Electronic Journal of Applied Statistical Analysis: Decision Support Systems and Services Evaluation
EJASA:DSS (2010). Vol 1, Issue 1, 66 – 78
e-ISSN 2037-3627, DOI 10.1285/i2037-3627v1n1p66

CONSTRUCTION OF THE BALANCED SCORECARD BY USING STRUCTURAL EQUATION MODELS WITH LATENT VARIABLES

Giuseppe Boari[*], Gabriele Cantaluppi
Dipartimento di Scienze Statistiche,
Università Cattolica del S. Cuore, Italy

Received 30 April 2010. Accepted 19 October 2010
Available online 17 December 2010

Abstract*: The Balanced Scorecard is one of the most important quantitative tool for the business strategic planning. Its implementation usually concerns the construction and analysis of proper weighted averages of the so-called Key Performance Indicators (KPI); these are either objective or subjective evaluations of the performance levels attained by the various sub-systems constituting a business organization. Recent evolutions of the model are considered and a particular version of the Balanced Scorecard, based on Structural Equation Models with Latent Variables, is introduced.*

Keywords*: Balanced scorecard, business scorecard, structural equation models, latent variables.*

1. Introduction

The Balanced Scorecard (BSC), introduced by Kaplan and Norton [14], represents a valuable instrument for measuring the performance of a business organization, with the main objective of aligning business units to the leadership goals. Section 2 presents the BSC implementation by introducing the so-called KPI (Key Performance Indicators) summarized into a compositive index. Section 3 considers the classical statistical latent factor approach from which Parasuraman *et al*. [19] and Cronin *et al*. [5] derived their paradigms for measuring service quality: the SERVQUAL and SERVPERF models. The natural evolution of these models, within the Strategy-Focused-Organization model and the Business Excellence model, gave rise ([11], [12]) to the so-called Kanji Business Scorecard, which is implemented, see Section 4, by means of the structural equation model with latent variables. Section 5 introduces a practical example of evaluation of a business process, [22]; it represents a particular Business Scorecard devoted to

[*]Corresponding Author. Email: giuseppe.boari@unicatt.it

measure the compliance of a quality system with the requests stated by the international ISO 9000:2000 standards.

2. The Balanced Scorecard and compositive models

The Balanced Scorecard (BSC), introduced by Kaplan and Norton [14], represents a valuable instrument for measuring the performance of a business organization, with the main objective of aligning business units to the leadership goals. The BSC approach had further developments, [15], [16], with the introduction of the Strategy-Focused-Organization model, aimed at translating the top management strategy into operational actions, addressed to a continuous improvement of the organization performance. The BSC implementation starts with the measurement of all the dimensions influencing the future results of an organization; then, proper analyses are produced, in order to assess the continuous improvement toward the business excellence and consequently the fulfilment of the targets stated by the strategic planners. In this perspective, the so-called KPI (Key Performance Indicators) are considered; their assessment is the main activity of the top management. The direct measure of KPI may be combined with subjective evaluations of those aspects by a sample of managers or experts; their evaluation of the degree to which those indicators meet the global target may be done by means of data coming from interviews or questionnaires. A summary index of performance evaluation may thus help the final assessment by the top management.
Let us examine, for example, the Financial aspect, which leads to Business Excellence; it is linked to the following financial and marketing aspects:

- X_1 = Cash flow level,
- X_2 = Profit margin,
- X_3 = Return on equity,
- X_4 = Assets turnover,
- X_5 = Customer demand,
- X_6 = Ability to recruit and maintain outstanding staff,
- X_7 = Goals achievement,
- X_8 = Short and long term strategy,
- X_9 = Comparison with best-in-class.

Following the Fishbein [7] compositive approach, the BSC methodology suggests to produce a global performance index by first indicating a system of importance weights summing up to one. With regard to the previous example, once defined the subjective system of weights w_i (i=1,2,…,9), the following statistic (Financial Performance Indicator) may be used

$$\text{FPI}(k) = \sum_{i=1}^{9} w_i X_i \,, \qquad (1)$$

giving a direct summary measure of the level of the financial prospects for the firm k. Furthermore, as a benchmark, one can properly summarize similar indices FPI(j), j=1,2,…,n, obtained from analogous analyses realized over a sample of *n* competing firms, in order to compare the specific position of the company *k* with the average performance or with the best practice. Observe that, due to the subjective nature of the evaluations and in order to properly define the benchmark, a fair referee board should establish the most objective weighting system.

