Production Planning & Control: The Management of Operations
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tppc20

Impact of performance indicators on organisations: a proposal for an evaluation model

Fiorenzo Franceschini [a], Maurizio Galetto [a] & Elisa Turina
[a] DIGEP, Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino, 10129, Italy
Version of record first published: 13 Mar 2013.

To cite this article: Fiorenzo Franceschini , Maurizio Galetto & Elisa Turina (2013): Impact of performance indicators on organisations: a proposal for an evaluation model, Production Planning & Control: The Management of Operations, DOI:10.1080/09537287.2012.756128

To link to this article: http://dx.doi.org/10.1080/09537287.2012.756128

Production Planning & Control, 2013
http://dx.doi.org/10.1080/09537287.2012.756128

Taylor & Francis
Taylor & Francis Group

Impact of performance indicators on organisations: a proposal for an evaluation model

Fiorenzo Franceschini*, Maurizio Galetto and Elisa Turina

DIGEP, Politecnico di Torino, Corso Duca degli Abruzzi 24, Torino 10129, Italy

(*Received 13 June 2010; final version received 1 December 2012*)

This work aims at giving some guidelines to assess the impact of performance indicators on organisations. Performance measurement systems are usually introduced into organisations in order to monitor goal achievement, to allocate resources and to implement a strategy. However, the implementation of performance indicators may generate an alteration in the rational behaviour of the monitored structure. The risk of this impact is always present, and must be considered very carefully in order to preserve the organisation from a counter-productive effect. In the present analytical work, a reference model is proposed as a first step. This model considers all the organisational dimensions on which an indicator may exert its influence. The method makes use of the four Kaplan and Norton's balanced scorecard perspectives in order to identify the dimensions on which an indicator may exert its impact. Previous works reported in scientific literature do not provide operational models for impact analysis, whereas, the proposed model is linked to an operative procedure in order to support management to make this analysis. The aim is to make the impact analysis less complex by structuring it in a sequence of predefined steps. The proposal is supported by some practical examples.

Keywords: performance indicators; impact assessment; performance management; balanced scorecard; quality management; manufacturing engineering

1. Introduction

The performance of an organisation is usually monitored by means of indicators. A lot of research papers have addressed the design, the implementation and the updating of performance measurement systems (PMSs) which provide the indicators that will be collected, analysed, reported and used to make useful decisions (Neely, Gregory, and Platts 1995; Ghalayini, Noble, and Crowe 1997; Gosselin 2005; Alfaro, Ortiz, and Poler 2007; Azadeh et al. 2007; Bhagwat and Sharma 2009; Franceschini, Galetto, and Turina 2009).

However, indicators always exert an impact on the actions and decisions of companies despite their initial aim. Whether indicators are simply used to monitor a specific process or explicitly introduced to enhance its performance, they act as conceptual technologies embedding normative assumptions and influencing the behaviour of organisations (Barnetson and Cutright 2000). In general, the decision of introducing a new performance indicator (or a set of indicators) is enough to influence the organisation. This is a crucial aspect which must always be taken into account.

To better understand the phenomenon of impact, let us consider the following example (Hauser and Katz 1998). A telephone service centre, in order to create incentives for the telephone representatives and increase the level of service provided to customers, began to measure a variety of metrics such as the number of rings until the phone was answered, the time spent in the queue until a live representative could come to the line and the number of calls answered per hour by each representative. Soon the performance improved but the customers were ultimately dissatisfied. To increase the number of calls per hour and be ready to answer the next call immediately, telephone representatives rushed customers and gave them the most convenient answer. Some representatives even hung up on customers immediately after answering without saying anything in order to improve their metrics. As Hauser and Katz (1998) conclude the service centre became what it measured, a place to process a lot of calls quickly.

One of the main concerns in performance management is to find the 'right' indicators for monitoring a given process or system. In the selection of indicators, managers often consider only indicator relevancy (US Department of the Treasury 1994; PMB SIG 2001; Kennerly and Neely 2003; Micheli and Kennerley 2005; University of California 2010). However, as in the previous example, although indicators were considered well defined (Hauser and Katz 1998), coherent with the

*Corresponding author. Email: fiorenzo.franceschini@polito.it

monitored goals (e.g. a high number of calls answered per hour is an index of good service quality), easy to understand and use, and with an appropriate level of detail, customers were ultimately dissatisfied. Using Caplice and Sheffy's words (1994), the indicators were not 'behaviourally sound' since they created incentives for improper acts. This subtle effect is a consequence of performance indicator impact.

Up to now, the research conducted in order to understand how PMSs impact organisations has not yet produced definitive results, although this is a topic of great interest (Gomes, Yasin, and Lisboa 2004; Bourne, Kennerly, and Franco-Santos 2005).

The issue of the impact of performance indicators on organisations is complex and difficult to quantify. It is strictly dependent on the internal (e.g. cultural values, size and resources) and external (e.g. socio-economical) organisational contexts. The main aim of the present analytical work is to suggest an approach to identify which of the specific organisational dimensions are actually impacted on and evaluate if an overall positive or negative effect has occurred. Furthermore, a methodology to guide management in the selection of indicators according to their impact is proposed.

The paper is structured as follows. Section 2 provides the definition of indicator, and a taxonomy of its properties. Following that, the concept of impact is considered and an overview of the literature on this topic is given. Section 3 proposes a reference model for impact assessment and procedures to evaluate the impact of a set of indicators. An application example of the methodology in the field of physical distribution service (PDS) is also given. In Section 4, conclusions and future directions of this research are presented.

2. Basic concepts and literature review

In the present Section, the concepts of performance indicator and indicator impact are defined and discussed in order to give the basis to understand the methodology described in the following Sections.

2.1. *Performance indicator definition*

The definition of indicator is strictly connected to the notion of *representation-target*. A representation-target is the operation aimed at making a *context*, or part of it, 'tangible' in order to perform evaluations, make comparisons, formulate predictions, take decisions, etc. In a given context, one or more different representation-targets can be defined. A set of indicators is a tool which operationalises the concept of representation-target (Franceschini et al. 2006; Franceschini, Galetto, and Maisano 2007).

For example, if the context is the 'logistic process' of a company, the representation-target may be the 'classification of suppliers'. The 'delivery time' and the 'lead time' can be two of the possible related indicators.

Given a representation-target, the related indicator (or set of indicators) is not univocally defined. The same representation-target can be represented by more independent indicators (or sets of indicators). There is no algorithmic procedure to identify the 'optimal' set of performance measures (Roberts 1979; Roy 1996; Franceschini et al. 2006; Franceschini, Galetto, and Maisano 2007).

Usually, the selection of indicators, even if not optimal, is supported by the analysis of their properties. Basing on the literature, a taxonomy of indicators properties is reported in Table 1 (Caplice and Sheffi 1994; Tuck and Zaleski 1994; PMB SIG 2001; Kennerly and Neely

Table 1. Taxonomy of indicators properties (Franceschini, Galetto, and Maisano 2007).

Properties of indicators		
General properties	Consistency with the representation-target	The indicator should properly represent the representation-target
	Level of detail	The indicator should not provide more than the required information
	Non-counter-productivity	Indicators should not create incentives for counter-productive acts
	Economic impact	Each indicator should be defined considering the expenses to collect the information needed
	Simplicity of use	The indicator should be easy to understand and use
Properties of sets of indicators	Exhaustiveness	Indicators should properly represent all the system dimensions, without omissions
	Non-redundancy	Indicators set should not include redundant indicators
Properties of derived indicators	Monotony	The increase/decrease of one of the aggregated indicators should be associated to a corresponding increase/decrease of the derived indicator
	Compensation	Changes of different aggregated indicators may compensate each other, without making the derived indicator change
Accessory properties	Impact	For each indicator the impact on process should be carefully analysed
	Long-term goals	Indicators should encourage the achievement of process long-term goals

2003; Franceschini, Galetto, and Maisano 2006; University of California 2010).

2.2. *The concept of indicator impact*

The example of the call centre in Section 1 shows that indicators even if considered well defined (i.e. they satisfy a required set of properties) may exert an undesired impact on the monitored system. In the present work, the following definition of the concept of impact is applied: 'impact is any alteration of an organisation behaviour resulting from the implementation of a PMS'. It is worth noting that an indicator exerts an impact independently from the registered values. The behaviour of an organisation may be altered just because a performance measure is going to be introduced.

The aim of this paper is to propose a set of tools to analyse impact of alternative indicators (or sets of indicators) which are not further distinguishable considering their properties (see Figure 1). Impact analysis is developed *before* the implementation of a given PMS in order to support the selection of the most relevant set of indicators.

