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Full Length Research Paper

The relationship between effectiveness of quality management and total factor productivity

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In a large number of companies, quality management (QM) programs and standardization in the field of quality have not led to higher organizational efficiency or better performances; therefore, the goal of this work is to conduct empirical research into whether quality management factors serve as reliable and valid predictors of total factor productivity (TFP) and if so, how they influence it. The data were collected in the period 2004 to 2009 from a stratified random sample drawn from Serbian industrial firms certified according to ISO 9000 with a total number of 176 observations from the research instruments. In order to determine the total factor productivity through the production function, those variables which describe the dependence of added value and labour and capital factors of production were used. For the QM data, the results underwent factor analysis and composite reliability calculations so as to be used later as independent variables in multiple regression. The central finding of this study is that QM factors provide a reliable and valid instrument for predicting total factor productivity. Two of the elements of QM, leadership and management support for quality programs and continuous quality improvement, proved to have a significantly positive effect on TFP, while the other categories in our study did not. The results of the research are directed at showing companies with limited resources which QM elements they should pay more attention to in the aim of achieving higher productivity.

Key words: Quality management, total factor productivity, multiple regression.

INTRODUCTION

Although quality management has received significant attention during the last decades and its benefits are beyond any doubt, many questions have remained unanswered. This article contributes, via field study, to an understanding of the very important practical question: “does the effectiveness of quality management explain the variance in total factor productivity of industrial companies?”

In the initial phases of the development of quality management, Deming claimed that; “quality means improved productivity”, Juran added that “improved qua-lity means improved productivity”, and Garvin confirmed their findings with the words, “quality and productivity have similar roots” (Hoffman and Mehra, 1999). Many well known companies which were experiencing a decline in their fortunes, have experienced remarkable revitalization, and restored their market share and profitability based on TQM. According to Sila (2007) and McAdam and Bannister (2001), effective TQM practices will improve delivery performance and productivity.

However, it is also well known that in a large number of companies, TQM programs and standardization in the field of quality have not led to higher organizational efficiency and effectiveness and better performance. The results reported in Nakayo et al. (1996), Hutchens (1996) and Sila (2007) indicate that the TQM program failure rate is higher than 30%. After thirty years of experience with QM practices, it is clear that the performance improvements resulting from these ideals are certainly not clear, but remain very mixed (Samson and Terziovski, 1999)! Consequently, today, there is considerable scepticism about quality management value creation potential (Hendricks and Singhal, 1997), and we still do not know all the reasons why some companies go bankrupt despite implementing QM programs.

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Despite the existence of a considerable amount of research dealing with the connection between QM and business performance, studies which analyse the connection between QM and factor productivity are not common. Those studies which do research the connection between QM factors and TFP are rare, and mostly limited to the estimation of the influence of one QM synthetic factor; namely, whether or not the company has the ISO certificate. Escribano (2005) uses this same binary variable in estimating the influence of the investment climate on productivity.

Therefore the goal of this work is to conduct empirical research into the following:

1. Are QM factors reliable and valid predictors of total factor productivity?
2. If so, how do they influence total factor productivity?

The answers to these questions will help managers to allocate their limited resources to those QM categories which have a significantly positive influence on TFP, and assist the scientific public to gain a better understanding of the role of each element of QM in total factor productivity.

LITERATURE REVIEW

Although a literature review can identify over 1,000 articles on TQM philosophy and methods, only a small percentage of these articles have attempted to test the strength of the relationship between TQM and performance (Samson and Terziovski, 1999).

The results from studying the relationship between TQM practices and firm performance in literature have been mixed, so, the need remains to re-examine this relationship (Sadikoglu and Zehir, 2010). The same authors provide an extensive overview of literature which deals with the link between TQM and performance. The most frequently studied types of performance in the available literature are: quality performance, operating performance, market and financial performance, employee performance, customer satisfaction, innovation performance, project performance and aggregate firm performance.

Hendricks and Singhal (1997) explored the impact of effective TQM implementation on the operating performance of firms over a 10-year period and found that firms winning quality awards outperformed those in a matched control sample in terms of operating performance and sales growth. In addition, they discovered that these same firms were also more successful in controlling costs. The research carried out by Hendricks and Singhal (2001) also shows that TQM firms experience better financial performance (operating income, annual percentage change in sales and percentage change in cost per dollar of sales) than control firms; smaller firms do better than larger firms; less capital intensive firms do better than more capital intensive and less diversified firms outperform more diversified firms. There are no significant differences between early and later adopters of TQM.

Corredor and Goni (2010) show higher average profitability among quality award-winning firms in the period prior to winning the award than among the control firms, but no significant differences are found for that period between firms in any of the different segmentations applied.

Tsu-Ming et al. (2010) design a model, that helps companies to diagnose the effectiveness and efficiency of their QM practices; their model puts the emphasis on considering the level of importance, the level of easiness to implement and the level of accomplishment of each QM practice.

