Logistic service measurement: a reference framework

Carlo Rafele

The author

Carlo Rafele is Assistant Professor in the Department of Production Systems and Business Economics, Politecnico di Torino, Turin, Italy.

Keywords

Supply chain management, Logistics management, Performance measurement (quality), Service quality assurance, Customer service management

Abstract

Many companies measure their logistic performances using several methods. As a consequence, various sets of indicators can be found in practice and in the literature. In particular, the same event can be measured in different ways, so that the relative performance is sometimes totally different. The purpose of this paper is to suggest a hierarchy in logistic performance measurements. A referring model for evaluating the logistic performances is also proposed in this paper, together with the definition of a reference framework for the selection of supply chain performance measurements.

Introduction

Over the last half century, the role of logistics in business has increased in both scope and strategic importance. Logistic strategies have influenced customer selection, product design, partnership/alliance building, vendor selection and many other core business processes (Caplice and Sheffi, 1995). Moreover, logistics has given a strong impulse in the organised systems developed by the supply chain in which logistics is one of the fundamental elements. According to the definition of logistics declared by the Council of Logistics Management in 1998, logistics is:

> . . . a part of the supply chain process that plans, implements, and controls efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption in order to meet customers' requirements (CLM, 1998).

Then, logistics is part of the larger integrated process, called supply chain, in which a number of various business entities (i.e. suppliers, manufacturers, distributors and retailers) work together for acquiring raw materials, converting them into specified final products, which in turn have to be delivered to retailers (Beamon, 1996).

Unfortunately, the performance measurement systems have neither kept up with the changing role and scope of the supply chain nor systematically examined and evaluated this global process. Nowadays, the organisations are competing in complex environments, and an accurate understanding of their goals and of the methods for attaining them is therefore essential (Kaplan and Norton, 1996). Performance measurement systems should evaluate both the individual metric and system-wide level in order to maintain relevance and effectiveness (Caplice and Sheffi, 1995).

In the past years, attention was mainly devoted to the performance of the single process inside the supply chain. Recently, however, there has been more concern on the performances of the global supply chain itself (Beamon, 1996). The difficulty

of developing appropriate performance measures concerns the kind of evaluations (qualitative or quantitative) and the objects (single organisations or many, one product line or many, and so on) (Beamon, 1999).

Considering the supply chain as a whole, a measurement system should be more than a disparate assortment of individual metrics. It has to be valid, robust, useful, integrative, economical, compatible, with a correct level of detail, and behaviourally sound (Caplice and Sheffi, 1994; Rafele and Frizziero, 1996). Keegan *et al.* (1989) note that for most companies:

> . . . the problem is that there are too many performance measures – too many that are obsolete and too many that are not consistent.

While performance measures will readily accumulate, they are rarely removed. It has to be considered that inclusive performance measures for supply chain systems may be constructed by combining a number of different individual performance measures into a system or function of performance measures. But only the performance system resulting from the combination of individual measures would allow a more inclusive measure of the overall system (Beamon, 1996).

'... A generally applicable systematic approach to performance measurement has not been developed yet, mainly due to the specific measurement characteristics required by different systems...'

According to the literature available, a system's efficiency and effectiveness could be determined by a set of performance measures or indicators. In various spheres of competence and operative activities, different aspects of logistic service quality management are covered by a set of indicators. Moreover, these measures have to be referred to a service quality model evaluation (Parasuraman *et al.*, 1985, 1988).

Literature review

An important component in the design of a supply chain is to obtain an effective supply chain design, once a set of performance measures is established (Beamon, 1998). For this scope, a standard measure – called a metric – should be defined for assessing the organisation's ability to meet customers' needs and/or business objectives. Metrics can generally fall into two categories: performance and diagnostic (Trimble, 1996). The first measures what you are doing. The second analyses why a process is not performing as expected (English *et al.*, 1999). In our context, we are discussing a performance metric. The set of performance indicators is used to determine the efficiency and/or the effectiveness of a single system, or to compare alternative systems. The available literature identifies several important performance measures in the evaluation of supply chain efficiency and effectiveness (Beamon, 1998). Many authors have categorised them. Neely *et al.* (1995) consider four main categories: quality, time, flexibility, and cost; while Lockamy and Cox (1994) define customer, resource and finance as primary categories of performance measurements. According to Caplice and Sheffi (1994), a good metric has to capture the critical elements of the logistic process: time, distance, and money. For Mendoza there are three primary groups of performance measures: financial, quality, and resources (English *et al.*, 1999). Moreover, a "good" logistic performance measurement system should be comprehensive, casually oriented, vertically integrated, horizontally integrated, internally comparable, and useful (Caplice and Sheffi, 1995).