2.3. *Literature review*

The concept of impact has been often considered in the field of production and service management. The need to understand what impact is and to construct appropriate methodologies for its evaluation is a common matter.

Wainwright states that 'impact is any change resulting from an activity, project or organisation and it includes intended as well as unintended, negative as well as positive, and long term as well as short term effects' (Wainwright 2002). She concludes that 'no single tool measures the full spectrum of impact'. Impact may occur just because an organisation implements a set of indicators, regardless of the achieved values.

Barnetson and Cutright (2000) analyse that the indicators used to monitor the performances of Canadian higher education colleges. The authors state that indicators are normative tools that shape what we think and how we think about. They recognise six different typologies of embedded assumptions in each indicator: value, definition, goal, causality, comparability and normalcy.

Bourne, Kennerly, and Franco-Santos (2005) deal with the issue of how performance measurements impact organisations. They recognise three dimensions on which to base impact analysis: organisational context (internal and external), performance measurement content and process.

In literature, several elements are considered as they may exert a conditioning effect on indicator impact. It is worth citing, foremost among these:

- System maturity: this is reflected in the scope of measures used to assess organisational performance (Bourne, Kennerly, and Franco-Santos 2005). Evans (2004) demonstrated that organisations with more mature PMSs report better

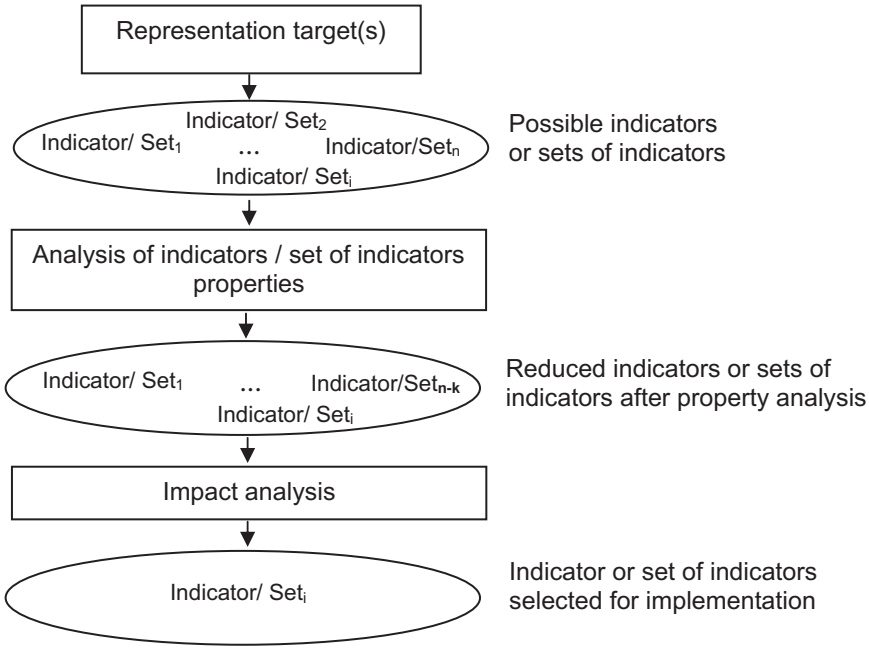

Figure 1. Impact analysis is applied when alternative indicators (or sets of indicators) may be not selected only on the basis of the examination of their properties. It is developed *before* the implementation of a given PMS.

results in terms of customer, financial and market performance. Organisation maturity is also influenced by the cultural values of an organisation (Andersen and Jessen 2003).

- Organisational size: Hoque and James (2000) observe that a greater usage of PMSs is associated with larger organisation size even if this does not imply performance improvement. Hudson, Lean, and Smart (2001) identify different elements contrasting with the implementation of PMSs in small and medium enterprises such as short-term focus, scarce resources, the length of implementation time and a flat organisation structure.
- Organisational structure: Nahm, Vonderembse, and Koufteros (2003) state that a time-based manufacturing strategy impacts performances. The introduction of a set of performance indicators is a typical time-based manufacturing practice, so there must be alignment between this and the organisational structure. The organisational structure dimensions considered are: the nature of formalisation (flexible or formal work rules), the number of layers in the hierarchy (few or many levels of management), the level of horizontal integration (integrated or functionally specialised departments and workers), the locus of decision-making (centralised or decentralised strategic decision-making) and the level of communication (fast, easy or slow, difficult and limited communication).
- Organisational culture: this can be defined by means of criteria flexibility and discretion vs. stability and control, internal focus and integration vs. external focus and differentiation (Cameron and Quinn 1999). According to Henry (2006), it is necessary to align organisational culture and PMS functions. For example, if the criterion flexibility is dominant, indicators are used to focus attention on those aspects considered the 'most convenient', while, if the control criterion prevails, indicators are used to legitimise management actions.
- Resources: competent employees who design, implement, analyse and modify performance measurements and proper infrastructures to gather and report data are fundamental (Kennerly and Neely 2002).
- Information system: its configuration should be suitable for the considered organisational structure (Heo and Han 2003).
- Management style (Schein 2004).
- Alignment with objectives: this refers to the agency theory which can be seen as an approach to analyzing indicator impact on organisations on the whole. According to the agency theory, the behaviour of an organisation may be modelled by identifying two actors, the principal and the agent, whose objectives are not aligned. Indicators are then introduced with the aim of inducing an impact. They are linked to incentives and are used to align the principal and agent objectives (Atkinsons 1998).
- Interpretation and evaluation, communication, and information provision: Kerssens-van Drongelen and Fisscher (2003) state that the actors involved in a performance measurement must adhere to implicit moral issues in order to avoid detrimental effects. For example, evaluators should declare the intended use of metrics, select a complete set of metrics that reflect the responsibilities of each single operator and design appropriate data collection methods.
- PMS content: this refers to the need for a structured approach in designing a PMS (Bourne, Kennerly, and Franco-Santos 2005).
- Structure and presentation: this is related to the format used to present indicators to managers (Lipe and Salterio 2002).

Following this bibliographic analysis, some critical aspects must be highlighted:

- Generally, impact models in literature are scarcely operational. A structured procedure to evaluate the impact on each model dimension is not suggested.
- Different sets of indicators cannot be compared from the impact point of view. If there is no operational procedure to assess impact, it is not possible to select a set of indicators according to the impact it exerts.
- Usually impact dimensions are not clearly identifiable. For example, to classify the culture which prevails within an organisation is not an easy task.
- Overall, the impact dimensions proposed in the different models are not independent. For example, factors characterising impact in SMEs include resources and organisational structure, which the authors consider to be independent of each other.

This paper introduces a methodology for impact assessment which tries to overcome the limits here discussed. In detail, first an operational model to identify the organisational dimensions impacted by indicators is proposed. Then tools for impact assessment are introduced. It is worth noting that the assessment of impact is strongly influenced by contextual factors which are not standardised, and must be carefully considered by decision-makers case by case.

3. A proposal for impact assessment

As stressed in Section 2, indicators are tools which make organisation processes tangible on the basis of a given representation-target. Furthermore, very often, for a given representation-target, the indicators are not unique. Impact analysis can be used to select an indicator (or a set of indicators) according to the impact it exerts (see Figure 1).

The current approaches considered in scientific literature illustrate fundamental but partial aspects of the impact of performance indicators. This paper proposes an evaluation model which enables different organisational dimensions influenced by the introduction of indicators to be identified. This framework should be general in order to be applied to different kinds of organisations (see Section 3.1). The dimensions of impact are then analysed by means of specific tools (see Sections 3.2 and 3.3). Figure 2 reports the steps of impact analysis which will be thoroughly described in the following sections.

In order to give an answer to the critical aspects originating from literature, reported at the end of Section 2, the first aim of the paper is to define a structured operational procedure with which to evaluate the impact of indicators. This can be done only if a clearly identified set of impact dimensions is specified.

On the whole, there are many models detailed in the literature which may inspire the definition of an appropriate set of *basic impact dimensions*. An essential condition is that the reference model and related dimensions have a general applicability in order to be used in any kind of organisation, independently of the commodity sector, structure, size, etc.

On the contrary, the *criteria of analysis* which stem from impact dimensions are defined according to the nature of the organisation and the related conditioning elements (see Section 2).