3. Non-observable variables and Factor analysis approach

The previous formulation of BSC considers only observable variables, whose levels are properly summarized by means of a weighted linear combination. A first evolution of these models is represented by the adoption of a Factor Analysis (FA) approach, which typically considers the reconstruction of non-observable variables (factors and factor scores) starting from the observation of a collection of manifest variables (proxies) assumed to be linear functions of the corresponding latent variable. Two well-known examples are represented by the SERVQUAL and the SERVPERF models, developed by Parasuraman *et al*. [19] and Cronin *et al*. [5]; they suggest two distinct procedures, devoted to measure the level to which the users of service businesses perceive quality or evaluate satisfaction/performance, with reference to several aspects not directly measurable. The different use of the paradigm of the gap between expectations and perceptions distinguishes these procedures. The refinement of the analysis allowed to identify a purified set of manifest variables, which may be used to evaluate the following 5 key aspects, describing the customer-service relationship:

a) tangibles,
b) reliability,
c) responsiveness,
d) assurance,
e) empathy.

According to the Factor Analysis procedure, one can evaluate the levels of the 5 latent variables (factor scores) and identify the aspects best satisfying the customers. Furthermore, in this instance, a global (quality or satisfaction) index may be defined as a linear combination of the mean levels of the above 5 variables in a fashion similar to (1), by using a weight system previously specified, or obtained as a result of surveys over a sample of customers.

4. The Business Scorecard and the Structural Equation Model approach

The Structural Equation Model with Latent Variables (SEM-LV) approach represents a further development in the measurement of the business performance. This method joins the attitude of the FA procedures, which are mainly addressed to obtain an estimate of the latent scores, with the feature of evaluating the strength of the (linear) relationship among the non-observable variables establishing the dimensions of the construct. The involved relationships may be graphically described by the so-called path diagram and may be interpreted as the representation of a linear multivariate multiple regression model with a causal or recursive structure. Observe that also FA models may consider solutions with correlated latent variables, but this ensues only in presence of oblique or non-orthogonal rotations; on the contrary, the SEM-LV approach assumes the existence of those relationships among the latent variables, which may be statistically estimated and tested by using the experimental data. We recall briefly that SEM-LV models are defined by the following two sets of relationships:

$$\boldsymbol{\eta} = \mathbf{B}\boldsymbol{\eta} + \boldsymbol{\Gamma}\boldsymbol{\xi} + \boldsymbol{\zeta}, \tag{2}$$
$$\mathbf{y} = \boldsymbol{\Lambda}_Y \boldsymbol{\eta} + \boldsymbol{\varepsilon} \quad \text{and} \quad \mathbf{x} = \boldsymbol{\Lambda}_X \boldsymbol{\xi} + \boldsymbol{\delta}\,, \tag{3}$$

called, respectively, the inner and the outer model, where $\boldsymbol{\eta}$ and $\boldsymbol{\xi}$ are two arrays of endogenous ($m\times1$) and exogenous ($n\times1$) latent variables, $\mathbf{B}$ and $\boldsymbol{\Gamma}$ are matrices ($m\times m$) and ($m\times n$) of unknown parameters; $\mathbf{y}$ and $\mathbf{x}$ are the sets ($p\times1$) and ($q\times1$) of manifest variables, linearly dependent on the respective latent variables, through the matrices $\boldsymbol{\Lambda}_Y$ ($p\times m$) and $\boldsymbol{\Lambda}_X$ ($q\times n$), which are assumed to be block diagonal. $\boldsymbol{\zeta}$, $\boldsymbol{\varepsilon}$ and $\boldsymbol{\delta}$ are the equation error components. In (3) the relationships among manifest and latent variables are formulated according to a so-called reflective measurement model. One can also encounter situations where the relationship between the set of manifest indicators and the respective latent variable ξ_i is of the formative type, say $\xi_i = \boldsymbol{\pi}_i\mathbf{x}_i + \delta_i$ (see [6], [4] and [8]). In model (2) the matrix $\mathbf{B}$ is assumed to be lower triangular with zero elements on the main diagonal, so the resulting model is said to be of the recursive type.
With reference to the BSC, in [12] and [13] an alternative version is proposed, which is called Kanji Business Scorecard and is formulated according to the SEM-LV approach. The model consists of two sections related to the measurement of the relationships of Performance Excellence with Leadership and Organizational Values respectively.

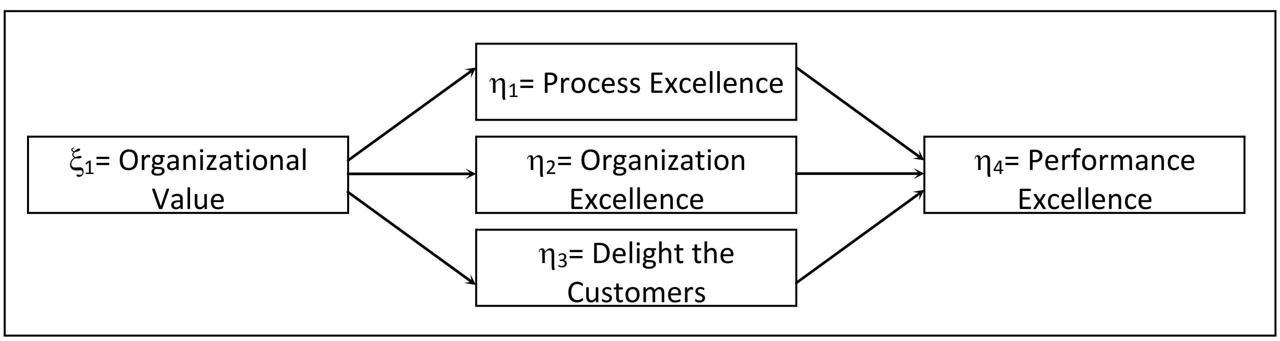

Figure 1: Organizational Values - Performance Excellence relationship

The second section of the model is defined according to the path diagram in Figure 1. The latent variables are measured by proper manifest indicators, which give the extent stakeholders feel that the organization satisfies the items shown in Table 1 (manifest variables are listed under the corresponding latent variables).

