benchmarking Values are chosen. All the strategic actions will be carried out to align the parameters with the desired values of Benchmarking. The method is placed in a dynamic context, because it allows a change of strategy and, therefore, the appraisal of the performances based on the change of the costumers' needs.

The mere use of this method in a firm could cause the managers to follow only market tendencies, without considering a 'vision' that could carry the company towards the exploration of a new product or a new market. This disadvantage could be resolved with a strategy which combines the perspective of the market with those related to the vision or mission, but it is not

clear which are the means that the company would have to follow to align the actual values and the benchmarking values of the performance pointers.

Balanced ScoreCard (BSC)

Kaplan and Norton (1996) defined the BSC as a "*multi-dimensional framework to describe, implement and manage the strategy at every level of a firm, joining, through a logical structure, objects, initiatives and measures to the strategy of the organization*". The *BSC* delineates a management system in which the tasks in the short term are connected with strategic tasks in the long term, using financial and non-financial measures organized in a scorecard, which includes all the performances of the company (Butter et al., 1997).

To have an exhaustive vision of the entire business situation, no pointers of performance can be considered singly, for it is necessary to create an organized set of indicators that give a total appraisal of the firm's business (Johson,1998). Therefore company economic results are analysed with regard to the so called four perspectives:

- *Financial*, represents essentially the profitability and the long-term objectives of the company: the measures identify how the company wishes to be viewed by its stakeholders.
- *Customer*, relates to the activities to satisfy the customer, so as to create a loyal and satisfied client.
- *Internal Business Process*, focuses on the location of the critical success factors;
- *Learning and Growth*, involve innovation and improvement of the process, which the company needs to make its vision come true.

The BSC method answers to a top-down logic, since the actions that are defined at the strategic level are then elaborated to the lower levels. The definition of the strategy is carried out through a 'strategic map' that puts in a cause-effect relationship the performance indicators (lag indicators) and the drivers that will generate strategic indicators (lead indicators). It is important for the success of the company that the four perspectives are balanced. The BSC is one of the first methods that pays attention to more than just financial measures, and in fact it has been defined also as a *stakeholders' approach* (Martinson et al., 1998).

Some studies (Winters et al., 1994), have defined this method as a complete system of measurement and control of strategy. Moreover, another author defines it in the following way "*It provides relevant and balanced information in a concise way for managers, thereby reducing the time for digestion of information and increasing the time for decision-making. It also creates an environment which is conducive to a learning organisation through the testing of hypotheses regarding cause and effect relationship and by laying the groundwork for a 360⁰ feedback process*" (Mooraj et al., 1999).

Supply Chain Management is a topic that is receiving increasing attention in the literature,

especially after the introduction of the BSC method by Kaplan and Norton; this is because this method gives a valid alternative to the classic diagnostic control systems based on financial measures. In fact, there are several studies that address the problem to analyse BSC characteristics.

At the time of writing the scientific literature can be divided into two tendencies:

- Authors who confirm the validity of the method and describe its application in different business contexts. An example are the studies of Martinson et al. (1998): they propose BSC applied to Information Systems. Another example is the work of Papalexandris et al. (2005), that develops a framework for the application of BSC. Craven et al. (2000) offer a framework for the application of BSC to the existence of strategic alliances between competitors.
- Authors who recognize the innovative contribution of the method, and who also characterize some limits and propose integrated systems, such as Butler et al. (1997). They apply BSC to the Rexam Custom Europe adapting it to the particular requirements of the company. They replace the four perspectives with three new perspectives: *shareholders, extraordinary increase and continuous improvement*. Johnson (1998) integrates the BSC perspectives with environmental indicators regarding the economic context in which the company works. In fact the consumer's perspective is integrated with that related to external stakeholders, such as government or organizations. Another interesting model is proposed by Van vee Dirks and Wijn (2002). They integrate the BSC with the CSF method, obtaining in this way a control system of the strategy; in other words the method allows a reformulation of the strategy if the managers find that the adopted strategy is not effective.