Among the models most cited in scientific literature and widespread both in the field of services and manufacturing it is worth mentioning:

- The *European Foundation for Quality Management (EFQM) Excellence model* (EFQM 2011), which is used to assess an organisation's progress towards excellence, independently of the organisation's type, size, structure and maturity.
  The model is based on nine criteria (dimensions). Five of these are classified as 'Enablers' and four as 'Results'. The 'Enabler' criteria cover what an organisation does, and the 'Result' criteria cover what an organisation achieves. Feedback from 'Results' helps to improve 'Enablers'.
  The EFQM model is based on the premise that excellent results with respect to Performance, Customers, People and Society are achieved through Leadership driving Policy and Strategy, which is delivered through People Partnerships and Resources and Processes. Each criterion can be considered as a specific area to be examined from the impact point of view.
- The *Malcolm Baldrige National Quality Award model* (Baldrige Foundation 2011), which recognises US organisations in the business, health care, education and non-profit sectors for performance excellence. It is administered by the Baldrige Performance Excellence Program,

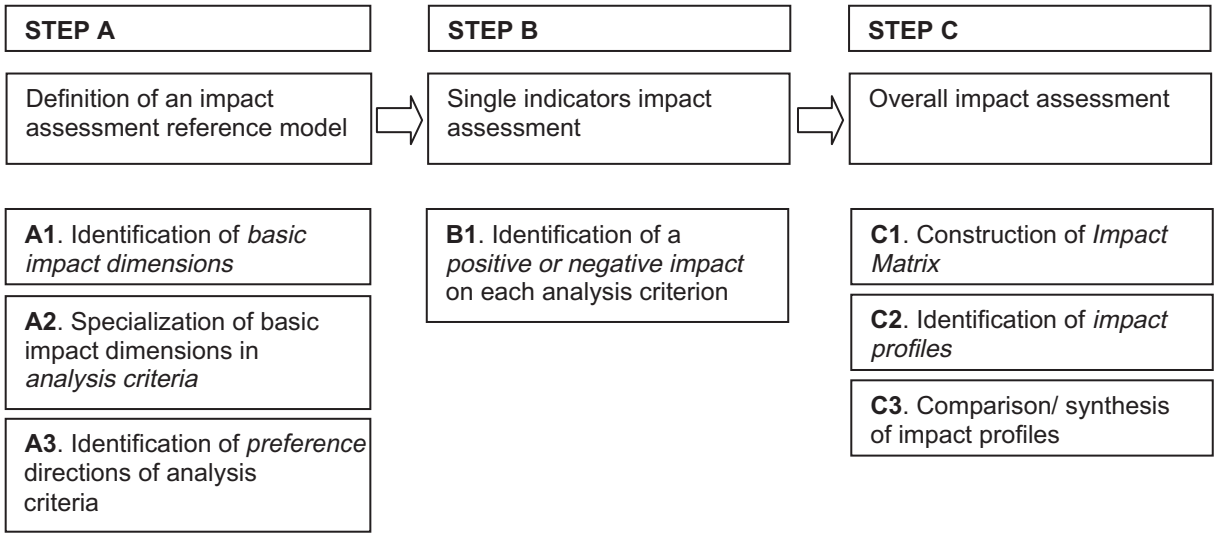

Figure 2. Steps of the proposed methodology for impact assessment. Each macro-step is detailed in sub-steps which are fully described in the following sections.

which is based at and managed by the National Institute of Standards and Technology, an agency of the US Department of Commerce.
The award promotes the sharing of successful performance strategies and the benefits derived from using these strategies. The award is not given for specific products or services.
The model is based on a set of criteria (dimensions) which work as an integrated framework for managing an organisation. Respectively they are: Leadership, Strategic planning, Customer focus, Measurement, analysis and knowledge management, Workforce focus, Operations focus and Results. Again these criteria can be considered as the dimensions for impact evaluation.

- The *balanced scorecard (BSC) model* originally introduced as a way of motivating and measuring an organisation's performance (Kaplan and Norton 1992). The concept takes a systematic approach in assessing internal results, while probing the external environment. It focuses as much on the process of arriving at 'successful' results, as on the results themselves. Use of the BSC requires organisations to limit the number of measures to a vital few.
The method looks at four interconnected perspectives (dimensions) which are fully described in the next Section 3.1.

Each of these approaches can be used as a starting reference model for the definition of the *impact dimensions*. In the following, as an example, the use of the BSC is proposed and discussed.

3.1. *The reference model (BSC-IM)*

The proposed approach originates from Kaplan and Norton's BSC model (Kaplan and Norton 1992, 1996, 2001), which is widely recognised to be a balanced framework in describing an organisation. It recognises four perspectives (or dimensions): *financial*, *internal business process*, *learning and growth* and *customer*. The *financial* dimension is related to the organisation's financial aspects. The *customer* perspective considers what an organisation has to do for its customers in order to ensure financial success. The *internal business process* dimension concerns which processes most influence customer satisfaction. Finally, the *learning and growth* perspective concerns what improvements can be made to ensure sound business processes and satisfied customers. BSC perspectives are common to all kinds of organisation.

Over the years, the BSC approach has become more widespread and has been extensively used and tested in a variety of organisational contexts. For that reason it can represent an effective starting point for impact assessment.

As the BSC model considers all the operative aspects of an organisation, it could be used as a reference model to identify the areas impacted by performance indicators. In this way, the four perspectives of BSC are interpreted as the basic dimensions on which indicators may exert their impact. However, it must be remarked that other reference models may be used.

The proposed methodology is organised in two steps. A first step identifies each BSC perspective as a *basic impact dimension*. Then, starting from basic impact dimensions, *analysis criteria* are defined as shown in Figure 3, referring to the example of a manufacturing firm.

The criteria are a further specialisation of the basic impact areas and contextualise them in the organisation examined. For example, in a manufacturing firm, two analysis criteria for the 'Internal Business Process' (basic impact dimension) may be the 'quantitative production level' and the 'cycle time'.

Using this approach, the BSC model is transformed into a *reference model for impact assessment*, which is called as BSC Impact Model (BSC-IM). As an example, Table 2 reports the BSC-IM for a manufacturing organisation. Each basic dimension is split into a set of analysis criteria deriving from the literature about performance measurement in manufacturing companies (Ghalayini, Noble, and Crowe 1997; Gosselin 2005; Azadeh et al. 2007). Similarly, an analogous list of criteria may be drawn up for an organisation operating in the domain of services. When the BSC-IM is developed for a particular organisation, criteria are identified by top management in order to depict that specific context.

Criteria indicated in Table 2 may have different *preference* directions. In general, the preference direction is the way towards which there is a strategic improvement from the organisation point of view. As an example, if the strategic plan includes the growth of the market share, the criterion 'Sales' has an increasing (↑) preference direction. On the opposite, the criterion 'Environmental impact' may have a decreasing (↓) preference direction due to environmental regulations. Other examples are reported in Table 3.

The preference direction of a given analysis criterion must be considered in conjunction with the effect produced by the introduction of the indicator as better explained in Section 4.2.

3.2. *Procedure for impact assessment of a single indicator*

As remarked in the previous sections, the assessment of impact involves several contextual factors which can be

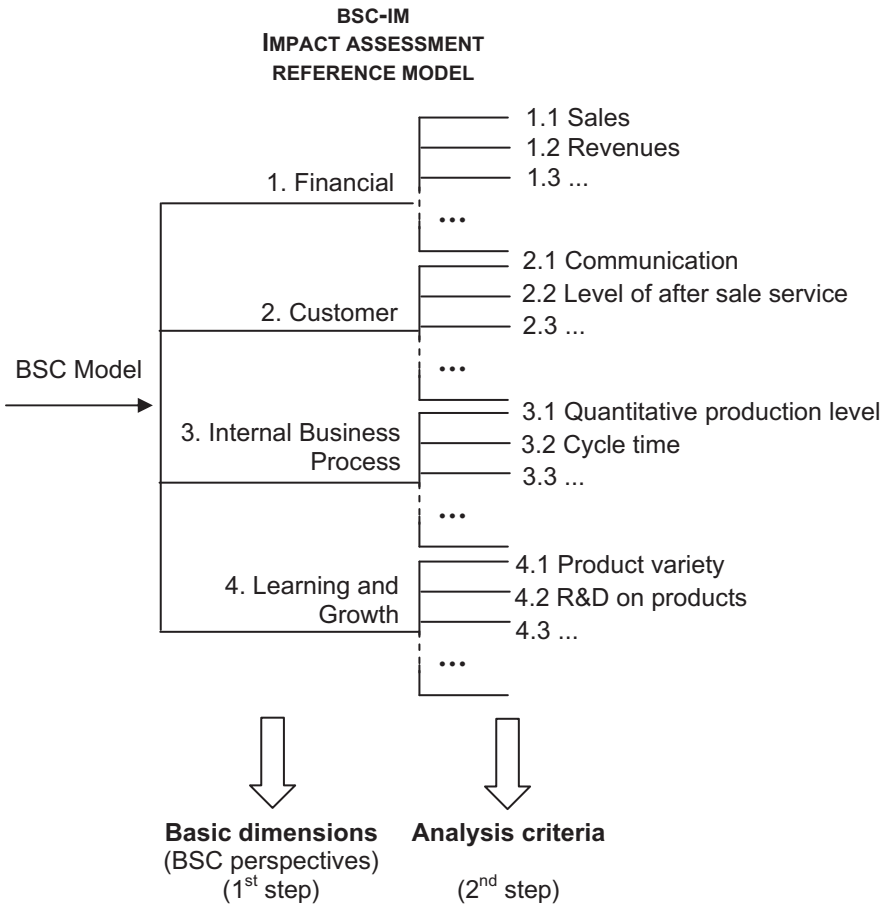

Figure 3. Construction of the impact assessment reference model. The four BSC perspectives (Kaplan and Norton 1992, 1996, 2001) become a support to define basic dimensions (1st step) and analysis criteria (2nd step) for impact assessment. The scheme takes as an example a manufacturing firm.