Table 1. Latent variables and corresponding proxy variables

ξ_1	**ORGANIZATIONAL VALUE**
X_1	has a mission
X_2	has values reflecting concerns with all stakeholders
X_3	strategy and policy are consistent with the stated aims and purposes
X_4	values foster cooperation among the stakeholders
η_1	**PROCESS EXCELLENCE**
Y_{11}	products have no defects or other non-conformities and exhibit the stated characteristics
Y_{12}	services run smoothly and as advertised
Y_{13}	disseminates accurate and reliable performance indicators
Y_{14}	uses benchmarking to improve its processes
η_2	**ORGANIZATION EXCELLENCE**
Y_{21}	regularly introduces new and innovative products and services
Y_{22}	works in partnership with them
Y_{23}	has a culture of continuous improvement and a learning attitude
η_3	**DELIGHT THE CUSTOMERS**
Y_{31}	actively listens to their needs and requirements
Y_{32}	effectively deals with complaints
Y_{33}	provides relevant and reliable information to them
Y_{34}	has an ethical conduct
η_4	**PERFORMANCE EXCELLENCE**
Y_{41}	provides good value for money
Y_{42}	has a healthy financial situation
Y_{43}	has a good overall image
Y_{44}	has a good quality reputation

The first section of the model considers the relationship between Leadership and Performance Excellence (see e.g. [3]). The path diagram represented in Figure 2 corresponds to the final part of this section of the model proposed by Kanji and Wallace [13] and applied to a specific manufacturing company: the estimates of the mean levels of the latent variables (in the ellipses, on a centesimal scale) and of the path coefficients (near the corresponding arrows) are reported.

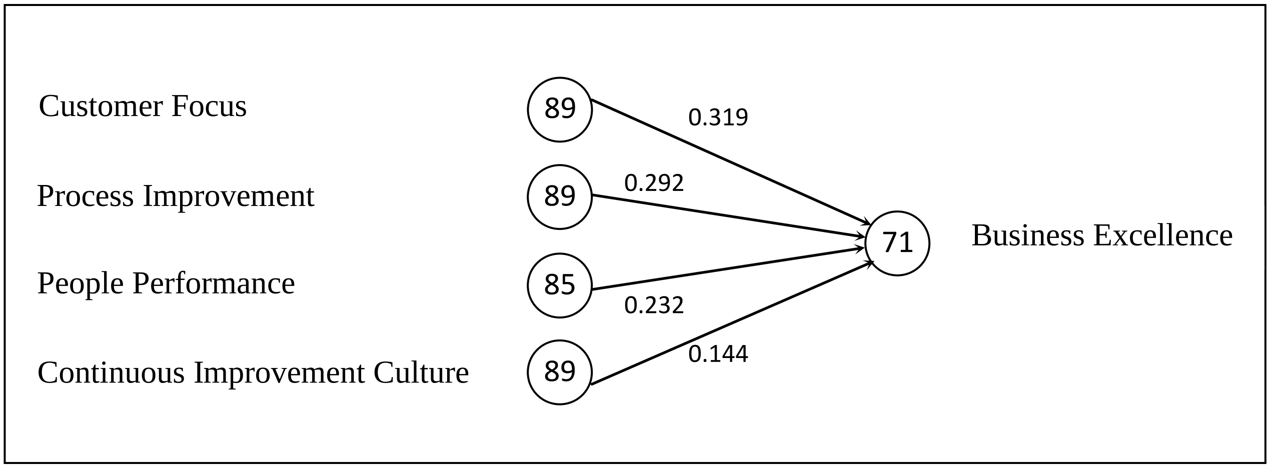

Figure 2. Final section of the Path Model for Leadership-Performance Excellence relationship

The values of the preceding estimates can also be represented into the Strategic Satisfaction Matrix, [6], which reports, see Figure 3, the impact levels or opportunities (regression coefficients) along the vertical axis and the performance mean levels (computed with the estimated latent scores) on the horizontal axis.