Fotopoulos and Psomas (2010) examined the relationships between the total quality management (TQM) factors and organizational performance described with market benefits, customer satisfaction and protection of natural and social environment, in 370 Greek companies using structural equations modeling and concluded that quality practices of the top management and quality tools application have the strongest impact.

Studies which analyse the link between QM and productivity are rare, and when this connection was researched, productivity was not measured precisely, but as a percentage improvement by means of the Likert scale. We should also emphasise that these were cross-section studies. Using multiple regression, Samson and Terziovski (1999) demonstrated that the categories of leadership, people management and customer focus are the most significant predictors of operational performance, within which productivity is one of the factors with a factor loading of 0.524. Productivity is measured according to the Likert scale, where 1 is decreasing, and 5 major and significant gain. They see the limitation of their research in the fact that it deals with a cross-sectional study, and propose that further research include a set of longitudinal studies which would measure QM elements across time, examining the relationships with performance and their development through time.

Feng et al. (2008) have the central finding that ISO 9000 certification has a positive and significant effect on operational performance, but a positive weak effect on business performance. Productivity is considered to be an integral part of operational performance, as factor loading 0.792. The limitation of their study is that it presents a cross-sectional snapshot.

According to Agus et al. (2009), QM has had a significant impact on the productivity and profitability of the Malaysian electronics and electrical industry. Again, using the Likert scale, QM variables, especially quality measurement, benchmarking and training are shown to have had a significant impact on productivity.

Hofman and Mehra (1999) conclude that a lack of top management support, coordination among functions, and organizational communications in combination with project planning, training, and employee relationships form a framework that discourages success in productivity projects at all levels of an organization. They have shown that businesses facing complex productivity programs should establish leadership-based processes first, and then embark on the journey towards improving productivity. Available literature that connects quality management and performances tabulated in Table 1 points out the need for research into the link between the critical factors of quality management and total factor productivity, longitudinally on a sample of adequate size and with precise calculations opposite to subjective assessments to overcome the gap that exists in literature.

Research problem background

Consideration of the effectiveness of quality management in explaining the variance in the total factor productivity of industrial companies, demands the defining of QM and TFP measures in order to test any hypotheses:

H_1: QM factors are reliable and valid predictors of total factor productivity (previous research by Samson and Terziovski, 1999; Agus et al., 2009; Hoffman and Mehra, 1999; Feng et al., 2008 points to a possible connection).
H_2: Some QM factors exert a significant, positive or negative influence (according to Agus et al. (2009) quality measurement, benchmarking and training have a significantly positive influence on total factor productivity; according to Samson and Terziovski (1999), it is the categories of leadership, people management and customer focus that have a significantly positive influence on operative performance and productivity as its part, while according to Hoffman and Mehra (1999) this is leadership).

The research instrument developed in this study consists of two basic parts. The first part contains measures for quality management elements and the second, TFP calculation.

Quality management element measurement

Quality management elements or critical QM factors were considered for the first time by Saraph et al. (1989) and the number of available works reported to date is not negligible (Nakayo et al., 1996; Hutches, 1996; Sila, 2007; Badri et al., 1995; Samson and Terziovski, 1999; Hendrics and Sigal, 2001; Grandzol and Gershon, 1998; Motwani, 2001; McAdam and Bannister, 2001; Sadikoglu and Zehir, 2010; Terziovski and Samson, 2008; Sila and Ebrahimpour, 2002; Benson et al., 1991; Tamimi, 1998; Sousa and Voss, 2001; Prajogo and Sohal, 2001; Hendrics and Sigal, 1997). In available literature, certain differences in the authors' stands are noticeable; however, what unites them is the tendency to define critical QM factors as the components that will lead to the successful application of the QM concept. Following an analysis of frequency incidence in available literature, the following QM critical factors can be segregated: 1) leadership and management support for quality programs (15), 2) training and involvement of employees (15), 3) process approach (14), 4) systemic approach and documentary evidence for quality systems (13), 5) beneficial interaction with suppliers (11), 6) permanent quality improvement (9), and 7) product design according to user demands (7). This part of the research instrument proposed, initially contains 7 factors with 31 dimensions (Table 2), which is substantially the lowest of all offered to date. Using recommendations by Grandzol and Gershon (1998) to recode 25 to 50% of the questions (posed in reverse order relative to other questions), 45.88% of the questions were recoded. All questions had a five-level Likert scale. The majority of questions in the research instrument were taken from or designed using previous research (which is of critical importance in research of this kind as stated by Madu (1998). The proposed instrument has shown statistical validity in describing critical QM factors through second order confirmatory factor analysis on a sample of 111 Serbian industrial companies, which is presented in study by Spasojević et al. (2011). Therefore, the aforementioned elements, which have proved to be adequate in field studies in this area, such as the Serbian industrial context, will also be tested in this work.