hardly quantifiable. For example, as reported in Section 2, organisations with different cultures may react in a different way to the introduction of the same indicator. Another critical contextual factor is the method of data capture. The way the data are collected (e.g. automated acquisition or not, monitoring frequency, etc. …), including the option of communicating the monitoring results to the employees, may strongly affect the impact of an indicator. The analysis of all the contextual factors and of their interrelations may be not standardised. In view of these conditions, it may be very complex for the management to give a reliable global impact evaluation. As a preliminary approach, the proposal reported in this paper is that of evaluating the impact of each single indicator by means of an ordinal scale (i.e. positive, null or negative impact). At this stage, the aim is obtaining a rough estimation of the impact exerted.

The choice of a three-level ordinal scale is suggested by the intrinsic nature of impact evaluation. It allows limiting ambiguities of interpretation, preserving the properties of empiricity and objectivity of a measurement (Roberts 1979; Finkelstein 1982; Franceschini, Galetto, and Maisano 2007).

It follows that the mathematical operators employed for analysing and aggregating data obtained using an ordinal scale should comply with its related properties (Roberts 1979).

Long-term and short-term impacts are considered as well when properties are analysed (see Section 1). In detail, impact assessment of single indicators is based on the assumption of *rational reaction* of the organisation, meaning that the decision-maker is able to anticipate the reaction of the organisation. Expectations are based on the know-how of the management on the specific contextual factors (e.g. existing technologies, collective agreement, organisational culture, etc. …). It is worth noting that the assumption of rational behaviour does not imply that people automatically react to improve the organisation performances, but they may try to optimise their own workspace.

To better understand the assumption of rational behaviour, consider the two following examples.

Table 2. Reference model for impact assessment of a manufacturing firm.

BSC IM	
Basic dimensions	Analysis criteria
Financial	Sales Revenues Cost of human resources Cost of raw materials, goods and external services Other costs Investments Amount of debt
Customer	Communication After sale service Perception of final product/service Organisation image
Internal business process	Quantitative production level Cycle time Qualitative production level (final products) Qualitative production level (incoming products) Delivery Stock level Capacity utilisation Expansion Satisfaction of human resources Productivity of human resources Security of human resources Environmental impact
Learning and growth	Product variety Research and development on products Research and development on process Competitiveness Response time Conformity to customer requirements Rationality in setting and development of projects Education, training and qualification of human resources Self-learning

The first column represents the basic dimensions (Kaplan and Norton 1992, 1996, 2001). The second column shows the analysis criteria for the specific typology of organisation (Ghalayini, Noble, and Crowe 1997; Gosselin 2005; Azadeh et al. 2007).

Case a. A manufacturing organisation measures the productivity of a production line (i.e. products realised in a given unit of time) to define future salaries based on this indicator. Supposing that the purpose of evaluation is declared, decision-makers, basing on the knowledge of the specific context, forecast that people will try to work as hard as possible to get excellent performances.

Case b. A manufacturing organisation assesses the productivity of a production line to set new standard times for the assembly process. Assuming that the aim of this evaluation is declared, decision-makers forecast that people will try to work as slow as possible to avoid that the new standard times for their process get shortened.

The foresight of the organisation reaction to indicators depends then on the specific purpose of evaluation and on the contextual conditions which may vary case by case.

After the definition of the impact reference model (Step A of Figure 2), the assessment of a single indicator impact is then developed for each analysis criterion as follows (Step B of Figure 2):

- Step 1. Identify the indicator to be analysed.
- Step 2. Identify the analysis criterion and its preference direction.
- Step 3. Forecast the organisation reaction.
- Step 4. Identify the effect of the hypothesised reaction on the analysis criterion.
- Step 5. Identify a positive (P) or negative (N) impact.

Referring to the two previous examples (Case a and Case b) on 'productivity' indicator, we explain the methodology considering the criterion 'cycle time' with a decreasing preference direction (↓) (see BSC-IM in Table 3).

Case a. Hypothesising that people will try to work as hard as possible, the effect of this reaction is that the cycle time will decrease. In this case, we may say that the criterion is subjected to a decreasing effect since the cycle time reduces. To represent this effect on the criterion, we introduce a second arrow (↓) (see Tables 4 and 5). The last step of analysis (Step 5) entails the identification of a positive or negative impact.

In general, in order to identify if a positive or negative impact occurs, the following logic is implemented: the resulting impact is positive (P) if there is an increasing effect on a criterion with an increasing preference direction or a lowering effect on a criterion with a decreasing preference direction. Otherwise, the impact is negative (N). If there is no effect on the criterion the impact is null. Table 4 shows all the possible configurations which may or may not generate a positive (P) or negative (N) impact.

In the current example (Case a, see Table 5), a positive impact occurs (↓⊗↓ ⇓ P in Table 4).

Case b. Assuming that people will work as slow as possible, the cycle time will increase. In this case, we may say that the criterion is subjected to an increasing (↑) effect since the cycle time growths (see Table 6). The impact on the criterion 'cycle time' is then negative (↓⊗↑ ⇓ N in Table 4).

We remark that the most critical step is the identification of organisation reaction and its effect on each criterion. This requires the analysis of all the contextual factors. Then the evaluator can deduce the resulting positive or negative impact by observing which case of Table 4 is present.

Table 3. Preference direction of the BSC-IM criteria for a manufacturing context (see Table 2).

Financial		Internal business process		Customer		Learning and growth	
Sales	↑	Quantitative production level	↑	Communication	↑	Product variety	↑
Revenues	↑	Cycle time	↓	After sale service	↑	Research and Development on products	↑
Cost of human resources	↓	Qualitative production level (final products)	↑	Perception of final product/service	↑	Research and Development on process	↑
Cost of raw materials, goods and external services	↓	Qualitative production level (incoming products)	↑	Organisation image	↑	Competitiveness	↑
Other costs	↓	Delivery	↑			Response time	↑
Investments	↑	Stock level	↑			Conformity to customer requirements	↑
Amount of debt	↓	Capacity utilisation	↑			Rationality in setting and development of projects	↑
		Expansion	↑			Education, training and qualification of human resources	↑
		Satisfaction of human resources	↑			Self-learning	↑
		Productivity	↑				
		Security of human resources	↑				
		Environmental impact	↓				

The symbol '↑' indicates an increasing preference direction, while '↓' stands for a decreasing preference direction.

In Figure 4, the logical scheme for impact analysis of a single indicator is summarised. For each indicator, the described procedure produces a record of P and N symbols (impact record). Different indicators identified for a given representation-target may be compared according the *impact record* of Ps and Ns they attain (see Figure 5).

Even if a critical aspect of the proposed method is the alignment of expected changes in a company, the strengths of this approach lies in the fact that it forces the manager (decision-maker) to deeply analyse the organisation behaviour, the possible reactions to the introduction of a given indicator (or set of indicator) and the context in which it operates.

3.3. *Overall impact assessment*

A different matter is comparing the impact of different sets of indicators. Approaches pursuable in order to face this problem entail the use of a synthesis procedure.

To support this activity, an *impact matrix* (Figure 5) is built: rows correspond to indicators and columns to analysis criteria. Each cell of the matrix contains the impact evaluation obtained by the procedure proposed in Section 3.2. The impact matrix allows to:

- Obtain a picture of the impact on all the organisational dimensions.
- Obtain a first rough information on the impact exerted by specific indicators observing the *impact records* (see Figure 5). In this case, the most critical indicators may be preliminarily identified and modified in order to vary the overall impact.
- Highlight the *cross impact* of an indicator. An indicator may exert an impact on different organisational dimensions as shown by its *impact record* (see Figure 5). For example, suppose that a manufacturing organisation introduces the indicator 'inventory costs'. Basing on the BSC-IM,

Table 4. Reference table for the identification of an indicator positive or negative impact (Step 5 of the procedure for single indicator impact assessment).