The literature also offers examples of integrated systems for performances evaluation which differ from the BSC. For example, Laitinem (2002) introduces a method based on the ABC approach. The method distinguishes between inner and external factors which are linked by a causal relationship; the main idea being to follow the creation of the product from the allocation of the first resource to the finished product. Another example of an integrated system is that of Nanni, Dixon and Wollan (1992). However, the method has not every fundamental requirement for an analysis system; the main lack being the impossibility of creating a Supply Chain model. A Supply Chain model, in fact, would allow an understanding of which measures are necessary, and in the event of those that are lacking to verify which link of the chain has generated the lack, and therefore to take the necessary countermeasures.

Other studies, moreover, identify the lack of attention to the business environment in which the company works (Tarokh and Shooshtari, 2005). There are also disadvantages for strategy implementation, because the strategy is supposed to be fixed, and therefore it is not possible to change it, so the method is useful for strategic and interactive control but not for the control of strategy (Veen-Dirks and Wijn, 2002).

SCOR Model

The approach based on the SCOR Model allows a standardization of the logistic chain and the modelling of flows between the firms through an identification of the processes and their classification (Supply Chain Council, 2003). This is realized through the definition of five Core Processes: PLAN, SOURCE, MAKE, DELIVER, RETURN. These are the categories in which every activity of the firm is identifiable. Moreover the structure, as soon as described, is applicable to all the actors in the chain, that is the SC can be seen as one chain of MAKE, SOURCE, and DELIVER.

There is also a second dimension to identify processes (Process Type): planning, execution, enable. The combination between SCOR Process and Process Type determines 29 Process Categories. Through the Process Categories we can describe each element or activity carried out in the Supply Chain and create a model of the flows and the relationships between the activities.Also, the metrics for the measurement of the processes are standardized and give an evaluation of cycle times, costs, service, quality, resources and supplies. These measures express the '*as is*' that through a benchmarking process have to stretch to '*to be*'.

For the definition of the KPI, this model considers a limited set of measures regarding only two perspectives (Customer and Inner processes). Moreover some inner processes such as marketing and sales are considered fixed and therefore it is not possible to model and compare them. In this method there are no incentives towards increase and innovation because the method is centred essentially on the analysis of the consumer and the inner processes but does not analyze the efforts and the resources expenses in Research & Development.

Studies that analyse the SCOR Model are actually fewer than the previous ones. This is mainly due to the characteristics of the method that appears strongly standardized and defined in all its steps. The literature in this field is limited to a description of the method and its application to some case studies. For example, Kasi (2005) discusses the application of SCOR to Time Wise Instruments. However, there are no proposals for integration of this method with others.

From the analysis of the methods previously described, based on the literature review and existing studies, it is evident that to have a complete outline of the Supply Chain performances and in order to apply strategic control, a single evaluation method is not sufficient. In fact each approach deals only with some aspects of the SC, neglecting some others. Moreover some methods can be applied only to specific industrial environments. In order to manage a complex industrial system an integrated approach is needed that yields the advantages of several methods and can be applied to most parts of industrial environments. Such an approach should allow a clear analysis of the Supply Chain, and offer meaningful measures able to support management in making effective and on-time decisions.

AN INTEGRATED APPROACH FOR SUPPLY CHAIN MANAGEMENT

The approach described in this section integrates the above described methods for performance measurement and management, giving a complete method of analysis, management and control that can be adopted in the most common industrial environments. With this method we have attempted to answer the requirements that, according to Otley (1999), must be met to have a good system of management. This means that the proposed method must:

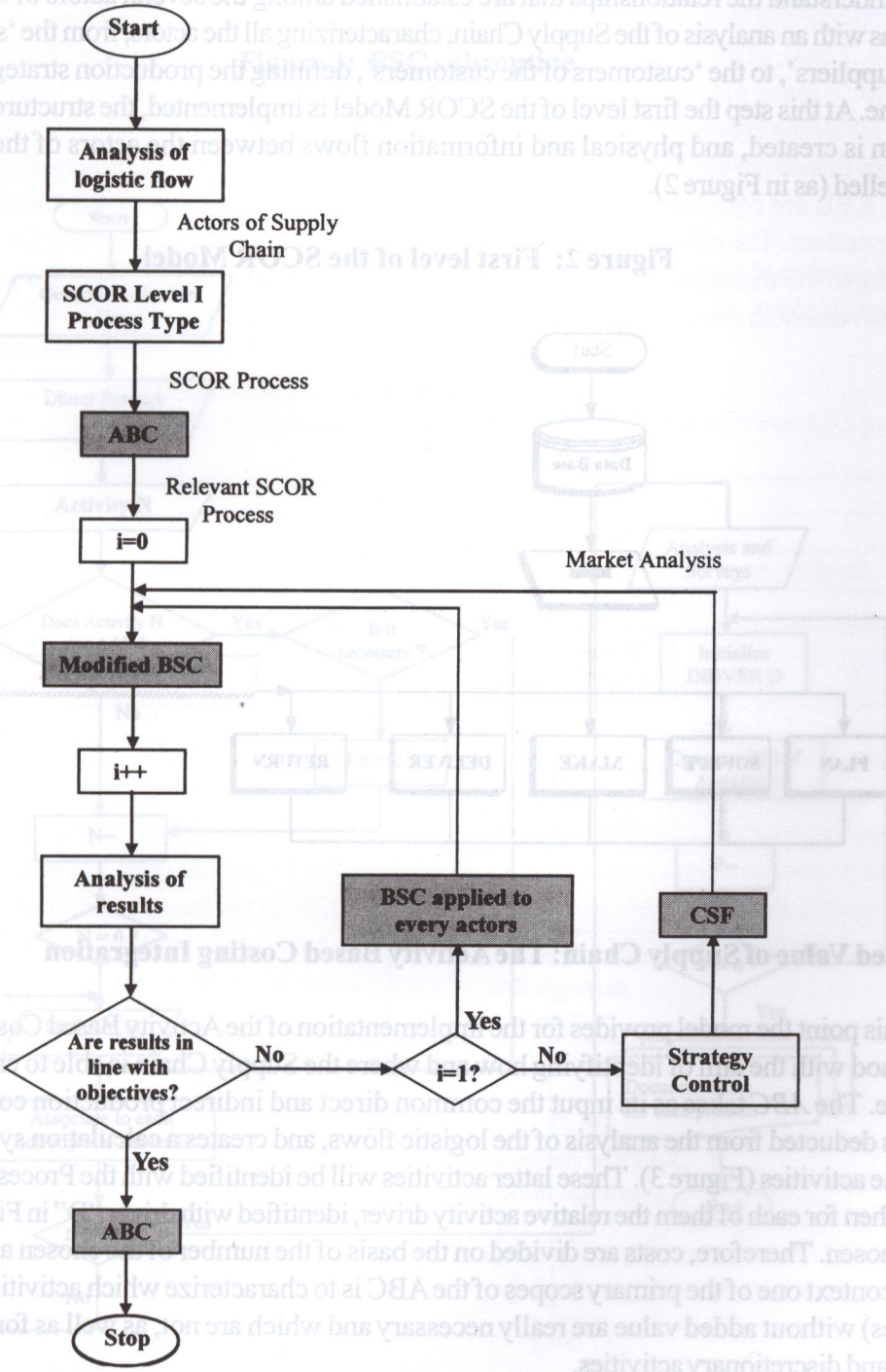
- "*understand activities of the organization leave only... having a detailed knowledge on how the business works*". This statement can be accomplished through the ABC, which analyses the SC creation of value, and EVA, that verifies the economic efficiency and effectiveness of the SC;
- "*connect control systems design with issues of strategy, both espoused and emergent*", which is made through integration of a modified version of BSC with the analysis of the market deriving from the CSF method;
- "*need to focus on the external context*", accomplished through the integration between the SCOR model and the modified BSC. This analysis is made explicit in a strategy map that connects the actors of the chain and their performances;
- be "*process oriented and focuses on value chain to complete the vertical and hierarchical approach*"; that is realized by the three levels of SCOR.