Total factor productivity measurement

Total factor productivity is a neoclassical concept which attributes productivity to all production factors and has more recently become a predominant approach for the empirical evaluation of company performance in countries in transition (Djankov, 2002; Earle, 2002; Orazem, 2003). The core of the approach is the production function of different specifications, whereby the linear production function is most frequently used in the econometric evaluation:

$$\ln(y_{jt}) = \beta_0 + \beta_k \ln(k_{jt}) + \beta_l \ln(l_{jk}) + \delta_{jt} + \mu_{jt}$$

where $\ln(y_{jt}), \ln(k_{jt}), \ln(l_{jt})$ are the values or quantities of production, capital, and labour of firm (j) in year (t), (δ_{jt}) represents the level of total factor productivity (TFP) of the company (j) over time (t).
In the aim of appraising the robustness of the results, the parameters for the various specifications of the production functions were determined by means of regression. The ordinary least square method (OLS) was used to determine the parameters for two specifications of the production function (Cobb-Douglas and Translog), while the binary (dummy) variables of the industrial

Table 1. Literature that connects quality management and productivity.

Authors	Conclusion	Is productivity researched / calculated
Hendricks and Singhal (1997)	Firms winning quality awards outperformed those in a matched control sample in terms of operating performance and sales growth are also more successful in controlling costs	No/No
Hendricks and Singhal (1997)	TQM firms experience better financial performance (operating income, annual percentage change in sales and percentage change in cost per dollar of sales) than control firms	No/No
Hendrics and Singhal (2001)	TQM firms experience better financial performance (operating income, annual percentage change in sales and percentage change in cost per dollar of sales) than control firms	No/No
Corredor and Goni (2010)	Higher average profitability among quality award-winning firms in the period prior to winning the award than among the control firms	No/No
Agus, Ahmad and Muhammad (2009)	Quality measurement, benchmarking in particular as well as employee focus, supplier relations and training appear to be of primary importance and exhibit significant impact toward productivity and profitability. Productivity mediates the link between QM and profitabilityQuality measurement, benchmarking in particular as well as employee focus, supplier relations and training appear to be of primary importance and exhibit significant impact toward productivity and profitability. Productivity mediates the link between QM and profitability.	Yes/No
Hofman and Mehra (1999)	Study identifies critical factors that are potentially fatal to productivity improvement programs (the lack of top management support, coordination among functions, and organizational communications in combination with project planning, training and employee relationships). There is proposal to research the relationship of TQM to productivity.	Yes/No
Samson and Terziovski (1999)	The leadership, people management and customer focus are the most significant predictors of operational performance, within which productivity is one of the factors.	Yes/No
Feng, Terziovski, Samson (2008)	The results show that planning ISO 9000 certification has a significant positive relationship with operational performance. However, there is a positive, but not significant relationship between planning for ISO 9000 certification and business performance.	Yes/No

sectors were used as the control variables. The level of total factor productivity was then calculated as the residual of such determined production functions:

$$\ln TFP_{jt} = \ln(y_{jt}) - \beta_k \ln(k_{jt}) - \beta_l \ln(l_{jk}) \qquad (2)$$

In this study, the production level was measured as the level of added values; labour as the number of employees, and capital as the value of fixed assets. Equation (2) is thus transformed in the following form:

$$\ln TFP_{jt} = \ln(VA_{jt}) - \beta_k \ln(k_{jt}) - \beta_l \ln(l_{jk}) \qquad (3)$$

The obtained TFP is further used for the assessment of the influences of different quality variables on productivity:

$$\ln TFP_{jt} = \Phi_{jt}(\upsilon_{jt}) + \varphi_{jt} \qquad (4)$$

where Φ_{jt} is the vector of the specific quality variables of

Table 2. The dimensions of critical QM factors (Brkic et al., 2011).

Critical QM Factor	Dimensions for critical QM factor
Leadership and management support for quality program (LID)	L1: Management assumes responsibility for quality
	L2: Care of Department manager for quality
	L3: Efforts of company management to improve quality
	L4: Goal setting and quality policy
	L5: Establishing regulation for quality
	L6: Management encourages employees to independently make decisions and introduce innovations
	L7: Motivating the employees and rewarding them for high-level of job done
Training and involvement of employees (OB)	OB1: Responsibility of employees in Department of quality and other departments for quality
	OB2: Employees training as priority of the company
	OB3: Existence of financial resources for employees training
	OB4: Employees training to apply methods and techniques (tools) for quality improvement
Systemic approach and documentary evidence for quality system (SIST)	SIST1: Availability of data on quality to each employee
	SIST2: Analysis of collected data on quality in order to improve it
	SIST3: Existence of Department of quality
	SIST4: Possession of documents for quality system
Process approach (PROC)	PROC1: Differentiation and description of each process in the company
	PROC2: Continuous monitoring of key processes in the company and their improvement
	PROC3: Determination of quality measure for each process in the company
	PROC4: Participation of machine operator in maintenance
Beneficial interaction with suppliers (ISP)	ISP1: Relying upon a small number of reliable suppliers
	ISP2: Selection of certified suppliers
	ISP3: Participation of supplier in program development
	ISP4: Participation in employees training in quality field at supplier's firm
Permanent quality improvement (PK)	PK1: Permanent tendency to eliminate internal process leading to waste of time or money
	PK2: Innovating production program
	PK3: Application of advanced IT to better analyze data and determining priorities to improve quality
	PK4: Revision of documents for quality system if necessary
	PK5: Application of methods and techniques to improve quality
Product design according to user demands (PP)	PP1: Coordination of employees from different organizational units in product development process
	PP2: New product quality as priority in its design and manufacture
	PP3: Analysis of possibility for manufacture and cooperation in product development

the company (j) over time (t), υ_{jt} describes how such variables influence total factor productivity, whereas φ_{jt} represents a random error.