Case number	Column 1 Criterion preference direction	Column 2 Effect of the organisation reaction on the criterion	Column 3 Positive/negative impact
(1)	↑	↑	↓⊗↓ ⇓ P
(2)	↑	↓	↑⊗↓ ⇓ N
(3)	↑	–	O
(4)	↓	↑	↓⊗↑ ⇓ N
(5)	↓	↓	↓⊗↓ ⇓ P
(6)	↓	–	O

Column 1 shows the criterion preference direction. Column 2 schematises the effect on the criterion of the organisation reaction to the indicator. The criterion may be subjected to an increasing (↑) or lowering (↓) effect. Column 3 shows impact evaluation. If, for a given criterion, both columns 2 and 3 present the same symbol, a positive (P) impact is obtained. Otherwise, the impact is negative (N), (O) = null impact.

Table 5. Impact analysis of indicator and productivity' on the criterion 'cycle time' – case a.

Step 1	Step 2	Step 3	Step 4	Step 5
Indicator	**Analysis criterion preference direction**	**Organization reaction to the indicator**	**Effect of the organization reaction on the criterion**	**Impact**
Productivity (products realized in a given unit of time)	Cycle time Decreasing preference direction: ↓ A shorter cycle time is preferable	People will try to work as **hard** as possible since future salaries will be based on productivity	Cycle time Decreasing effect: ↓ Cycle time reduces	↓⊗↓ ⇓ **P** Positive impact

Table 6. Impact analysis of indicator and 'productivity' on the criterion 'cycle time' – case b.

Step 1	Step 2	Step 3	Step 4	Step 5
Indicator	**Analysis criterion preference direction**	**Organization reaction to the indicator**	**Effect of the organization reaction on the criterion**	**Impact**
Productivity (products realized in a given unit of time)	Cycle time Decreasing preference direction: ↓ A shorter cycle time is preferable	People will try to work as **slow** as possible since new standard times for assembly will be set	Cycle time Increasing effect: ↑ Cycle time increases	↓⊗↑ ⇓ **N** Negative impact

the indicator 'inventory costs' impacts the financial area (e.g. criterion 'other costs' is affected since there may be a reduction of inventory costs) as well as the internal business process one (e.g. criterion 'stock level' is affected since to cut inventory costs the amount of stock keeping units may be reduced).

Starting from the impact matrix, an overall comparison of different sets of indicator is possible. Two are the main issues addressed (see Figure 5):

(1) The assessment of the impact of a set of indicators on a specific criterion.
(2) The assessment of the impact on all criteria.

Given a set of n indicators ($i = 1, ..., n$) and a corresponding set of m criteria for impact assessment ($j = 1, ..., m$):

step 1: identify indicator i to be analyzed;
step 2: for criterion j: identify its preference direction;
step 3: forecast the organization reaction to indicator i;
step 4: identify the effect of the organization reaction on criterion j:
- if there is no effect, impact is null, then STOP;
- else: identify if the effect on criterion is increasing or decreasing, then go to step 5;

step 5: compare criterion j preference direction and the effect of the organization reaction on criterion j:
- if they are consistent (both increasing or decreasing), impact is positive;
- else, impact is negative.

Figure 4. Scheme for impact analysis.

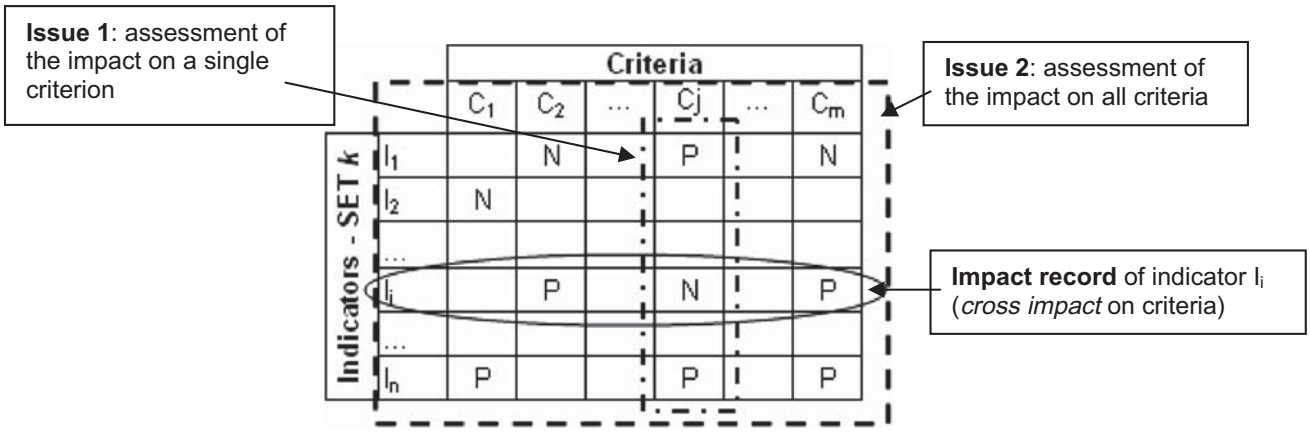

Figure 5. Schematic representation of the 'impact matrix'. Rows represent the 'impact records' of each indicator of a set. Columns represent the impact exerted by the set of indicators on each single criterion. The two main issues of impact analysis are also highlighted.

The above issues entail the synthesis of the information contained in impact matrix. In order to determine the most appropriate logic of synthesis, many questions arise such as identifying the set with the maximum positive impact, the minimum negative impact, etc ... Furthermore, in the assessment of the impact of the set indicators it could be required to assign different weights to BSC-IM criteria.

A rigorous analysis of the impact matrix, in order to get a comparison between the overall impacts of two (or more) set of indicators, may be based on a two-steps approach:

(1) First, the impact of the whole set of indicators on each single criterion is evaluated (construction of the set profile). This entails the definition of an appropriate logic for impact synthesis. Two possible examples are:

- *minimum negative impact* logic: for each column of the impact matrix the total number of 'Ns' is counted and
- *maximum positive impact* logic: for each column of the impact matrix the total number of 'Ps' is counted.

Referring to the set of indicators in Table 7, two different set profiles have been obtained by applying, respectively, the 'minimum negative impact' logic and the 'maximum positive impact' logic. More refined techniques for the synthesis of impact on a criterion may be applied. For example, fuzzy operators may be used to aggregate data expressed on ordinal scale (Yager and Filev 1994).

(2) The second step consists in a graphical representation of the different set profiles. A multiple axes Cartesian Graph is constructed (impact chart). For each criterion, an axis is drawn in order to report the synthesis value obtained in the set profile. In this way, set profiles can be represented and compared with other profiles (see Figure 6).

Referring to Figure 6, two cases are considered:

Figure 6(a)) set 2 exerts an impact higher or equal to set 1 on each criterion.

Figure 6(b)) the result of the comparison is not automatically achievable; the two profiles intersect each other.

A deeper analysis may be performed by introducing specific methods for profiles comparison. As an example, the Borda's indicator may be adopted (Borda 1781; Saari 1995). This is given by the sum of the ranking of each set of indicators on analysis criteria (1 for the first position in the ranking, 2 for the second one and so on):

$$I_B(x) = \sum_{i=1}^{m} r_i(x)$$

where $r_i(x)$ is the ranking of set of indicators x on the criterion i ($i = 1, \ldots, m$).

The set of indicators which exerts the highest positive impact is given by:

$$I_B(x^*) = \min_x \{I_B(x)\}$$

The mathematical operator used for computing Borda's indicator does not violate the properties of ordinal scales used for impact evaluation (Roberts 1979). Other methods in order to analyse and process ordinal data may be introduced with the only restriction that they must comply with the ordinal scale properties (Franceschini, Galetto, and Varetto 2005).

Table 7. Example of impact matrix with two different synthesis set profiles obtained by applying, respectively, the minimum negative impact logic and the maximum positive impact logic.