As Beamon (1998) highlights, some questions are now opened in this research field:

- Are the existing performance measures systems appropriate for the supply chain?
- What are the appropriate performance measures for supply chains?
- Is there a hierarchy among the performance indicators?

However, a generally applicable systematic approach to performance measurement has not been developed yet, mainly due to the specific measurement characteristics required by different systems (Beamon, 1999).

The literature analysis shows that a basic design of performance metrics is required for monitoring the quality of logistic functions within most organisations (English *et al.*, 1999). The metric should cover several sides of service quality management (Franceschini and Rafele, 2000). According to the Parasuraman, Zeithaml and Berry (PZB) model (Parasuraman *et al.*, 1985, 1988), the following main factors – also called dimensions – should be considered:

- *Tangibles* (appearance of physical facilities, equipment, personnel, and communication).
- *Reliability* (ability to perform the promised service dependably and accurately).
- *Responsiveness* (willingness to help customers and provide prompt service).
- *Assurance* (knowledge and courtesy of employees and their ability to convey trust and confidence).
- *Empathy* (caring, individualised attention, which the firm provides its customers) (Franceschini and Rafele, 2000).

These are fundamental factors for the quality of a service. A correct and comprehensive metric of performance measurements should therefore include them.

The PZB model is one of the best-known models for the quality service evaluation. It is applicable to all kinds of services, including logistics.

The paper introduces a proposal for a supply chain performance measurement system according to the service quality requirements, defining an ordered framework for the logistic indicators. The framework should be able to cover all the logistic activities inside the supply process.

A measurement model

Each company develops lots of processes in order to gain market share with its own products or services. Every process is a mix of different activities and each of them is measurable with several indicators.

A product-oriented firm maintains several supplier-client relationships. The overall process is traditionally divided into sequential tiers. For each tier of the process, a set of suppliers and a set of clients can be found: every supplier puts its inputs into the process; inputs are transformed into outputs and passed successively to clients (Lambert *et al.*, 1998).

The transformed product can be either a finished product, that is sent to retailers or to the final client, or a semi-finished product transferred to another company that creates its added value. Thus you cannot deal with a single process, but with several processes that together generate the supply chain.

Therefore, supply chain is a mix of processes, which ties together firms from purchasing to distribution. It is also seen as an integrated process, wherein raw materials are manufactured into final products and then delivered to customers (Beamon, 1996). In this process, numerous entities work together in order to modify semi-manufactured products, developing some main activities such as: manufacturing (transformation of inputs into outputs); warehousing (recovery of stock); transport (satisfaction of customer request) and others. Each of these activities can influence the logistic performance.

'... In order to analyse performance measures, the logistic supply chain can be broken down into its elementary links; each of them includes activities for transforming inputs into outputs...'

Two basic aspects are detected in every single step of the chain: the first is internal to the firm, called intra-firm aspect; the second one ties together suppliers and clients, creating the inter-firm aspect. Thus, it is very important to analyse how a firm is internally organised and managed, but it is also significant to evaluate its behaviour in external phases.

In order to analyse performance measures, the logistic supply chain can be broken down into its elementary links; each of them includes

activities for transforming inputs into outputs, as shown in Figure 1 (European Committee for Standardization, 2000).

Three main points should be analysed at each step: input side for purchasing activity, transformation for production activity, and output side for distribution activity. Input and output sides relate to suppliers and customers; instead of transformation, which is internal to the firm.

As discussed above, a very difficult issue in logistic measurement is the deployment of an effective performance measurement system. The selection of what to measure and the relevant targets can be complex because of the interdependence of all activities in the supply chain. A good performance measure system is necessary to determine the efficiency and the effectiveness of a single productive system or to compare competing alternative systems (Beamon, 1996). It is a part of the "control cycle" and all its elements should be implemented to achieve a fully functional control process.