In order to avoid the restrictive hypothesis of constant input-output production factor elasticity, which Cobb-Douglas's original production function implies, in the following specification, the trans-logarithm transformation of the production function was used to determine total factor productivity (Christensen, 1973):

$$\ln(VA_{jt}) = \beta_0 + \beta_k \ln(K) + \beta_l \ln(L) + \beta_{k^2} \frac{1}{2}(\ln K)^2 + \beta_{l^2} \frac{1}{2}(\ln L)^2 + \beta_{kl} \ln K \ln L + \delta_{jt} + \mu_{jt} \quad (5)$$

The total level of factor productivity (lnTFP) in this specification of the production function was obtained in the same way as in Equation 3. In order to consistently determine the production function parameters in the previous specification, by means of the ordinary least square method (OLS), the variable function has to be independent of error (lnTFP). However, there is a correlation in the panel sample between the error and the variables which leads to the so called problem of simultaneity (Griliches, 1995). The use of the ordinary least square method in such a case distorts the parameters of the production function. In order to overcome this problem two methods for the semi-parametrical determination of the production function were developed by Olly and Pakes (OP) (Olley and Pakes, 1996) and Levinsohn-Petrin (LP) (Levinsohn and Petrin, 2003)). Because of the nature of our data the LP method was used to determine the total factor productivity. Total factor productivity as the synthetic measure or company performance was calculated in the same way as in Equation (3) and the (β_k) and (β_l) parameters were determined by means of the LP method.

Therefore, three specifications of the production function were used to test the robustness level of the total factor productivity. In the first two specifications, the parameters of the production function were determined according to the ordinary least square method (OLS) and LP semi-parametrical estimation and in the third specification, the parameters of the translog production function were determined by the OLS method.

METHODOLOGY

Background

The stated hypotheses were tested using data from different sources: a) from the research instrument – the poll used to gather data regarding QM, and b) from official financial reports used to collect data relating to TFP. Various statistical techniques such as validity and reliability testing and multiple regression were used and carried out using SPSS for Windows 17. Our sample was a genuinely random sample of Serbian industrial companies. The data was collected in the period 2004 to 2009 so that the analysis could be done longitudinally.

The Serbian context

According to Ivanovic and Majstorovic (2006), the number of ISO 9000 certified organizations in Serbia in 2004 was around 400, while a total number of 556.16 (max 1,000) points had been obtained from assessment with the EQA model, showing that Serbian companies are in transition from the quality assurance phase to the TQM phase. The number of certificates in Serbia is rapidly growing, day to day; therefore, in 2008, there were 1987 certificates in Serbia which is still far from the desirable 2.5 certificates per one thousand citizens. Serbia is a country in transition, which means the transformation of public and state owned property to private ownership, the introduction of new trading procedures and foreign investment in local companies, in the aim of increasing the level of technology and the growth of productivity. Countries in transition today have the highest rate of increase in the number of certificates, and those which stand out among them are the Check Republic, China, Hungary, etc. (Ivanovic and Majstorovic, (2006). Industrial companies in Serbia were the first to set off on the path towards TQM, which was expected since the standard was firstly developed for such companies (Martinez-Costa et al., (2009). Therefore, Serbian industrial companies are highly appropriate for an analysis of the link between QM and TFP.

The data and sample

The sample is a stratified random sample drawn from the population of Serbian industrial firms certified according to ISO 9000 (it includes companies of all three sizes from all 19 industrial sectors). Industrial companies form the subject of the analysis because the ISO 9000 was originally developed for them (Martinez-Costa et al., 2009). Each industrial sector cell contained a minimum of 10 firms, so the questionnaire was sent to 190 industrial firms, thus encompassing a large part of the population of certified industrial companies (47.5%). Since the data was collected over a 6 year period, the sample was gradually reduced over time and the final one contains the non-balanced panel data for 50 industrial companies from 19 industrial sectors for the period 2004 to 2009. The minimum number of observations (time periods) per company was 1 and the maximum 6. The total number of observations (time periods) was 176. The primary information about QM practice comes from a questionnaire with 31 questions. The distributed questionnaires (Appendix 1) were largely completed by quality managers, directors or those with supervisory functions. The persons responsible for the delivered responses have, on average, 14.6 years of practical experience in the field and, for the most part, have a university degree. The research instruments were delivered to industrial companies throughout Serbia. The primary information on company productivity comes from different data sources. The official financial reports submitted annually and bi-annually under uniform accounting procedures provide information on the firms' revenue from domestic and foreign sales, material inputs and the companies' capital stock. The financial reports are provided directly from the companies, the National bank of Serbia, the Belgrade stock exchange and independent auditing firms. Output and capital price deflators come from the Serbian Statistical Office.