The approach is structured in the following four fundamentals steps:

- **system definition and modelling**: a fundamental requirement of every management system is the creation of a Supply Chain model. Often, in fact, it can highly complex demanding, therefore, the representation only of the important elements for the analysis.
- **characterisation of objectives**: the Supply Chain is a net of interdependent processes oriented to creation of a business, and therefore it is necessary to define the dimensions on which to measure the performance;
- **creation of a performance measurement system**: it is necessary to construct a clear outline of the Supply Chain state, so as to characterize the weak points and to apply action for improvement;
- **control and management**: objectives have to be aligned with results, and then have to estimate the efficiency of the Supply Chain in economic terms.

The work flow in Figure 1 gives the entire development of the method. The shaded blocks represent subroutines that will be described in details in the following paragraphs.

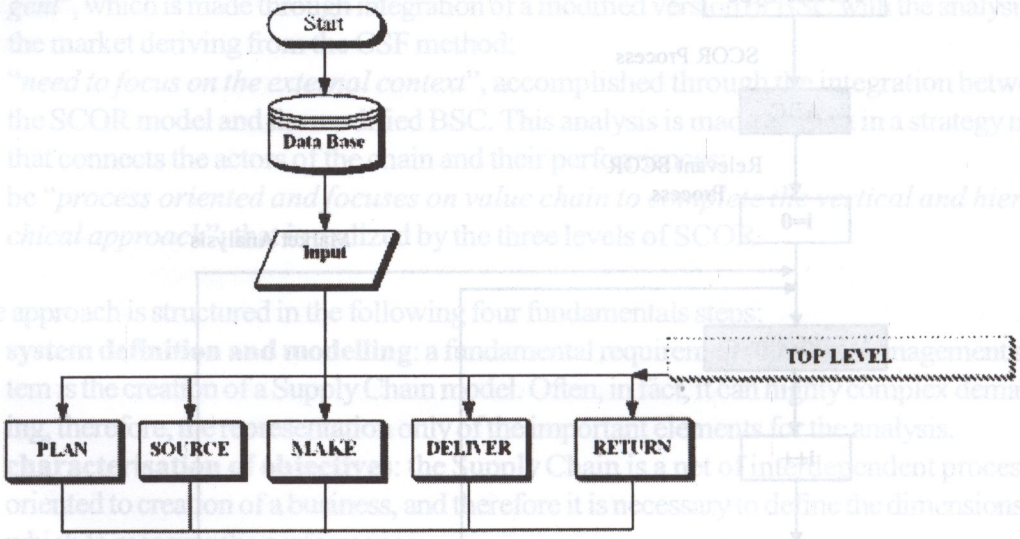
Figure 1: Integrated System for Supply Chain management



System definition and modelling

The method starts by exploiting the typical concepts of the SCOR, for in this way management can understand the relationships that are established among the several actors of the chain. It begins with an analysis of the Supply Chain, characterizing all the actors, from the 'suppliers of the suppliers', to the 'customers of the customers', defining the production strategies for everyone. At this step the first level of the SCOR Model is implemented, the structure of Supply Chain is created, and physical and information flows between the actors of the chain are modelled (as in Figure 2).