Referring to Figure 1, our analysis is focused on a part of the entire supply chain process; in particular, we consider what happens to the single *N* process and how it is linked to the others in the supply chain. Also, we might observe all the elements that can modify the service level.

Obviously, a product-oriented firm brings up several costs that are visible during the entire logistic process. In fact, process has costs tied to its physical organisation and its way of operating, because they depend on productive and technological choices and also on investment strategies.

In our study, the financial measurements will be considered in a next phase, as a consequence of the operational performance. Of course, the economic aspect influences the logistic performances, since it defines the responsiveness of the logistic process but, looking to the measurement definition, they could be considered as an effect.

Traditionally, financial performance has been the primary measure of success in most companies but conventional financially-based reporting systems generally do not provide all the required information about logistics performance (Brewer and Speh, 2000). Indeed, a complete performance measurement system has to consider both engineered/operational and financial indicators (Brewer and Speh, 2000). Each engineered ratio leads to a particular cost. The global consideration of the two sides of the logistic organisation allows the firm to find the best compromise between cost and quality in the supplied service. That is the reason why financial indicators have to be related to engineered indicators, as shown in Figure 2. In fact, it is possible to determine sets of indicators related to company effectiveness, efficiency, and productivity. They could be called engineered indicators. Measures derived from these indicators could influence the company's financial and economic indicators. The choices derived from the analysis of the two groups of indicators (engineered and financial) will influence the future logistic performances through the investment decisions.

Figure 2 Engineered and financial indicators

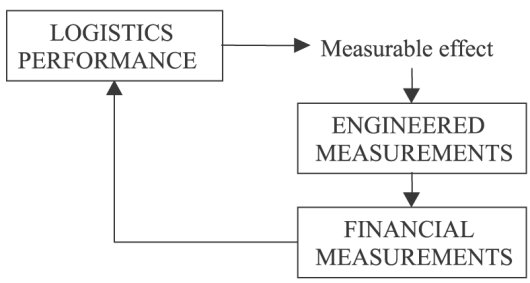
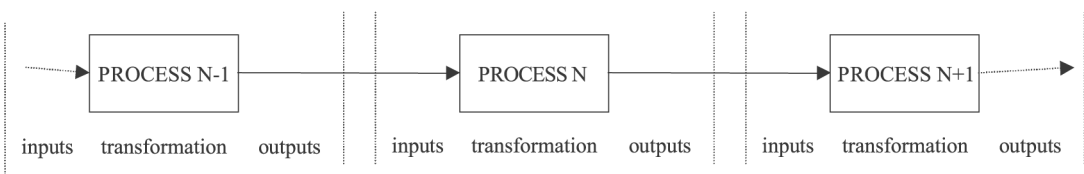


Figure 1 Supply chain as a series of different processes



The model deployment

We have identified the logistic process that we intend to analyse. Now we need to define the basic elements of the process, which represent the main activities leading to the process development.

To identify these "key elements", first we have to answer the following question: what is the most important scope of the logistic process? The best answer lies in the known definition of the "seven right conditions" for the logistic service: product, quantity, time, condition, customer, place, and cost (Shapiro and Heskett, 1985). Of necessity, an evaluation of the logistic performances will have to comprise these main components of the service.

The following step is how to obtain a quantitative measure of the service: first, we have to measure the single events, creating appropriate indicators, then we try to express a measure of service level with progressive aggregations of simple indicators. Obviously, there are a lot of indicators and their units of measurement could be quite different.

It could be possible to define a taxonomy of indicators, capable of representing the activities congruent with the logistic process. In order to create a hierarchy of indicators, basic service elements have to be identified and aggregated in homogeneous groups, successively named "classes".