Empirical strategy

The empirical estimation of the influence of management quality oncompany performance was provided through an analysis of the interdependence of total factor productivity (TFP) as the measure of company performance and those variables which determine quality practice at company level.

Since the level of total factor productivity as a residual is given on the basis of equations (2) and (3), regression is carried out in the next step on the basis of equation (4) in relation to the selected variables of management quality:

Table 3. Statistics of variables for TFP calculation (2004 to 2009).

Variable	Mean value
Value added (000 RSD)	1933814
Capital (K) (000 RSD)	16218839
Labour (L)	1241

$$\ln TFP_{jt} = \alpha + \beta_1 LID_{jt} + \beta_2 OB_{jt} + \beta_3 SIST_{jt} + \beta_4 PROC_{jt} + \beta_5 ISP_{jt} + \beta_6 PK_{jt} + \beta_7 PP_{jt} + \sum_m \tau INDUSTRY_m \quad (6)$$

where $\ln TFP_{jt}$ is the level of multi-factor productivity in log terms, LID_{jt} - Leadership and management support for quality programs, OB_{jt} - Training and involvement of employees, $SIST_{jt}$ - Systemic approach and documentary evidence for quality systems, $PROC_{jt}$ - Process approach, ISP_{jt} - Beneficial interaction with suppliers, PK_{jt} - Permanent quality improvement (PK), and PP_{jt} - Product design according to user demands (PP), whereby the regression coefficients (β) represent the dependence (direction and intensity) of the change ln TFP for the unit change of the related management quality variable. INDUSTRY is the vector of industrial dummy variables classified by the standard two-digit classification of activity.

Analysis procedure

The variables which describe the dependence of value added and production factors of labour and capital were used to determine the total factor productivity through the production function. Value added is calculated on the basis of the value of production and subsidy reduced by the costs of tax on products and the value of intermediate consumption. The production value is determined on the basis of the turnover value (the market sale of goods and services to third parties), corrected with changes in stocks of finished goods and work in progress and reduced by the values of purchases of goods and services purchased for resale. The calculation of the value added includes the value of production and subsidy reduced by the costs of tax on production and products and the value of intermediate consumption, which includes the costs of material, tangible and non-tangible services and other personal expenses. The nominal values of the items used for the calculation of the value added are corrected with appropriate price indices, whereby the year 2004 is taken as the base period. The value of turnover is deflated by appropriate sectoral price indices. The nominal value of the direct costs of material and goods intended for resale is deflated by the weight price index of the sector from which the material or goods originate. Considering the fact that there are still no input-output tables for the Serbian economy, the weights were calculated, where applicable, at the level of the company on the basis of the general ledger. The general ledger contains a detailed structure of costs and allows the determination of the relative participation of certain types of costs within the total costs, as well as assumptions on the sector of origin. The index for the deflation of the company's material costs is calculated as the sum of the weighted indices of the main cost components, whereby the weighted indices of the cost components represents the multiplication of the relative participation of certain types of costs in the total costs and the price indices of the sectors of such cost origin. The value of the capital is measured by means of the value of the company's fixed assets. The value of fixed assets in the balance sheets of privatised and private companies is the purchase value corrected with the depreciation amounts. According to new accounting standards, applied in practice since 2004, companies are obliged to revalorise, in cases of any major discrepancy between bookkeeping and actual value, the value of fixed assets at fair value, which represents the assessed market value of the fixed assets. Production factor labour is measured as the average number of employees (headcount) at the end of each month. The average number of employees is calculated on the basis of working hours. Statistics of variables for TFP calculation is shown in Table 3.

Firstly, the QM data shown on Figure 1 was screened for outliers and checked for normality. Adequate values of skewness and kurtosis were achieved and outlier problems were not detected. In Figure 1, it can be seen that initial factor with lowest value is ISP4: Participation in employees training in quality field at supplier's firm, while the highest value has factor L1: Management assumes responsibility for quality.

The data were then exposed to factorial analysis to ensure that they constituted reliable indicators of QM constructs (factors). A cutoff loading of 0.450 was used to screen out those variables which represented weak indicators of the constructs (Hair et al., 1998). Five variables failed to make this cutoff, leaving a total of 26 variables constituting 7 QM constructs (Table 4). This was followed by the calculation of the composite reliabilities, also shown in Table 2, where we see that 6 out of 7 constructs has a Cronbach alpha higher than 0.60 as recommended by Hair et al. (1998). Construct product design according to user demands has a reliability of 0.550; however, further culling of variables will not improve this situation. Similar results were achieved in the study conducted by Van de Ven and Pool (1995), awarded as the best work in the Academy of Management review. The factor scores were then calculated from the remaining variables to provide estimates for all 7 constructs, which were later used as independent variables in multiple regression.