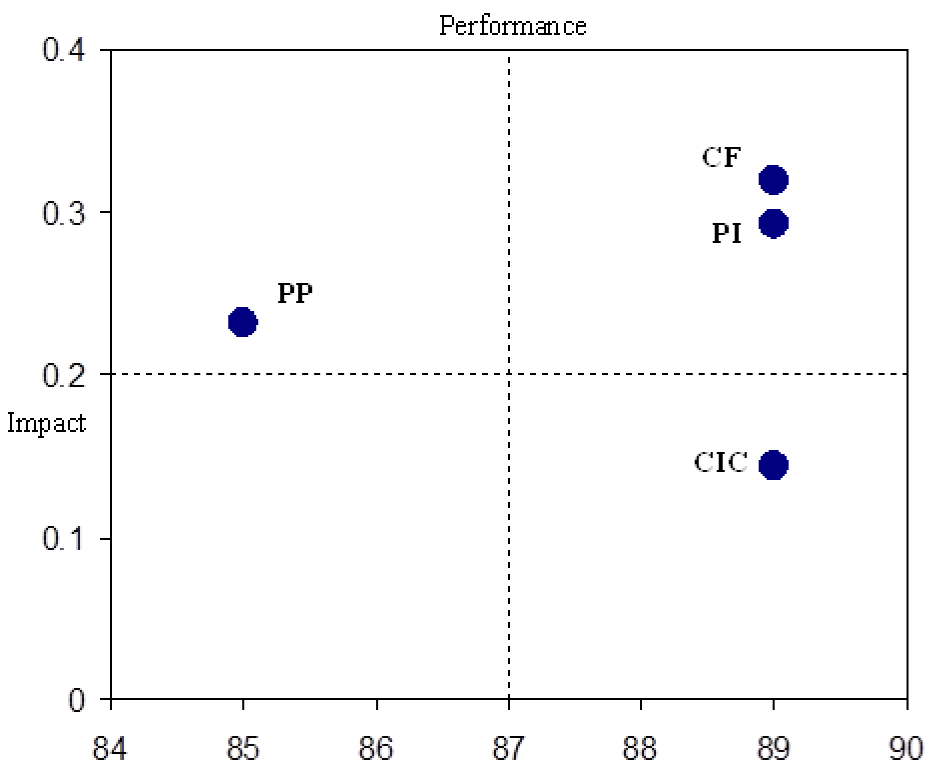

Figure 3: Strategic Satisfaction Matrix for the analyzed company

By considering this matrix one can identify the aspects on which interventions are more useful and effective, in order to improve the final performance of the process. Observe that the People

Performance (PP) aspect is clearly the one on which to concentrate the most improving actions.
Another interesting example, developed in the sanitary context, is given in [9]. This represents an evolution of the SERVPERF model, since the model includes also the latent variable Overall Patient Satisfaction (measured by using four judgements regarding the quality level perception on the medical and surgery personnel and on the whole Hospital). The following graph shows the estimates of the impact of the five aspects considered in the SERVPERF model (see §2) on the Patient Satisfaction, together with the mean levels of the 5 above aspects, also using the Strategic Satisfaction Matrix technique. Observe that it is advisable to intervene on the aspect a) tangibles, while the aspect c) responsiveness had probably received more attention than necessary.