We propose also to consider the main service dimensions as defined in the PZB model. Parasuraman *et al.* (1985, 1988) have shown that in every service evaluation – thus also in the logistic one – it is possible to identify common aspects. These basic aspects (tangible components, reliability, responsiveness, assurance, and empathy) need to correspond to the activities developed for a logistic service. Adapting the PZB model to our issue, we think that the logistic performance classification for a manufacturing supply chain could be identified by three macro-classes, including the main activities of logistic process (Figure 3):

(1) *tangible components* (corresponding to tangible in the PZB model), which concerns means and resources applied for the service realization;
(2) *ways of fulfilment* (the class comprises the expressions of reliability and responsiveness in the PZB model); this class includes all manners and significant parameters of carrying out the service; and
(3) *informative actions* (putting together the empathy and the assurance expressions of the PZB model) adds to the model the communications with the customers about the developing of service activities.

Adapting again the PZB model, the first two macro-classes – tangible components and ways of fulfilment – contribute to define the supplied service, since they have relations with the physical or organising activities necessary for carrying out the service. The third class – informative actions – contributes to link supplier and client with an information flow. This class completes the first two classes on the side of communication with the customers to define the perceived service (PS). The perceived service is what the customer appreciates and comprehends of the supplied service. Indeed, the same supplied service could have a different impact on the customer activities, if information on delivery is quickly available.

If problems and relative solutions are immediately pointed out to the customer, his reaction will be surely different from having no information until the last minute (Franceschini and Rafele, 2000).

Developing the framework, each macro-class is divided into sub-classes, which identify specific features of the service belonging to the macro-class, as shown in Figure 4.

The class, tangible components, includes those elements or resources which allow a company to supply the service:

- *assets* (physical instruments and operative means), divided into internal (handling and warehousing) and external (transport);
- *personnel* (who really generate products and contribute to control); and

Figure 3 Comparison between service dimensions in PZB and logistic model

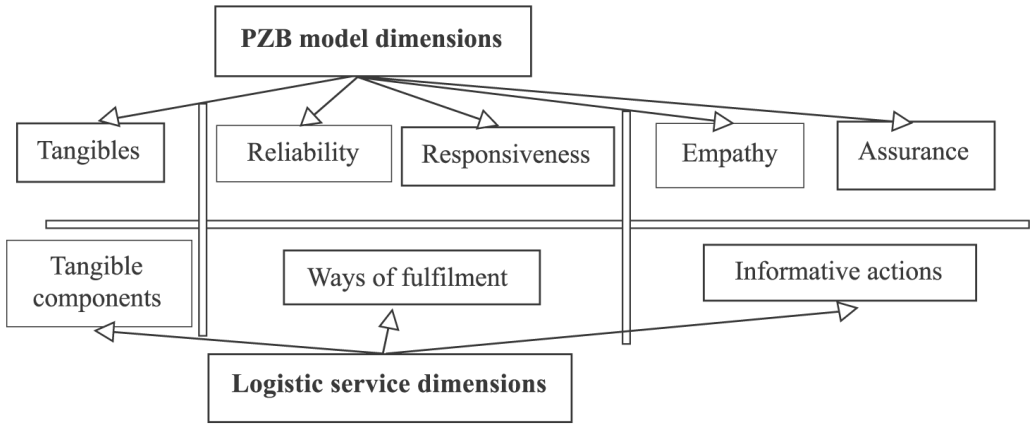
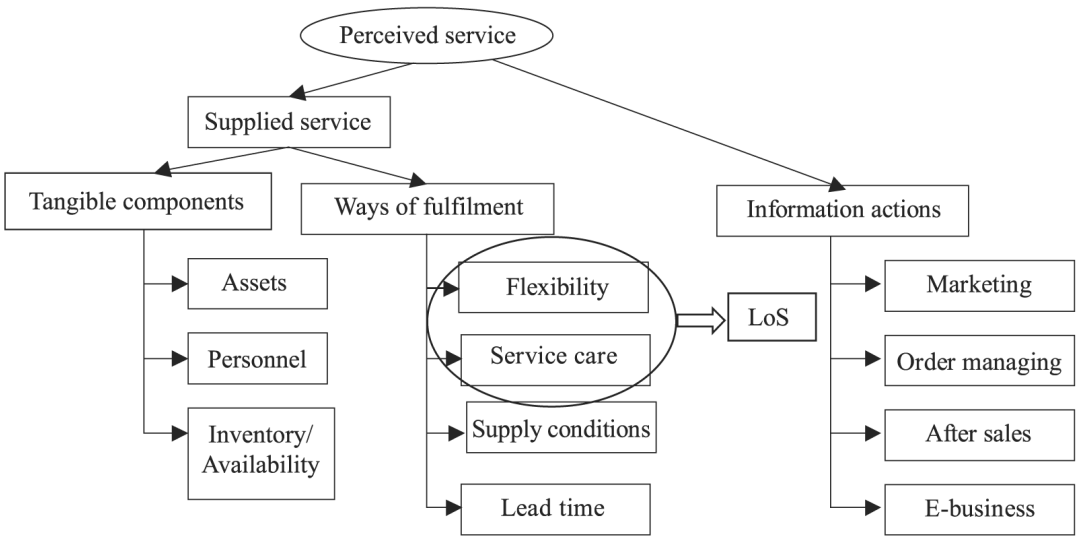