	Criteria					
Indication	C_1	C_2	C_3	C_4	C_5	C_6
I_1	P	0	N	P	P	0
I_2	P	0	N	P	N	0
I_3	N	P	N	0	0	P
I_4	N	P	P	N	N	P
I_5	0	P	P	N	P	P
I_6	0	N	N	N	N	0
'Minimim negative impact' profile	2	1	4	3	3	0
'Maximum positive impact' profile	2	3	2	2	2	3

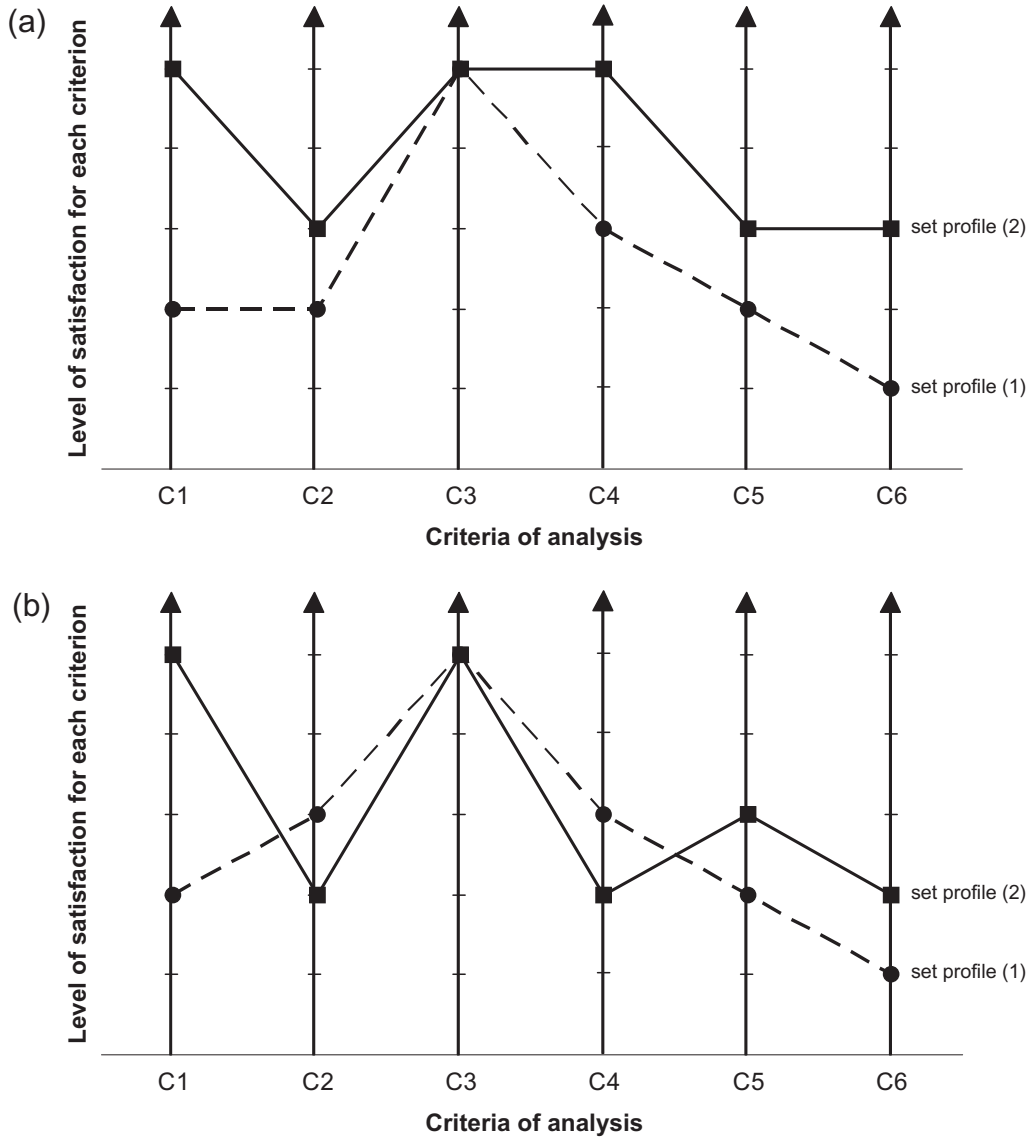

Figure 6. Example of *impact charts* for two different sets of indicators. Six criteria of analysis (C_1, .., C_6) are considered. Each axis corresponds to a criterion in impact analysis. Two different cases are represented: in 6 (a) set 1 exerts on each criterion an impact higher or equal to set 2 and in 6 (b) the result of the comparison is not automatically achievable.

Table 8. Construction of the *impact records* for each indicator of two different sets proposed by (a) Jackson, Keith, and Burdick (1986) and (b) Levy (1981) in the field of (PDS) for customer service evaluation. In this example, there is a subset of the BSC-IM criteria reported in Table 2.

(a)

SET 1 (Jackson et al., 1986)	DIMENSIONS OF THE BSC-IM MODEL																	
	FINANCIAL						PRODUCTION						CUSTOMER			INNOVATION AND LEARNING		
	C_1 Sales			C_2 Cost of raw materials, goods and external services			C_3 Quantitative production level			C_4 Productivity of human resources			C_5 Level of offered service			C_6 Research and development on processes		
Order progress information	↑	0	0	↓	0	0	↑	0	0	↑	↑	P	↑	↑	P	↑	0	0
Average order cycle time	↑	0	0	↓	↑	N	↑	↑	P	↑	↑	P	↑	↑	P	↑	↑	P
Order cycle time variability	↑	0	0	↓	↑	N	↑	↓	N	↑	↑	P	↑	↑	P	↑	↑	P
Availability	↑	↑	P	↓	↑	N	↑	↑	P	↑	↑	P	↑	↑	P	↑	0	0
Protective packaging	↑	0	0	↓	↑	N	↑	0	0	↑	0	0	↑	↑	P	↑	0	0
Cooperation	↑	0	0	↓	↑	N	↑	↑	P	↑	↑	P	↑	↑	P	↑	0	0

(b)

SET 2 (Levy, 1981)	DIMENSIONS OF THE BSC-IM MODEL																	
	FINANCIAL						PRODUCTION						CUSTOMER			INNOVATION AND LEARNING		
	C_1 Sales			C_2 Cost of raw materials, goods and external services			C_3 Quantitative production level			C_4 Productivity of human resources			C_5 Level of offered service			C_6 Research and development on processes		
Ordering convenience	↑	↑	P	↓	0	0	↑	0	0	↑		0	↑	↑	P	↑	0	0
Average order cycle time	↑	0	0	↓	↑	N	↑	↑	P	↑	↑	P	↑	↑	P	↑	↑	P
Order cycle time variability	↑	0	0	↓	↑	N	↑	↓	N	↑	↑	P	↑	↑	P	↑	↑	P
Availability	↑	↑	P	↓	↑	N	↑	↑	P	↑	↑	P	↑	↑	P	↑	0	0
Terms of sale	↑	↑	P	↓	↑	N	↑	↓	N	↑	0	0	↑	↑	P	↑	↑	P

Legend: P = Positive impact, N = Negative impact, 0 = no impact.

The impact of each single indicator has been assessed by applying the procedure of Section 3.2. For each criterion, the first column shows the criterion preference direction, the second one schematises the effect on the criterion of the organisation reaction to the indicator and the third one shows if a positive or negative impact is exerted.

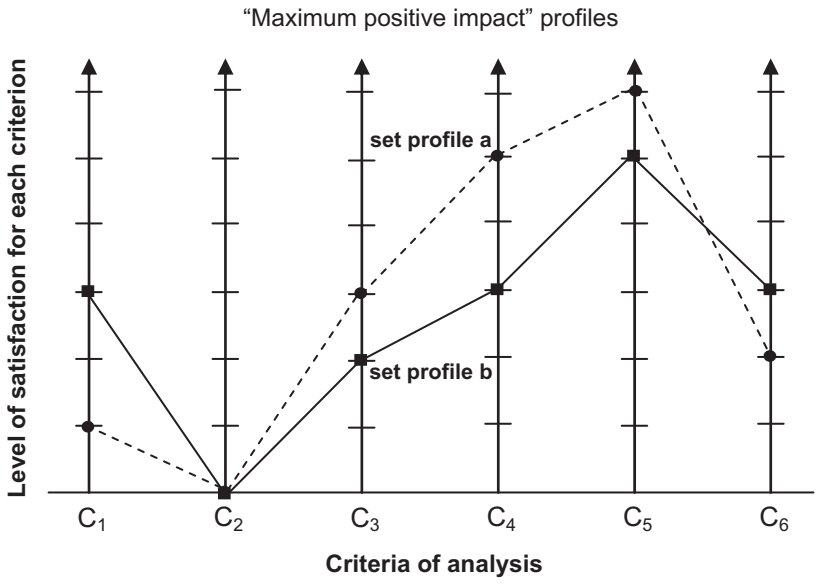

Figure 7. *Impact chart* obtained for the comparison of two different sets of indicators proposed by (a) Jackson et al. (1986) and (b) Levy (1981), respectively, in the field of PDS for Customer Service evaluation (see Table 7).