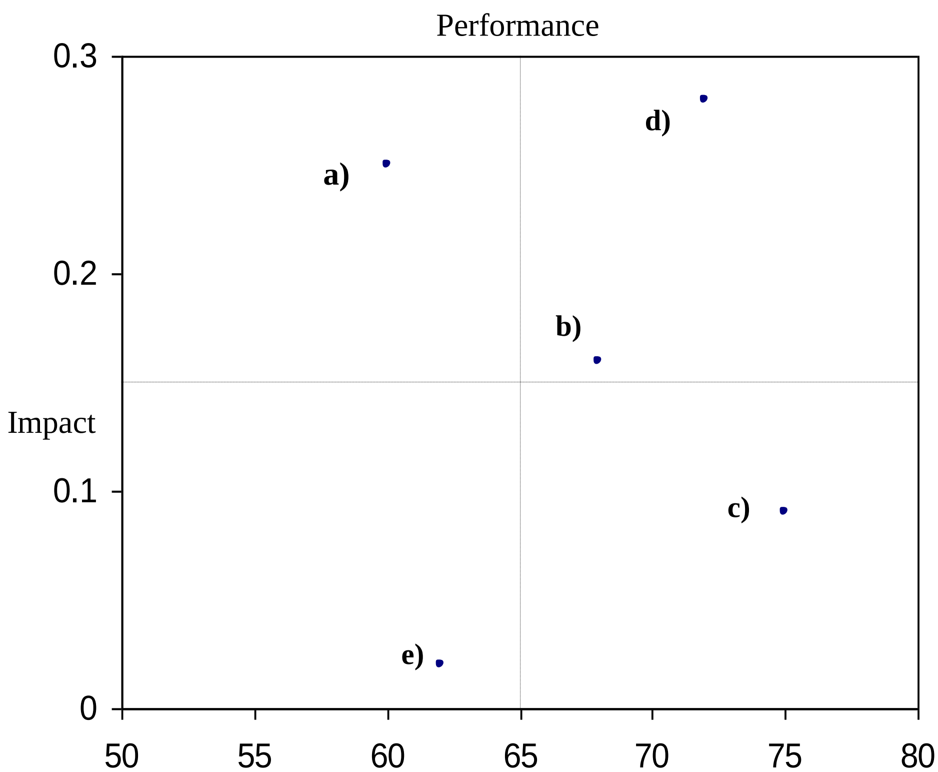

Figure 4. Strategic Satisfaction Matrix for Patient Satisfaction

5. A case study

In order to present a practical implementation of a SEM-LV to the evaluation of a business process we want to recall an example reported in [22] referring to an analysis for assessing the degree of compliance of the Quality Management System of a firm with the requirements of the standard ISO 9000:2000.
Data were collected by means of a questionnaire administered to a group of 100 middle managers belonging to a worldwide business organization, which were elected to judge if their Quality Management System is aligned with the international ISO standards.
Figure 5 shows the path diagram defining the relationships among all the initially chosen latent variables; it also contains the parameter estimates referring to the final inner model, where the

sole significant relationships are highlighted by solid bold lines and arrows.

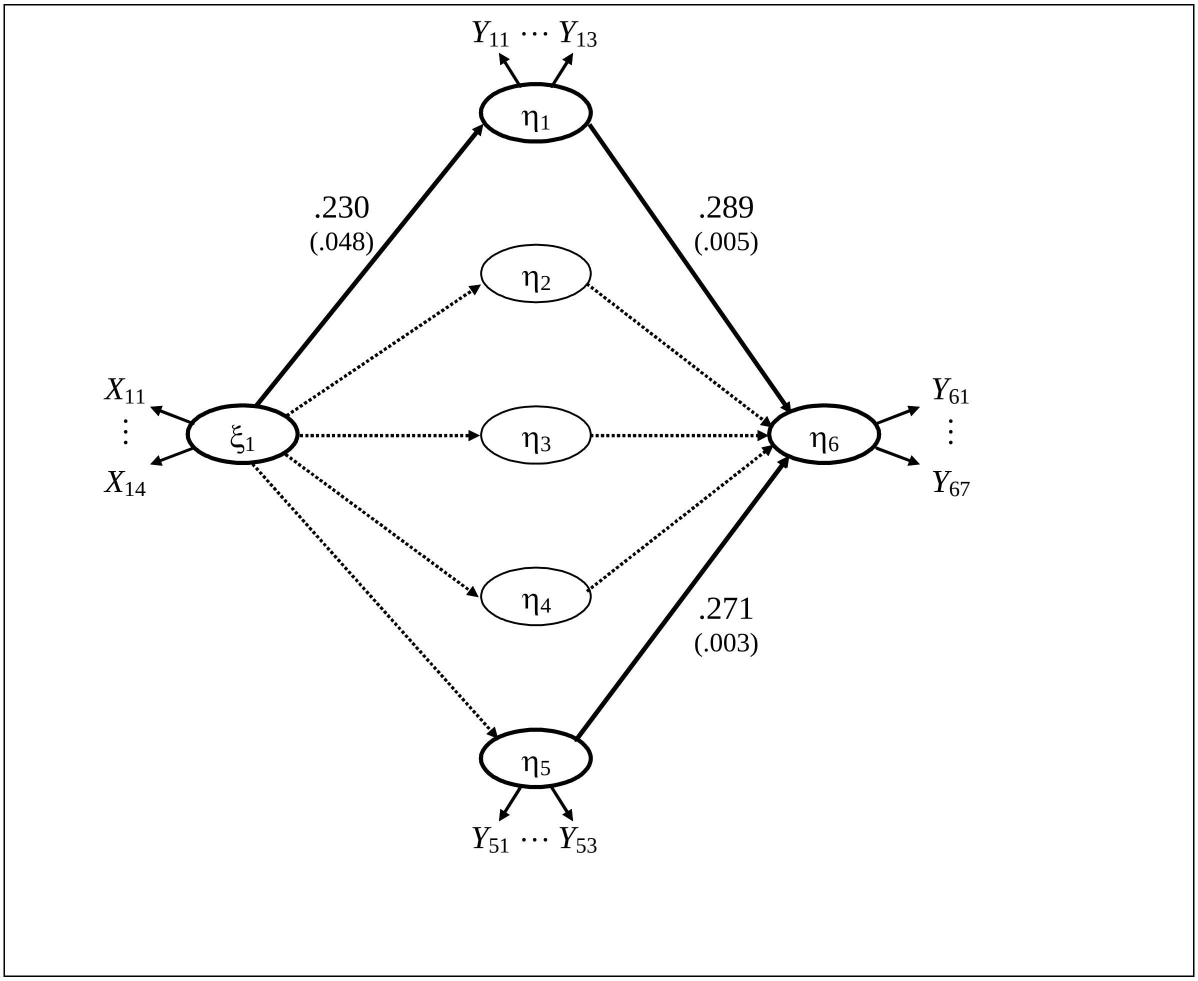

Figure 5. Path diagram structure of the model and final PLS parameter estimates

Table 2 contains the detailed definition of all the latent variables and the English translation from the Italian original formulation, see [22], of the items proposed in the questionnaire for the sole proxy variables pertaining the final model. Should the following scale be used outside the Italian context, we recommend performing appropriate control and purification procedures.