Figure 4 The structured model for the service level measurement



- *inventory* (raw materials and semi-finished products to transformed into finished products to push along the chain); and
- *availability*, which indicates the existence of products along the process.

The ways of fulfilment class considers how the service is supplied to customers, and the ability of suppliers in managing order variations in terms of quantity or time. Also this class is divided into four sub-classes:

(1) *flexibility* (it represents the ability of a company to satisfy variations in scheduled orders);
(2) *service care* (it comprises the parameters for carrying out a supply service);
(3) *supply conditions* (it defines the physical way of the supply service); and
(4) *lead time* (it indicates the duration of the delivery activities).

The last branch, informative actions, is divided into four sub-classes comprising the informative activities before, during and after the order, and the new way to communicate with the network. In the informative actions class, the division is as follows:

(1) *marketing* (information on products and selling conditions);

(2) *order management* (checks on order flow);
(3) *after-sales* (relations with the customers to solve problems or needs); and
(4) *e-information* (it considers the new way to manage and control orders by the e-network).

Now, we have defined the model structure and we have highlighted the main actions or subjects involved in the service. In order to provide consistency to the classification described, we have to identify measures of performance able to evaluate the several sides of the service included in each sub-class.

Really, measures could be either qualitative (there is no direct numerical measurement, although some aspects of them may be quantified) or quantitative (that may be numerically described, referring to activities performed, customer responsiveness, etc.). In the informative actions class, most of the indicators are mainly qualitative, with the result that the definition of a quantitative value for the PS is rather difficult. Certainly the informative actions influence all the other service indicators, but they are not separately appreciable.

The identification of measures – that mainly are referable to indicators, as viewed from the literature – is almost infinite and it depends on the peculiar industrial sector, and inside each sector from the aspect either of underlined competitiveness or of the data available. Rather, one of the main goals in a mapping of a process is the right identification of the most significant indicators, frequently named key performance indicators. As examples, in Table I we have reported some examples of indicators more related to the meaning of each sub-class.

In the ways of fulfilment class, it is possible to single out some homogeneous indicators, which lead to the satisfaction of customers. These indicators can be summed up in a single value called "level of service towards the customer" (LoS). From our point of view, LoS is the synthesis of a set of activities, which can be singularly measured by defining an indicator for each activity; sometimes it is called reliability.

Drawing from literature review and practitioners' indications, the most general way to consider LoS could be expressed through the following ratio:

$$\mathrm{LoS} = \frac{\text{Deliveries}}{\text{Orders}}.$$

In the ratio, the deliveries to be considered are those satisfying completely the requests of the customer in normal or urgent conditions: right shipments, deliveries on time, in the correct ordered quantity, in the way requested, suited for the customer, without damage and without mistakes in the paper work.

In other words, the deliveries which satisfy the seven Rs of logistics (Shapiro *et al.*, 1985). The orders are the total requests of the customers in the same period of time.

'... The framework described was tested by a survey on several companies in the manufacturing and shipment sectors...'

A further concept deriving from the present analysis concerns the impossibility of summarising all the service components in a single measure or indicator. The several components of the service consist of factors which differ very greatly, one from another, that are neither comparable nor numerically linked (for example, lead time vs flexibility, delivery frequency vs equipment productivity). The concept of service level takes into consideration needs of specification about the peculiar factors. The proposed framework identifies the contributions of the logistic activities inside the supply process.