Figure 2: First level of the SCOR Model

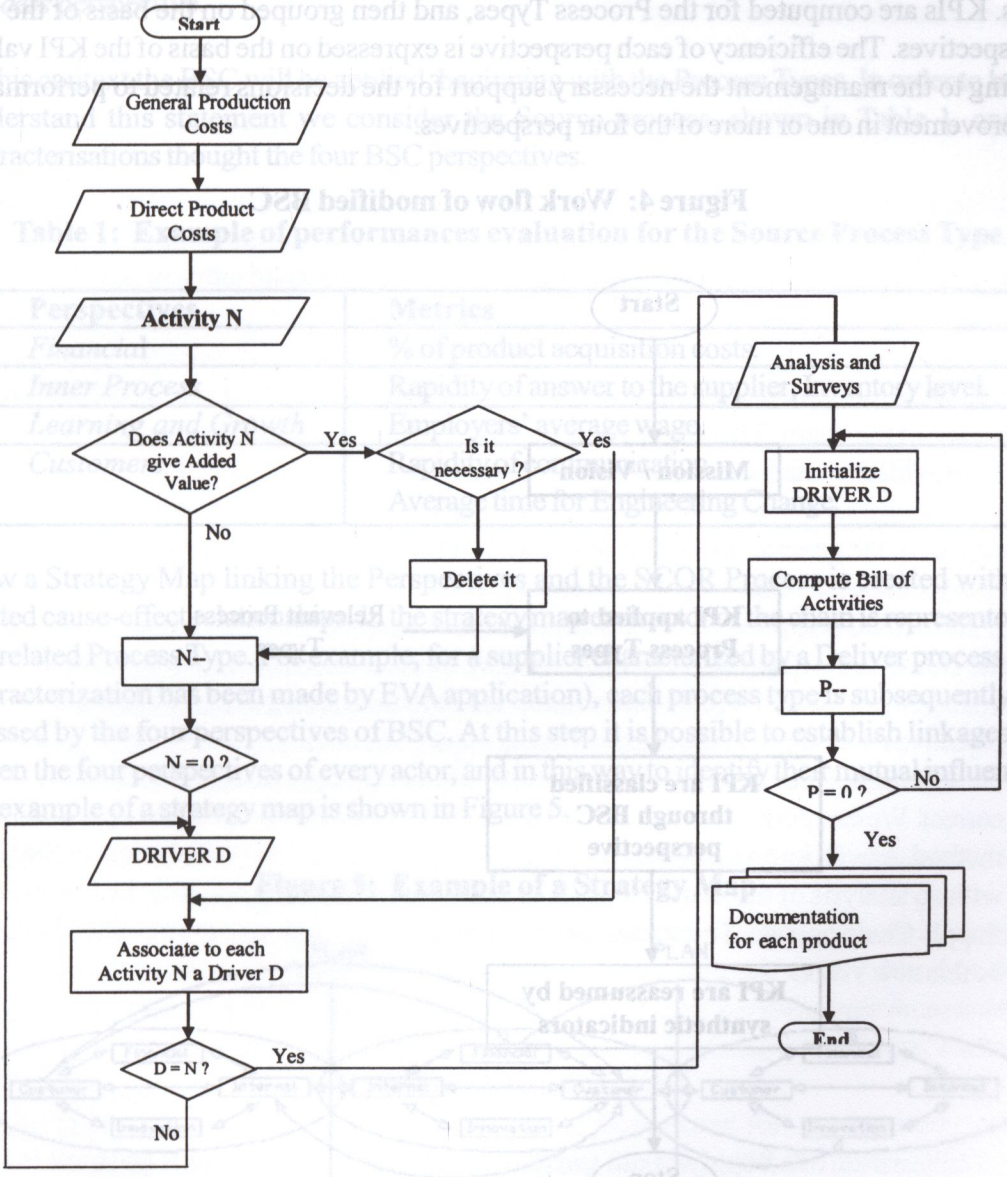


Added Value of Supply Chain: The Activity Based Costing Integration

At this point the model provides for the implementation of the Activity Based Costing - ABC method with the aim of identifying how and where the Supply Chain is able to create added value. The *ABC* takes as its input the common direct and indirect production costs, actors' costs deducted from the analysis of the logistic flows, and creates a calculation system based on the activities (Figure 3). These latter activities will be identified with the Process Elements and then for each of them the relative activity driver, identified with driver "D" in Figure 3, will be chosen. Therefore, costs are divided on the basis of the number of the chosen activities. In this context one of the primary scopes of the ABC is to characterize which activities (Process Types) without added value are really necessary and which are not, as well as for the necessary and discretionary activities.

The ABC method provides, in this way, important information for the development of the integrated model giving the parameters for the phases of mission/vision formulation of the subsequent BSC, oriented to the strategic decisions. Moreover it allows us to model only the important aspects of the chain, i.e. to characterize only the relevant Process Types.