Table 2. Used latent variables and detailed list of the proxy variables included in the final model

ξ_1	LEADERSHIP
X_{11}	Your top management adequately states and updates the quality targets
X_{12}	Your top management adequately promotes awareness and involvement of the personnel toward quality policy and targets
X_{13}	Business actions are properly customer oriented
X_{14}	Our organization considers quality results as important as financial ones

η_1	CONTINUOUS PROCESS IMPROVEMENT
Y_{11}	Continuous process improvement is a key target in your organization
Y_{12}	Actions for non-conformities correction are supported by adequate cause analyses
Y_{13}	Analysis of system improvements usually follows the correction of immediate causes of non-conformities to reduce the likelihood of their recurrence

η_2	CUSTOMER FOCUS

η_3	HUMAN RESOURCES COMMITMENT

η_4	EFFECTS OF THE MEASUREMENT SYSTEMS ON QUALITY MANAGEMENT

η_5	PROCESS APPROACH
Y_{51}	Process inputs, controls and outputs, ensuring desired results, are clearly stated to the management
Y_{52}	Interface between interrelated processes to ensure system effectiveness is achieved
Y_{53}	The evaluation that actions meet targets and specifications is performed

η_6	QUALITY MANAGEMENT SYSTEM PLANNING
Y_{61}	Actions performed at monitoring and managing the quality process are adequate
Y_{62}	Planned quality targets are generally met
Y_{63}	Achieved quality results correspond to the level of the provided resources
Y_{64}	Definition and monitoring of the quality management process meet targets
Y_{65}	Management responsibilities are clearly specified
Y_{66}	Actions regarding quality management are properly filed and procedures updated
Y_{67}	The management process is effective in order to achieve the planned quality levels

Interviewees were asked to give their opinions regarding the degree of compliance (or level of presence) of the specific characteristic in the organization; the answers were expressed on a 7 point Likert scale (1= very low, …, 7= very high).

Data were analyzed by means of the LVPLS 1.8 programme by Lohmöller [17] implementing the Partial Least Squares (PLS) approach for parameter estimation (see [18] and [20]). Table 3 shows the results of the so-called reliability analysis of the measurement models: this is the preliminary step establishing the validity and existence of the constructs, before the PLS estimation procedure; see [21] for a detailed presentation of a proper test on the reliability Cronbach's α coefficient.

Table 3. Cronbach's α estimates for the constructs considered in the initial model

Latent variables	**No. proxies**	$\hat{\alpha}$
Leadership (ξ_1)	4	0.6811
Continuous process improvement (η_1)	3	0.5190
Customer focus (η_2)	4	0.7336
Human resources commitment (η_3)	2	0.6634
Effects of the measurement systems on quality management (η_4)	3	0.7783
Process approach (η_5)	3	0.8310
Quality Management System Planning (η_6)	7	0.9018

Notwithstanding that the construct Continuous process improvement, η_1, did not appear to be a definitely reliable one, it was anyway kept in the subsequent analysis, being it generally considered a KPI.

Following [1] the observed scores were re-scaled from 0 to 100, in order to improve the interpretability of the estimated values, using e.g. for X_{1k} the transformation $100\cdot(x_{1kh} - 1)/6$, for $k = 1,\ldots, 4$ and $h = 1,\ldots, N$ (here $N = 100$ units).

The PLS algorithm consists of two main phases: an iterative procedure aimed at estimating the scores of each latent variable as a linear function of the corresponding manifest indicators (by also taking into account the relationships of that latent variable with its adjacent ones in the path diagram); it is then followed by the ordinary least squares estimation of the regression coefficients in the inner and outer models.

The final inner model, containing the sole significant relationships, consists of the following equations (latent scores are scaled from 0 to 100):

$$\hat{\eta}_1 = 53.875 + 0.230\hat{\xi}_1 + \hat{\zeta}_1, \qquad (R^2 = 0.0388), \tag{4}$$

$$\hat{\eta}_6 = 21.695 + 0.289\hat{\eta}_1 + 0.271\hat{\eta}_5 + \hat{\zeta}_6, \qquad (R^2 = 0.1395). \tag{5}$$

The p-values, reported in the brackets in Fig. 5, confirm the statistical significance of the corresponding parameter estimates. However, the determination coefficients are quite weak, maybe suggesting the possible presence of some non-linear relationships, see [2].

Figure 6 shows the strategic impact matrix, which may be used to establish, according to the model and score estimates, where top managers should focus their attention in order to improve the middle management evaluation about the perceived assessment of the quality system implementation to the ideal model proposed by the ISO standard.