Furthermore, the single indicator or measurement is set out in definite links with other sides of the service. In relation to the specific indicators or features of the logistic service, which a company intends to highlight, they are recognisable inside the model, understanding their own influence on the overall service. Thus, the effect of activities on the final result of the service could be anticipated, trying to modify the action during the development of the service.

A quantitative evolution of the proposed model could be developed, starting from a

Table I Performance indicators in the specific sub-classes

Tangible components	
Internal assets	Equipment productivity = Number of orders (or UL$^{(*)}$, or quantity) delivered/produced divided by the period of time considered Surface utilisation = Used surface of warehouse divided by the total surface of warehouse Volume utilisation = Used volume of warehouse divided by the total volume of warehouse etc.
External assets	Trucks fill rate = Number of UL$^{(*)}$ or quantity loaded divided by the number of UL$^{(*)}$ or quantity available in the same period of time Accident impact = Number of accidents divided by the number of journeys in a certain period of time etc.
Personnel	Personnel efficiency = Number of orders (or UL$^{(*)}$, or quantity) delivered/handled divided by the number of persons working or hours worked in the same period of time Accident severity rate = Number of accidents divided by the number of persons working or hours worked etc.
Inventory/ availability	Slow/medium/fast moving = Number of orders (or UL$^{(*)}$, or quantity) included in slow/medium/fast moving class divided by the total number of orders (or UL$^{(*)}$, or quantity) in the warehouse in the same period of time Physical and accounting correspondence = Number of orders (or UL$^{(*)}$, or quantity) with mistakes divided by the total number of orders (or UL$^{(*)}$, or quantity) in the warehouse in the same period of time Stock turnover = Number UL$^{(*)}$ or quantity delivered or shipped divided by the average stock in the warehouse in the same period of time Stockout = Number of orders (or UL$^{(*)}$, or quantity) out of order divided by the total number of orders (or UL$^{(*)}$, or quantity) ordered in the same period of time etc.
Ways of fulfilment	
Flexibility	Flexibility = Number of special/urgent/unexpected orders (or UL$^{(*)}$, or quantity) confirmed to the customer divided by the total number of special/urgent/unexpected orders (or UL$^{(*)}$, or quantity) required by the customer multiplied by 100 in the same period of time etc.
Service care	Punctuality = Number of orders (or UL$^{(*)}$, or quantity) delivered on time divided by the total number of orders (or UL$^{(*)}$, or quantity) delivered multiplied by 100 in the same period of time Regularity = Number of orders (or UL$^{(*)}$, or quantity) delivered with a Δt of delay/advance divided by the total number of orders (or UL$^{(*)}$, or quantity) delivered multiplied by 100 in the same period of time Completeness = Number of full orders (or UL$^{(*)}$, or quantity) delivered divided by the total number of orders (or UL$^{(*)}$, or quantity) delivered multiplied by 100 in the same period of time Correctness = Number of mistake orders dispatched divided by the total number of orders dispatched multiplied by 100 in the same period of time or Number of codes/articles sent back divided by the total number of codes/articles sent multiplied by 100 in the same period of time Harmfulness = Number of "damaged" orders dispatched in a period divided by the total number of orders dispatched in the same period multiplied by 100 Delay = Number of days of delay or (number of days of delay divided by the number of days promised) multiplied by 100 etc.
Supply conditions	Delivery frequency = Number of orders (or UL$^{(*)}$, or quantity) delivered in a certain period of time Shipped quantity = Quantity shipped in a certain period of time or quantity dispatched for each shipment Way of packaging and way of shipment, etc.
Lead time	Total order cycle time occurring from the arrival of a customer order to the receiving of goods or cycle time of the single activities (order transmission, order processing, order composition, order transfer to the production plant, article production, warehouse delivery, final delivery to the customer)
Informative actions	
Marketing	Range completeness, information on products and sell assistance, etc.
Order management	Documents management (invoices and orders), client contacts and order advancement state, etc.
After sales	Back orders, claims management, use assistant and payment management, warranty conditions, etc.
e-information	Web site completeness, ease of making orders by network and data transmission security, etc.