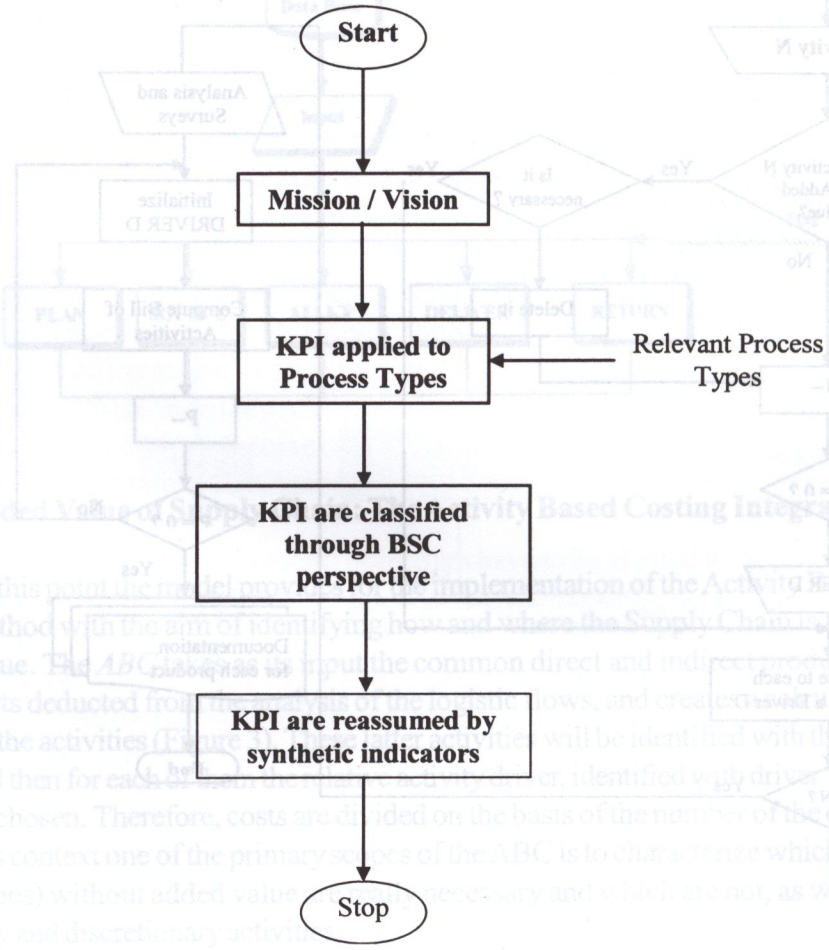
Figure 3: BSC subroutine



Objects characterisation and performances measurement system definition: the modified BSC

This step of the approach is realized through a modified version of the BSC (Figure 3). This necessity arises from the requirement to conciliate the Process Types with the objectives definition. These, in the proposed approach, are established on the basis of the Four Perspectives of BSC - *Inner process, Customers, Learning and Growth, Financial.* Metrics and Targets for all the Process Types will be referred to them. Here the difficulty is to obtain data not related directly to the firm, but deriving from the interactions between inner and external factors. KPIs are computed for the Process Types, and then grouped on the basis of the four perspectives. The efficiency of each perspective is expressed on the basis of the KPI values, giving to the management the necessary support for the decisions related to performance improvement in one or more of the four perspectives.

Figure 4: Work flow of modified BSC



Of course, the improvement of one or more of these perspectives depends on the specific Supply Chain. For example, a firm always oriented to explore new products or markets will give importance to the performance in terms of effectiveness, such as success of a new product, percentage of new customers for a new product or market, which are typical measures of the *Learning and Growth* perspective, for which another possible element can be the market in terms of customer satisfaction and product quality.

In another firm, a Supply Chain characterized by low costs will give importance to factors of time, and process efficiency (e.g. the inventory level) that are typical indicators of the *Inner process* perspective.