EMPIRICAL RESULTS AND DISCUSSION

The values of total factor productivity were established (lnTFP) on the basis of model (3) for three different production function specifications. Those values were then regressed in relation to the quality management variables, presented in Table 4. Based on model (6),

In Figure 2, it can be seen that in Serbian context, factor with the highest average value is Product design according to user demands (PPSR), while the lowest

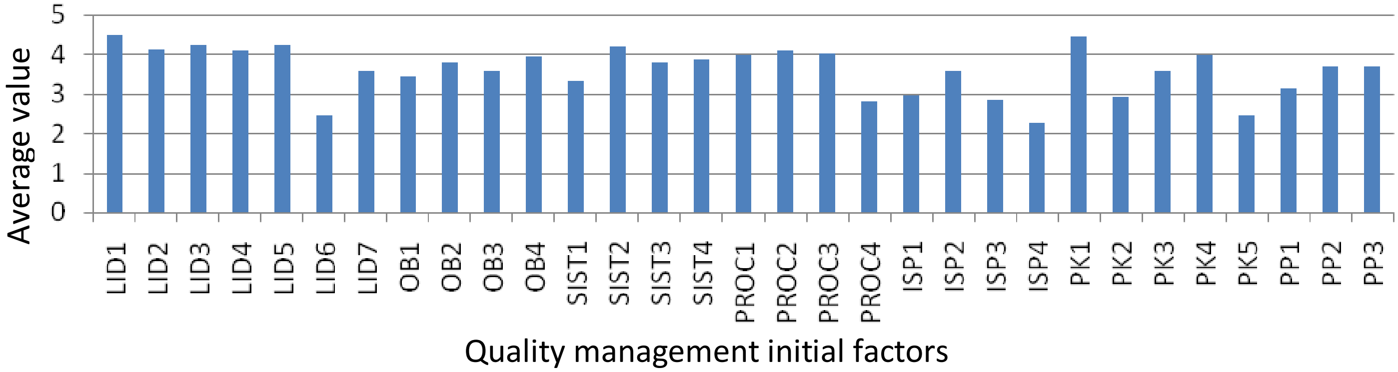

Figure 1. Average values of Quality Management initiial factors - dimensions

Table 4. Factor and reliability analysis for QM.

Variables	Description	Initial factor	Revised factor	Reliability of revised construct
LID1	L: Leadership and management support for quality program	0.394	/	ά =0.899
LID2		0.769	0.788	
LID3		0.752	0.795	
LID4		0.788	0.862	
LID5		0.586	0.652	
LID6		0.150	/	
LID7		0.318	/	
OB1	OB: Training and involvement of employees	0.214	/	ά =0.814
OB2		0.804	0.829	
OB3		0.777	0.796	
OB4		0.529	0.564	
SIST1	SIST: Systemic approach and documentary evidence for quality system	0.518	0.518	ά =0.718
SIST2		0.978	0.978	
SIST3		0.803	0.803	
SIST4		0.796	0.796	
PROC1	PROC: Process management	0.772	0.772	ά =0.685
PROC2		0.875	0.875	
PROC3		0.832	0.832	
PROC4		0.998	0.998	
ISP1	ISP: Supplier quality management	0.658	0.658	ά =0.633
ISP2		0.721	0.721	
ISP3		0.751	0.751	
ISP4		0.637	0.637	
PK1	PK: Continuous quality improvement	0.848	0.987	ά =0.615
PK2		0.315	/	
PK3		0.758	0.761	
PK4		0.795	0.819	
PK5		0.558	0.591	

Table 4. Contd.

PP1		0.541	0.541	
PP2	PP: Product design according to user demands	0.504	0.504	ά =0.550
PP3		0.569	0.569	