Note: UL$^{(*)}$ = unit loads

conversion of the indicators based on a weighted scale representing the achieved performances, i.e. value one for low performance, value five for optimum. Therefore, in order to achieve an overall value of the service, the converted value can be grouped by a ranking method. The global index obtained in this way represents a score that reflects several features of the service in a homogeneous scale. This logistic service index can be used for comparison in several evaluations: for monitoring the same company at different times, for a benchmarking analysis of the competitors, for a target definition of the services with the partners in the supply chain, and so on.

The framework described was tested by a survey on several companies in the manufacturing (for example, Valeo, Embraco) and shipment (for example, TNT, Federal Express) sectors. Information concerning Italian companies or international companies operating in Italy was obtained by direct contacts and Web site analysis. In particular, the following issues of the logistic service were investigated:

- the most important indicators for the logistic service;
- the concept of customer service; and
- the comprehension of the logistic service component links.

The first results of the analysis indicate that companies use almost the same main indicators, sometimes with different interpretations. There is a misunderstanding about the meaning of customer service and there is low comprehension of the influences among the different components of the service.

As regards the first point, the most commonly used indicators were reliability, completeness, correctness, harmfulness, productivity, lead time (especially towards the customer), delay (in total days or in percentage towards the due date), regularity, flexibility, availability, scrap level.

As regards the second point, most of the companies indicate a different meaning of the "level of service", which is generally identified with the most important indicators: for example, for the courier sector the lead time is one of the "musts"; in the jewellery trade security and the prevention of damage are the most relevant aspects; in the automotive chain, operating in just-in-time, punctuality and correctness are the basic factors.

Finally, all the companies strongly underline the necessity to deepen the comprehension of the links among the service parameters together with a classification, which could permit an oriented research of the sources of inefficiencies and mistakes.

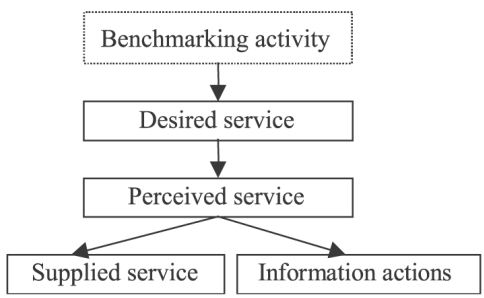
Conclusions and further questions

We draw the conclusion that customer service is measurable even though it is quite difficult to identify client quality perception in consequence of the informative actions component. The level of service is certainly influenced by not completely measurable factors like marketing, order managing and after-sales activities: these elements modify the appraisal of the service, but they cannot be separately evaluated.

From this point of view, the measure of the service we can obtain should be close enough to the PS. But what about customers' needs? Can the firm really offer what the client needs? In other terms, what about the desired service?

The desired or expected service (DS) is what the customer has in mind, what really satisfies his needs. The desired service is influenced by external information, which customers get from the market, developing a benchmarking activity (Figure 5). Therefore, it is necessary to supply a perceived service closest to the

Figure 5 Perceived service and desired service



desired service. Knowing that it is impossible to enter into the customer's mind, the company could reach this goal by identifying the basic elements, which influence customer delays.

It is not easy to identify these elements, as discussed again by Parasuraman *et al.* (1985; 1988). They showed that the elements that could influence DS are: personal experience, individual requirements, and marketing. These elements are not quantitative; thus you cannot obtain a value for client DS. Indeed, they are inside the clients' minds.

In conclusion, it is not possible to evaluate DS directly, but it could be modified through particular levers. These levers are tied up to firm variables as seen by clients. Regarding these variables we can achieve quantitative values of the PS. How to proceed? It is necessary to define those variables which interest clients and then try to evaluate them numerically. Thus, we cannot evaluate DS itself, but a PS level close to the DS level could be defined. At this stage, it is important to support the service-monitoring system with a benchmarking activity in order to compare the level of service of the single firm with the other competitors.

'...we have defined a hierarchy of activities classes, which contribute to the level of service in each tier of the supply chain, and we have shown some examples of the indicators inside each class...'