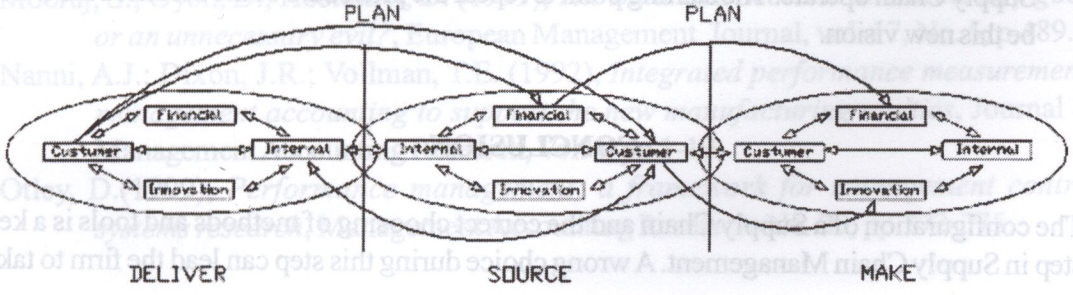
In this context the BSC will be applied, beginning with the Process Types. In order to better understand this statement we consider the Source process, shown in Table 1, and its characterisations thought the four BSC perspectives.

Table 1: Example of performances evaluation for the Source Process Type

Perspectives	Metrics
Financial	% of product acquisition costs.
Inner Process	Rapidity of answer to the supplier; Inventory level.
Learning and Growth	Employers' average wage.
Customers	Rapidity of communication. Average time for Engineering Change.

Now a Strategy Map linking the Perspectives and the SCOR Process is created with the related cause-effect relationships. In the strategy map each actor of the chain is represented by the related Process Type. For example, for a supplier characterized by a Deliver process (the characterization has been made by EVA application), each process type is subsequently expressed by the four perspectives of BSC. At this step it is possible to establish linkages between the four perspectives of every actor, and in this way to identify their mutual influences. An example of a strategy map is shown in Figure 5.

Figure 5: Example of a Strategy Map



The strategy map is very useful in this context because it allows us to identify possible inefficiencies in the chain, as well as how improvement of one of the above mentioned perspectives can influence the entire Chain. Of course the relationships shown in Figure 5 are just an example, since they have to be tailored to the particular Supply Chain that is analysed. For example, an improvement in the Customer perspective of a supplier (supposing a faster service) could be spread in positive way to the Source Process of the producer, and in fact here we can have an improvement of the Financial perspective, with smaller costs of acquisition. As a further example, a high percentage of commitments accomplished on time (Inner Process perspective for the Deliver) will determine a reduction of the supplies in the *Source Process* of the producer (Inner Process Perspective).

PERFORMANCES AND STRATEGY CONTROL

In the last step, the Strategy Control is implemented. Here results are analysed: if they coincide with the objectives we have to verify the economic aspect of the entire Supply Chain with EVA, quantifying the efficiency and the effectiveness of the chain in terms of the added value created.

At this step of the approach, the EVA method gives an evaluation of the profit contribution for each actor of the chain. These types of metrics can be used to quantify the added value that can be provided by each part of the chain.

We can see in the general flow-chart of Figure 1, if the results of BSC are not in line with the firm's objectives The following two cases are possible:

1. If the method is applied for the first time, we have to apply the BSC to each single actor of the chain, finding the weak link. In this way those actors who do not have an efficient management system will be able to audit the business management, aligning their own objectives with those of the Supply Chain;
2. Otherwise, we have to carry out a control of the strategy, in order to assess if that is correct. We carry out a strategy control using the Critical Success Factors approach. This method, as well known, allows the integration of the vision/mission, typical of the BSC, with an analysis of the market and the industrial environment in which the actors of the Supply Chain operate. The starting point to repeat the procedure of the modified BSC will be this new vision.

CONCLUSION

The configuration of a Supply Chain and the correct choosing of methods and tools is a key step in Supply Chain Management. A wrong choice during this step can lead the firm to take

wrong decisions and investments in terms of human resources, software and strategic objectives. Moreover the long term results can be affected in terms of not accomplishing specific market requirements, such as the level of service and certain product requirements. The present paper is intended to assess the problem of the choice of tools and methods for performance measurement in Supply Chain Management, with the proposition of an integrated approach based on the SCOR model that does not give to the user the possibility of selecting a wrong method or wrong parameters, because it guides the user in the configuration of its supply chain in part with existing approaches and in part with modified ones. Research is now in progress, with the application of this method to a complex industrial case, which could result in further developments of the concepts in this article.

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