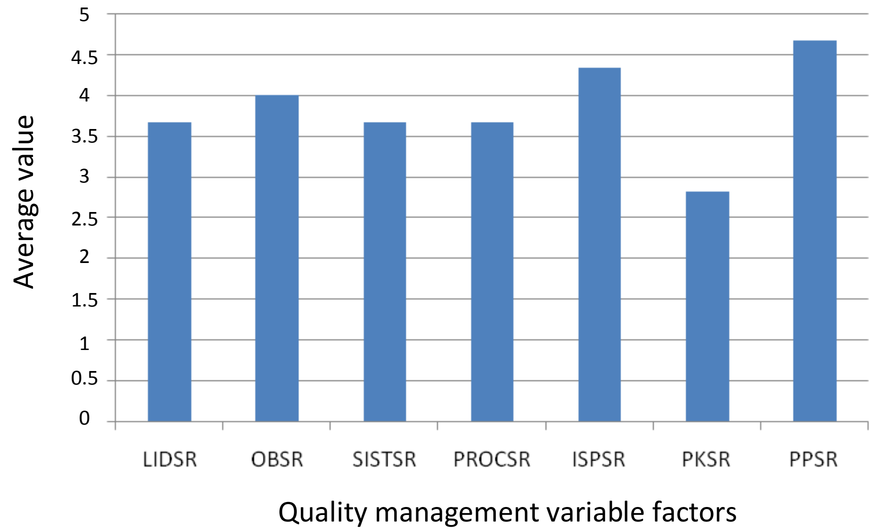

Figure 2. Average values of Quality Management variable factors - dimensions

value has permanent quality improvement (PKSR) according to managers' opinion. Table 5 presents the regression dependence of total factor productivity and those variables which describe quality management. The results presented in Tables 4 and 5 confirm the H_1 that seven QM factors, described with 26 dimensions, provide reliable and valid predictors of total factor productivity. Content validity is secured by the selection of initial measurement items on the basis of voluminous international literature. The construct validity of each QM category was evaluated by using principal component factor analysis, whose results are presented in Table 4. All factors loaded well. The criterion validity of the model is determined by examining the multiple R coefficient computed for the seven categories of QM and three measures of production function for total factor productivity. The results for the adjusted R^2 of 0.529405, 0.657594 and 0.519906 for three functions respectably present a high level of criterion related validity. Reliability was researched by means of the Cronbach alpha reliability coefficient; therefore the values in Table 4 meet or exceed prevailing standards of reliability for survey instruments. Considering the above findings, hypothesis 1 is proved.

The results of the regression analysis of the seven QM elements of total factor productivity (Table 5) provide some insights and challenges from both a practical and research perspective. Leadership and management support for quality programs is a factor of the highest significance, which has the strongest and most positive influence on total factor productivity in all three production function models. The QM factor which also exerts a significant and positive influence on TFP is continuous quality improvement with a less strong influence. Those QM factors which have both a negative and significant influence on TPF for all three functions are Training and involvement of employees and Product design according to user demands, and the Process Management factor in the case of the second function. The factors of Systemic approach and documentary evidence for quality systems and Supplier quality management in the case of the first function, and Process management for the cases of the first and third functions, are not significantly related to TFP. Overall, the multiple R^2 *adjusted* value of around 0.5 is interpreted as indicating a relatively strong relationship. Therefore, since this refers to the log-lin function, the interpretation of the beta coefficient is as follows; for instance, the increase of the leadership variable (LID) by one unit increases the TFP by 81%, the increase of the PP variable by one unit decreases the TFP by 21% or the increase of leadership variable (LID) by one standard deviation (0.820) increases the TFP by 74%. Considering the foregoing, we can claim that hypothesis 2, that certain QM factors influence total factor productivity significantly

Table 5. Regression results-dependent variable (ln TFP).

Cobb-Douglas (OLS)	**β**	**Std. Error**	**t-statistic**	**p-value**
Quality variable				
LID	0.8571	0.171091	5.0096	<0.00001
OB	-0.3107	0.105893	-2.9344	0.00401
SIST	0.08595	0.145024	0.5926	0.55454
PROC	-0.2385	0.163371	-1.4596	0.14701
ISP	-0.1298	0.165783	-0.7828	0.43529
PK	0.31674	0.115736	2.7367	0.00715
PP	-0.2372	0.0979369	-2.4222	0.01692
Adjusted R^2 = 0.529405				
Levinsohn-Petrin				
Quality variable	β	*Std. Error*	*t-statistic*	*p-value*
LID	1.11377	0.18483	6.0259	<0.00001
OB	-0.3393	0.103343	-3.2835	0.00134
SIST	0.0396	0.162755	0.2433	0.80817
PROC	-0.4278	0.188528	-2.2692	0.02504
ISP	-0.1222	0.162484	-0.7523	0.45337
PK	0.30528	0.110795	2.7554	0.00678
PP	-0.2969	0.0966991	-3.0703	0.00265
Adjusted R^2 = 0.657594				
TransLog (OLS)				
Quality variable	β	*Std. Error*	*t-statistic*	*p-value*
LID	0.8153	0.166717	4.8903	<0.00001
OB	-0.3168	0.105597	-3.0002	0.00328
SIST	0.1167	0.142773	0.8174	0.41533
PROC	-0.213	0.16117	-1.3218	0.18874
ISP	-0.1373	0.165289	-0.8308	0.40776
PK	0.31275	0.114708	2.7264	0.00736
PP	-0.2142	0.0950071	-2.2543	0.02599
Adjusted R^2 = 0.519906				

positively or negatively, is proved.

Conclusions

The central finding of this study is that QM factors, as we modelled them in a longitudinal study, are reliable and valid instruments for predicting total factor productivity – the effectiveness of quality management explains the variance in the total factor productivity of industrial companies. Two of the elements of QM, leadership and management support for quality programs and continuous quality improvement, have a significantly positive effect on TFP, but the other categories in our study did not. There is also a good deal of variance in TPF which remains unexplained by our QM elements, as tested by regression analysis. Therefore, the aim of this research is not to show what significantly influences TPF, but to provide directions to companies with limited resources as to which QM elements they should pay attention in order to increase productivity. Investment in leadership and management support for quality programs and continuous quality improvement are more likely to be fruitful than efforts in other QM factors. Our research accords well with practical experience and previous research such as that carried out by Samson and Terziovski (1999), Fotopulos and Psomas (2010) and Hoffman and Mehra (1999), which also emphasise leadership as a predictor of performance.