Other questions arise from the previous analysis, which we will develop in the next studies.

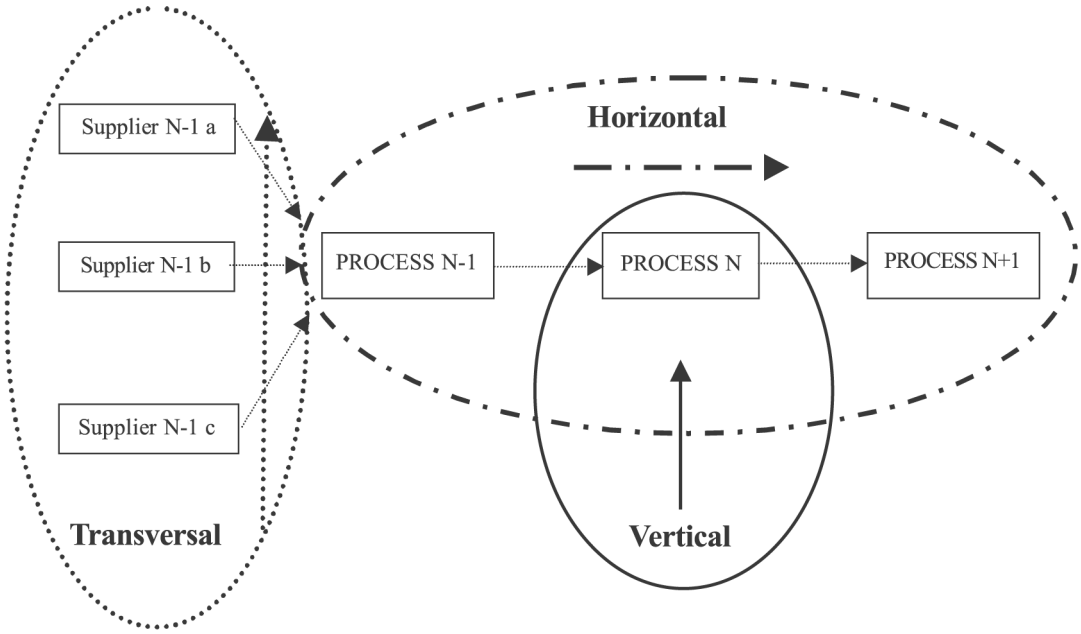
First, we have defined a hierarchy of activities classes, which contribute to the level of service in each tier of the supply chain, and we have shown some examples of the indicators inside each class. Now, we have to attribute each indicator used in the logistic practice to the classes. This is necessary for defining correctly the contribution of each activity (linked to a specific indicator) inside the overall process. In such a way, a company could identify its own indicators among the others or consider new ones individually.

Second, as we have explained, the economic and financial indicators arise from by the engineered indicators and the operational activities cause the relative costs. Anyway, a complete logistics measurement has to include both kinds of indicators. A next step of the research will be the identification of the specific link between each operational activity/indicator and its homologous financial one. The definition of the connections will allow one to evaluate completely the best level of service for the company.

Third, inside each process (i.e. process *N*), many resources work together for the same goal (i.e. several job shops building different parts of the product, more company partners developing services inside the same production process). The complete service is an aggregation of all these contributions. To evaluate the upper level of service, a vertical integration of the specific performance indicators should be defined. However, we supposed that – in some way – we can value service level at a single stage, but in a supply chain we have several service levels, one for each tier of the chain. Therefore, we have to join indicators in a horizontal line along the chain. Then, each level of service is a horizontal aggregation of other corresponding indicators, referring to the previous tiers along the logistic process. Finally, in each tier, there are more actors who take part in the process development (i.e. more suppliers for different components to be assembled in finished products). Thus, for each tier, the global level of service is the composition of the single contribution of any supplier and we can deal with transversal integration (Figure 6).

The definition of a logistic performance measurement system has been till now an open problem. In this paper, we have tried to show a way to classify the performance indicators, building a hierarchy among them. Anyway, many questions have to be solved before the analysis is finished and a complete outline of a logistic measurement system is effected.

Figure 6 Horizontal, vertical and transversal components of the service level



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