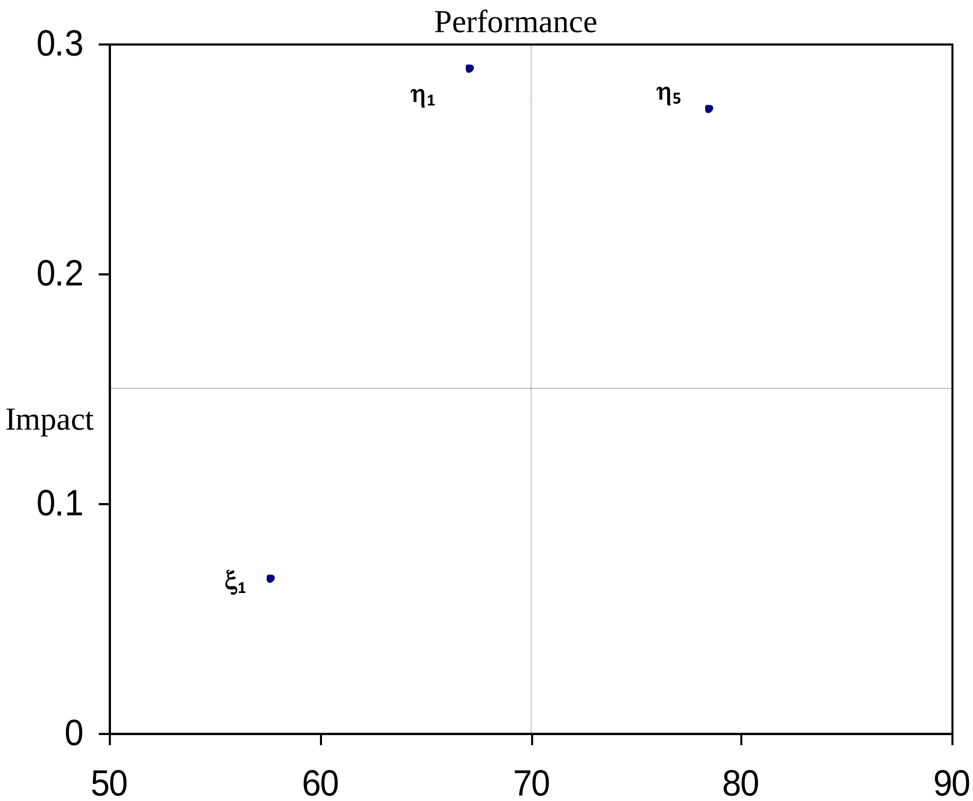

Figure 6. Strategic Impact Matrix for the key drivers of η_6 to evaluate the Quality Management System

The impact coefficient of ξ_1 on η_6 is obviously determined as the product of the partial effects 0.230 and 0.289 pertaining the corresponding path relationships. The following intervention priority stems from the analysis: increase the perception of the latent variable η_1, which shows both the highest impact coefficient and a quite limited mean level.

We can underline once again that the definition of a measurement device, by means of the SEM-LV approach, allows one to objectively evaluate the impact effect of each key driver on the system performance and to point out the most appropriate improvement actions.

1. Table 4. Summary statistics for the estimated latent scores in the final model

	2. $\hat{\xi}_1$	$\hat{\eta}_1$	$\hat{\eta}_5$	$\hat{\eta}_6$
min	20.358	35.292	54.278	21.279
max	74.212	90.098	95.943	87.768
average	57.763	67.183	78.504	62.355
s.dev.	12.725	14.877	14.726	14.749

It may be observed that the latent variable η_1 shows the highest impact coefficient on η_6 but a quite limited mean level, see Table 4: this suggests that we may expect the most effective enhancement of the Quality Management System Planning level by increasing the perception of the Continuous process improvement.

5. Final remarks and conclusions

To summarize, we believe the approach suggested by Kanji to be of a particular interest, since the application of SEM-LV to the analysis of the performance of a business process allows top managers to achieve two different complementary results: first of all, SEMs make it possible to evaluate the actual status of an organization and to compare the achieved levels with the expected ones (or the benchmark); moreover, SEMs give the opportunity of locating those factors most affecting the company performances and consequently choosing the best intervention.

Besides, from an operational point of view, the use of SEMs makes it possible to overcome the drawbacks deriving from the compositive way of obtaining a global performance index: the regression coefficients, estimated by SEMs, give an implicit and objective evaluation of that weighting system, provided that a global/overall measure of the outcome of the process be available as an endogenous variable included in the model. In this way the global performance index is settled up by means of the regression coefficients giving the evaluation of the relationships between the overall outcome and all the explicative variables directly and effectively linked to that measure. In fact, especially when the PLS estimation approach is adopted, the second step of the procedure is based on the multiple regression method.