Table 9. *Impact matrices* obtained for the comparison of two different sets of indicators proposed by (a) Jackson, Keith, and Burdick (1986) and (b) Levy (1981) in the field of PDS for customer service evaluation.

(a) SET a (Jackson et al., 1986)

	DIMENSIONS OF THE BSC-IM MODEL					
	FINANCIAL		INTERNAL BUSINESS PROCESS		CUSTOMER	LEARNING AND GROWTH
	C_1	C_2	C_3	C_4	C_5	C_6
INDICATORS	Sales	Cost of raw materials, goods and external services	Quantitative production level	Productivity of human resources	Level of offered service	Research and development on processes
Order progress information	O	O	O	P	P	O
Average order cycle time	O	N	P	P	P	P
Order cycle time variability	O	N	N	P	P	P
Availability	P	N	P	P	P	O
Protective packaging	O	N	O	O	P	O
Cooperation	O	N	P	P	P	O
"Maximum positive impact" profile	1	0	3	5	6	2

(b) SET b (Levy, 1981)

	DIMENSIONS OF THE BSC-IM MODEL					
	FINANCIAL		INTERNAL BUSINESS PROCESS		CUSTOMER	LEARNING AND GROWTH
	C_1	C_2	C_3	C_4	C_5	C_6
INDICATORS	Sales	Cost of raw materials, goods and external services	Quantitative production level	Productivity of human resources	Level of offered service	Research and development on processes
Ordering convenience	P	O	O	O	P	O
Average order cycle time	O	N	P	P	P	P
Order cycle time variability	O	N	N	P	P	P
Availability	P	N	P	P	P	O
Terms of sale	P	N	N	O	P	P
"Maximum positive impact" profile	3	0	2	3	5	3

Another possible approach might involve the introduction of specific weights in order to quantify criteria importance. When using weights, the problem of data analysing and processing can be dealt with by introducing apposite methodologies, such as, for example, MCDA (Multiple Criteria Decision Aid) techniques (Vincke 1992; Roy 1996) or other synthesis procedures such as Ordered Weighted Averaging operators (Yager and Filev 1994; Saari 1995; Franceschini et al. 2006). These methods are able to produce a ranking from different sets of indicators, as well as indicating which the most appropriate one is.

These approaches may be helpful in solving ambiguous situations such as for example that described in case (6.b).

3.4. *Example of application*

In order to better explain the methodology, let us consider the following example. An organisation which aims to evaluate its level of P.D.S. (PDS) finds in the literature seven alternative sets of indicators, respectively, proposed by Stephenson and Willett (1968), Perrault and Russ (1974), Perrault and Russ (1976), Jackson, Keith, and Burdick (1986), Hutchinson and Stolle (1968), Gilmour (1977) and Levy (1981). After a detailed analysis of indicators properties (see Table 1), two sets are considered equivalent (that proposed by Jackson, Keith, and Burdick (1986) and Levy (1981), see Table 8).

The selection of one of these sets of indicators is very critical since they contain similar indicators. Management decides then to analyse their impacts. Due to the specific case referred to the domain of services, and for the sake of simplicity, only a subset of the BSC-IM criteria reported in Table 2 are considered:

- Financial: sales, cost of raw materials, goods and external services.
- Internal business process: quantitative production level and productivity of human resources.
- Customer: level of offered service.
- Learning and growth: research and development on processes.

A limited number of criteria, specific for the domain of services, are considered since the main aim is to show an example of all the different steps of impact analysis. A complete analysis of the current case study should detail all the specific contextual considerations that bring to the identification of a positive or negative impact.

First the impact of each single indicator of the two set has been assessed (Section 3.2). The results are shown in Table 8. Table 9 reports impact matrices for the two considered sets.

Then a set profile has been constructed by applying the maximum positive impact logic (see Section 3.3). The obtained results and the graphical comparison of the profiles (impact chart) are reported in Table 9 and in Figure 7, respectively.

Observing Figure 7, it is not immediate to give an impact comparison. The two set profiles do not clearly dominate each other. In this case, an overall impact evaluation is critical. Profile (a) is dominant according to criteria C_3, C_4 and C_5, profile (b) prevails according to criteria C_1 and C_6. Referring to the corresponding BSC-IM, it is possible to conclude that set (a) is preferable according Internal Business Process dimension as it generates a more positive impact, while set (b) is preferable according to financial and innovation and learning dimensions.

Using Borda's indicator (Saari 1995), the set of indicators which exerts the highest positive impact is given by:

$$I_B(x^*) = \min_x \{I_B(x)\} = \min_x \left(\sum_{i=1}^{m} r_i(x) \right)$$

In this application $I_B(\mathrm{SET_a}) = 8$ and $I_B(\mathrm{SET_b}) = 9$, hence Set (a) is preferable.

4. Conclusions

Organisations often introduce PMSs in order to monitor goal achievement, to allocate resources and to choose a strategy. However, indicators exert a normative effect on the actions of an organisation. This introductory work aims at giving some guidelines to assess the impact of performance indicators.

The fundamental starting point in impact assessment is the definition of a reference model.

In this paper, Kaplan and Norton's BSC (1996) is suggested as a reference framework. Other models may be taken as reference framework, such as for example the EFQM Excellence model or the Malcolm Baldrige National Quality Award model. The core issue is to identify the basic dimensions of the organisation impacted on by introducing an indicator. In the approach proposed in this paper, the four main BSC perspectives are assumed to be basic organisational dimensions on which an indicator may exert its impact. Basic dimensions may then be used as analysis criteria within the specific context. The BSC-IM obtained becomes the basic framework for the evaluation of indicator impact. Based on the BSC-IM, the so-called impact matrix is constructed. This gives an overall picture of the impact exerted by a set of indicators and shows possible cross-impacts within the organisation. Given a set of indicators, the impact matrix helps in identifying any criticalities linked to a specific indicator as well as giving an overall impact

evaluation. Finally, a case study highlights the potential of the proposed methodology.

The evaluation model for the assessment of indicator impact may be applied to different contexts such as a manufacturing firm or a service organization.

Future work will consider the aspects that are still open to debate. Particular emphasis will be given to the methods for identifying how organizations/assessors may know what the impact of an indicator will be on a criterion and how to assess that.

Another important issue will concern the procedures to synthesize the impact evaluations expressed on the various criteria. Although in Section 3.3, some approaches have been proposed and discussed, some critical aspects still need to be debated, such as, for instance, the interrelations between positive and negative impacts and the introduction of specific weights for evaluating the importance of each single criterion of analysis.

Notes on contributors

Fiorenzo Franceschini is a professor of Quality Engineering in the Department of Production Systems and Business Economics at Politecnico di Torino (Italy). He is the author or co-author of six books and many published papers in prestigious scientific journals and international conference proceedings. He is the head of the Department of Production Systems and Business Economics, Politecnico di Torino. He is a member of the editorial board of Quality Engineering, International Journal of Quality and Reliability Management and Proceedings of the Institution of Mechanical Engineers, Part B, Journal of Engineering Manufacture. He is a senior member of ASQ. His current research interests are in the areas of quality engineering, performance measurement and service quality management.

Maurizio Galetto is an associate professor of Production Systems in the Department of Production Systems and Business Economics at Politecnico di Torino (Italy). He holds a PhD in Metrology from the Politecnico di Torino. He is the author or co-author of two books and many published papers in scientific journals and international conference proceedings. His current research interests are in the areas of industrial metrology, quality management and process modelling.

Elisa Turina graduated in Management Engineering at Politecnico di Torino (Italy) in 2005. She holds a PhD in Industrial Production Systems and Industrial Design from Politecnico di Torino where she is a research fellow at the Department of Production Systems and Business Economics. She is involved in different projects on performance measurement within public and private organisations. Her main scientific interests concern the areas of quality engineering and performance measurement systems.

References

Alfaro, J., A. Ortiz, and R. Poler. 2007. "Performance Measurement System for Business Processes." *Production Planning & Control* 18 (8): 641–654.

Andersen, E. S., and S. A. Jessen. 2003. "Project Maturity in Organizations." *International Journal of Project Management* 21: 457–461.

Atkinsons, A. 1998. "Strategic Performance Measurement and Compensation." *European Management Journal* 16 (5): 552–561.

Azadeh, A., S. F. Ghaderi, Miran Y. Partovi, V. Ebrahimipour, and K. Suzuki. 2007. "An Integrated Framework for Continuous Assessment and Improvement of Manufacturing Systems." *Applied Mathematics and Computation* 186: 1216–1233.