However, it can be observed that this procedure doesn't give rise to a perfect weighting system, since the obtained coefficients do not necessarily sum up to the unity and, in general, could also be non-positive. Anyway, the effects due to the presence of possible negative coefficients in the outer model may be easily overcome by considering the corresponding variables in their reverse form. It may be observed that this occurrence does not take place in general with the models measuring the performance of a process or an organization: in such a case a canonical weighting system can always be defined by properly rescaling the regression coefficients.

References

[1]. Bayol, M.P., de la Foye, A., Tellier, C., Tenenhaus, M. (2000). Use of the PLS Path Modelling to estimate the European Customer Satisfaction Index (ECSI) model. *Statistica Applicata*, 12(3), 361–375.

[2]. Boari, G., Cantaluppi, G., Bertelli, S. (2008). Non-linear relationships in SEM with latent variables: some theoretical remarks and a case study. In *First joint meeting of the Société Francophone de Classification and the Classification and Data Analysis Group of the Italian Statistical Society, Book of Short Papers*, Napoli: Edizioni Scientifiche Italiane, 201–204.

[3]. Ciavolino, E., Dahlgaard, J.J. (2009). Simultaneous Equation Model based on Generalized Maximum Entropy for studying the effect of the Management's Factors on the Enterprise Performances. *Journal of Applied Statistics*, 36(7), 801–815.

[4]. Chin, W. (2000). Partial least squares for researchers: An overview and presentation of recent advances using the PLS approach. Available at http://disc-nt.cba.uh.edu/chin/icis2000plstalk.pdf.

[5]. Cronin, J.J. Jr., Taylor, S.A. (1994). SERVPERF versus SERVQUAL: Reconciling Performance-Based and Perceptions-Minus-Expectations Measurement of Service Quality.

Journal of Marketing, 58, 125–131.
[6]. Diamantopoulos, A., Riefler, P., Roth, K.P. (2008). Advancing formative measurement models. *Journal of Business Research*, 61, 1203–1218.
[7]. Fishbein, M., Ajzen, I. (1980). *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, NJ: Prentice-Hall.
[8]. Fornell, C., Bookstein, F.L. (1982). Two structural equation models: LISREL and PLS applied to Consumer Exit-Voice Theory. *Journal of Marketing Research*, 19, 440–452.
[9]. Frassetto, G.F., Fierro, P., D'Ambra, L., Milone, G. (2008). Patient Satisfaction e progettazione organizzativa: un case study. In: *L'organizzazione fa la differenza?*, eds. A. Comacchio and A. Pontiggia, Roma: Carocci editore, 175–198.
[10]. Johnson, M.D., Gustafsson, A. (2000). *Improving Customer Satisfaction, Loyalty, and Profit*. San Francisco: Jossey-Bass.
[11]. Kanji, G.K. (2002). Performance measurement system. *Total Quality Management*, 13(5), 715–728.
[12]. Kanji, G.K., Moura, Sá, P. (2002). Kanji's Business Scorecard. *Total Quality Management*, 13(1), 13–27.
[13]. Kanji, G.K., Wallace, W. (2000). Business excellence through customer satisfaction. *Total Quality Management*, 11(7), 979–998.
[14]. Kaplan, R., Norton, D. (1992). The Balanced Scorecard – Measures that drive performance. *Harvard Business Review*, 70(January-February), 71–79.
[15]. Kaplan, R., Norton, D. (1996). Using the Balanced Scorecard as a Strategic Management System. *Harvard Business Review*, 74(January-February), 75–85.
[16]. Kaplan, R., Norton, D. (2001). *Trasforming the Balanced Scorecard from performance measurement to strategic management*. Boston, MA: Business School Press.
[17]. Lohmöller, J.B. (1987). *LVPLS Program Manual, Version 1.8*. Köln: Zentralarchiv für Empirische Sozialforschung.
[18]. Lohmöller, J.B. (1989). *Latent Variable Path Modeling with Partial Least Squares*. Heidelberg: Physica-Verlag.
[19]. Parasuraman, A., Berry, L.L., Zeithaml, V.A. (1991). Refinement and Reassessment of the SERVQUAL Scale. *Journal of Retailing*, 67(4), 420–450.
[20]. Tenenhaus, M., Esposito Vinzi, V., Chatelin, Y.M., Lauro, C. (2005). PLS Path Modeling. *Computational statistics and data analysis*, 48, 159–205.
[21]. Zanella, A., Cantaluppi, G. (2006). Some remarks on a test for assessing whether Cronbach's coefficient α exceeds a given theoretical value. *Statistica Applicata*, 18, 251–275.
[22]. Zanella, A., Boari, G., Cantaluppi, G. (2002). Indicatori statistici complessivi per la valutazione di un sistema per la gestione della qualità: esame del problema ed un esempio di applicazione. In *Atti della Riunione Satellite della XLI Riunione Scientifica della Società Italiana di Statistica, Il nuovo controllo statistico della qualità: processo produttivo, customer satisfaction, problemi ambientali*, Padova: CLEUP, 1–25.