Baldrige Foundation. 2011. Accessed November 7, http://www.baldrigepe.org/America-Needs-Baldrige/Index.html

Barnetson, B., and M. Cutright. 2000. "Performance Indicators as Conceptual Technologies." *Higher Education* 40: 277–292.

Bhagwat, R., and M. K. Sharma. 2009. "An Application of the Integrated AHP-PGP Model for Performance Measurement of Supply Chain Management." *Production Planning & Control* 20 (8): 678–690.

Borda J. C. 1781. *Mémoire sur les élections au scrutin* [Comptes Rendus de l'Académie des Sciences]". Translated by Alfred de Grazia as Mathematical derivation of an election system, Isis, Vol. 44, 42–51.

Bourne, M., M. Kennerly, and M. Franco-Santos. 2005. "Managing Through Measures: A Study of Impact on Performance." *Journal of Manufacturing Technology Management* 16 (4): 373–395.

Cameron, K. S., and R. E. Quinn. 1999. *Diagnosis and Changing Organizational Culture: Based on the Competing Values Framework*. Reading, MA: Addison Wesley.

Caplice, C., and Y. Sheffi. 1994. "A Review and Evaluation of Logistics Metrics." *The International Journal of Logistics Management* 5 (2): 11–28.

EFQM (European Foundation for Quality Management). 2011. Accessed November 7, 2011. http://www.efqm.org.

Evans, J. R. 2004. "An Exploratory Study of Performance Measurement Systems and Relationship with Performance Results." *Journal of Operations Management* 22: 219–232.

Finkelstein, L. 1982. "Handbook of Measurement Science." In *Theoretical Fundamentals*. edited by P. H. Sydenham. 1 Vol. New York, NY: John Wiley.

Franceschini, F., G. Brondino, M. Galetto, and G. Vicario. 2006. "Synthesis Maps for Multivariate Ordinal Variables in Manufacturing." *International Journal of Production Research* 44 (20): 4241–4255.

Franceschini, F., M. Galetto, and D. Maisano. 2006. "Classification of Performance and Quality Indicators in Manufacturing." *International Journal of Services and Operations Management* 2 (3): 294–311.

Franceschini, F., M. Galetto, and D. Maisano. 2007. *Management by Measurement: Designing Key Indicators and Performance Measurements*. Berlin: Springer.

Franceschini, F., M. Galetto, D. Maisano, and L. Viticchiè. 2006. "The Condition of Uniqueness in Manufacturing Process Representation by Performance/Quality Indicators." *Quality and Reliability Engineering International* 22: 567–580.

Franceschini, F., M. Galetto, and E. Turina. 2009. "Service Quality Monitoring by Performance Indicators: A Proposal for a Structured Methodology." *International Journal of Services Operations Management* 5 (2): 251–273.

Franceschini, F., M. Galetto, and M. Varetto. 2005. "Ordered Samples Control Charts for Ordinal Variables." *Quality and Reliability Engineering International* 21 (2): 177–195.

Ghalayini, A. M., J. S. Noble, and T. Crowe. 1997. "An Integrated Dynamic Performance Measurement System for Improving Manufacturing Competitiveness." *International Journal of Production Economics* 48: 207–225.

Gilmour, P. 1977. "Customer Service: Differentiating By Market Segment." *International Journal of Physical Distribution* 7 (3): 141–148.

Gomes, C. F., M. M. Yasin, and J. V. Lisboa. 2004. "A Literature Review of Manufacturing Performance Measures and Measurement in an Organizational Context: A Framework and Direction for Future Research." *Journal of Manufacturing Technology Management* 15 (6): 511–530.

Gosselin, M. 2005. "An Empirical Study of Performance Measurement in Manufacturing Firms." *International Journal of Productivity and Performance Management* 54 (5/6): 419–437.

Hauser, J., and G. Katz. 1998. "Metrics: You Are What You Measure!." *European Management Journal* 16 (5): 517–528.

Henry, J. F. 2006. "Organizational Culture and Performance Measurement Systems." *Accounting Organizations and Society* 31: 77–103.

Heo, J., and I. Han. 2003. "Performance Measure of Information Systems (IS) in Evolving Computing Environments: An Empirical Investigation." *Information & Management* 40: 243–256.

Hoque, Z., and W. James. 2000. "Linking Balanced Scorecard Measures to Size and Market Factors: Impact on Organizational Performance." *Journal of Management Accounting Research* 12: 1–17.

Hudson, M., J. Lean, and P. A. Smart. 2001. "Improving Control Trough Effective Performance Measures in SMEs." *Production Planning and Control* 12 (8): 804–813.

Hutchinson, W. M., and J. F. Stolle. 1968. "How to Manage Customer Service." *Harvard Business Review* 46: 85–96.

Jackson, D. W., Jr., J. E. Keith, and R. K. Burdick. 1986. "Examining the Relative Importance of Physical Distribution Service Elements." *Journal of Business Logistics* 7 (2): 14–31.

Kaplan, R. S., and D. P. Norton. 1992. "The Balanced Scorecard-Measures That Drive Performance." *Harvard Business Review* 70: 71–79.

Kaplan, R. S., and D. P. Norton. 1996. *The Balanced Scorecard*. Cambridge, MA: Harvard Business School Press.

Kaplan, R. S., and D. P. Norton. 2001. *The Strategy Focused Organisation: How Balanced Scorecard Companies Thrive in the New Business Environment*. Boston, MA: Harvard Business School Press.

Kennerly, M., and A. Neely. 2002. "A Framework of the Factors Affecting the Evolution of Performance Measurement System." *International Journal of Operations and Management* 22 (11): 1222–1245.

Kennerly, M., and A. Neely. 2003. "Measuring Performance in a Changing Business Environment." *International Journal of Operations & Production Management* 23 (2): 213–229.

Kerssens-van Drongelen, I. C., and O. A. M. Fisscher. 2003. "Ethical Dilemmas in Performance Measurement." *Journal of Business Ethics* 45: 51–63.

Levy, M. R. 1981. "Toward An Optimal Customer Service Package." *Journal of Business Logistics* 2 (2): 87–109.

Lipe, M. G., and S. Salterio. 2002. "A Note on Judgmental Effects of the Balanced Scorecard's Information Organization." *Accounting Organization and Society* 27: 531–540.

Micheli, P., and M. Kennerley. 2005. "Performance Measurement Frameworks in Public and Non-Profit Sectors." *Production Planning & Control* 16 (2): 125–134.

Nahm, A., M. A. Vonderembse, and X. A. Koufteros. 2003. "The Impact of Organizational Structure on Time-Based Manufacturing and Plant Performance." *Journal of Operations Management* 21: 281–306.

Neely, A., M. Gregory, and K. Platts. 1995. "Performance Measurement System Design." *International Journal of Operations and Production Management* 4: 80–116.

Performance Based Special Interest Group (PMB SIG). 2001. *The Performance-Based Management Handbook, Vol. 2: Establishing an Integrated Performance Measurement System*. Oak Ridge Institute for Science and Education (ORISE), US Department of Energy.

Perrault, W. D., Jr, and F. A. Russ. 1974. "Physical Distribution Service: A Neglected Aspect of Marketing Management." *MSU Business Topics* 22: 37–45.

Perrault, W. D., Jr, and F. A. Russ. 1976. "Physical Distribution Service in Industrial Purchase Decisions." *Journal of Marketing* 40: 3–10.

Roberts, F. S. 1979. *Measurement Theory.* Massachusetts: Addison-Wesley.

Roy, B. 1996. *Multicriteria Methodology for Decision Aiding*. Dordrecht: Kluwer Academic.

Saari, D. G. 1995. *Basic Geometry of Voting* (doi: 3–540–60064–7). Berlin: Springer.

Schein, E. H. 2004. *Organizational Culture and Leadership*. San Francisco, CA: Jossey-Bass.

Stephenson, P., and R. P. Willett. 1968. "Selling with Physical Distribution Service: How Logistics Services Affect Product Demand." *Business Horizons* 11 (6): 75–85.

Tuck, N., and G. Zaleski. 1994. *Criteria for Developing Performance Measurement Systems in the Public Sector*, edited by US Department of the Treasury. OPMA working paper series.

University of California. 2010. "Laboratory Administration Office, Appendix F". *Objective Standards of Performance*. Accessed 31 December http://www.ucop.edu/labs/labprimecontracts/LBNL/appendices/archives/apndx_f_lbnl_m345.pdf

Vincke, P. 1992. *MultiCriteria Decision Aid*. Chichester: John Wiley.

Wainwright, S. 2002. *Measuring Impact: A Guide to Resources*. London: NCVO.

Yager, R., and D. P. Filev. 1994. *Essentials in Fuzzy Modeling and Control*. 4th ed. New York, NY: John Wiley.