Despite the fact that our research achieved significant and verifiable results, it should be emphasised that any flaws in this research, stem firstly from the size of the sample, and although the internal validity of our variables is acceptably strong, it is far from perfect, so there are proposals for further research.

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APPENDIX

Appendix 1: Questionnaire

Quality management factors

Describe the effect of factors of quality management by circling responses on a scale of 1 to 5, or by entering specific data depending on your estimates.

1. Leadership and management support for quality program.

i. Our management is fully responsible for the quality / quality is our priority goal	1	2	3	4	5	Our leadership means that quality is not important / quality objectives are not defined
ii. Directors of Department do not give any weight to the quality	1	2	3	4	5	Directors of all sectors take responsibility for quality and monitor the implementation of quality system
iii. The management of our company is fully committed to the quality improvement	1	2	3	4	5	The management of our company is not committed to the quality improvement
iv. Objectives and quality policy are not defined	1	2	3	4	5	Quality goals and quality policy understands and implements every employee
v. We do not have quality regulation	1	2	3	4	5	Rules of the quality are understood by all employees
vi. Employees are encouraged to self-determination and to introduce innovations	1	2	3	4	5	Employees are not prone to self-decision making and innovation
vii. Employees are motivated and rewarded for a high level of work performed	1	2	3	4	5	Employees are not motivated, and standards in performing their jobs are not set

2. Training and involvement of employees.

i. People who deal with quality t bear the responsibility for quality (working in the field of quality)	1	2	3	4	5	In our company, each employee is responsible for quality
ii. Training employees is a priority in the enterprise	1	2	3	4	5	Leadership attaches great importance to training and development of employees
iii. We do not have the funds to train employees	1	2	3	4	5	Management always provides funding for staff training
iv. Special importance attaches to the training staff for the application of methods and techniques (tools) to improve the quality	1	2	3	4	5	To quality tools application we do not attach importance

3. Systemic approach and documentary evidence for quality system.

i. Data on quality are available to each employee	1	2	3	4	5	Data on the quality are provided to leaders
ii. Data on quality are collected to improve the quality	1	2	3	4	5	Data on quality are not used for further analysis
iii. We do not have the quality sector	1	2	3	4	5	We have a quality sector with a sufficient number of employees and excellent cooperation with other sectors

Our quality system consists of the following documents (please circle document/documents you have):

a) Documented statement about quality policy
b) Documented statement about quality objectives
v) Quality manual
g) Procedures that show how quality is controlled and the checks that are carried out.
d) Forms, work instructions and records used for recording observations, describing work tasks etc.

4. Process approach.

i. Processes in our company are strictly described and delimited	1	2	3	4	5	We do not use the principle of process approach. Machinery held a special service.
ii. Key processes in the enterprise are continuously monitored and work on improving them	1	2	3	4	5	Key processes in the enterprise are not defined
iii. For each process in the enterprise is determined by the measure of the quality of its execution	1	2	3	4	5	For the activities of an enterprise is not a measure of quality of its execution
iv. The operator of the machine is involved in its maintenance	1	2	3	4	5	Machinery maintenance is held by special service

5. Beneficial interaction with suppliers.

i. We rely on a small number of reliable suppliers	1	2	3	4	5	We have a large number of suppliers, we often change suppliers and strive to reduce costs
ii. We choose providers regardless of whether they have a quality certificate	1	2	3	4	5	All our suppliers have a quality system - have been certified
iii. Suppliers participate in the development of our products	1	2	3	4	5	We choose providers in the later stages
iv. Suppliers themselves take care of training of its employees in the field of quality	1	2	3	4	5	When necessary, we participate in training in the field of supplier quality

6. Permanent quality improvement.

i. We continually strive to eliminate internal processes that lead to irrational spending time or money	1	2	3	4	5	We do not analyze processes, we work as usual
ii. We have the same product line back a long time	1	2	3	4	5	We are constantly improving and perfecting our products, services and processes
iii. We use advanced information technologies to support quality management better data analysis	1	2	3	4	5	We do not use information technology
iv. Quality system documents are reviewed as necessary	1	2	3	4	5	Once a set of quality system documents do not change

7. Whether or not the following methods and techniques were used to improve quality and to what extent:

Methods and techniques to improve quality – Quality tools application	round off the scope *
Check list	1 2 3 4 5
Histogram	1 2 3 4 5
Control chart	1 2 3 4 5
Stratification	1 2 3 4 5
Team work	1 2 3 4 5
Iinput, process and output inspection	1 2 3 4 5
Analysis of quality costs	1 2 3 4 5
QFD	1 2 3 4 5
Pareto diagram	1 2 3 4 5
Cause-Effect Diagram	1 2 3 4 5
Brainstorming	1 2 3 4 5
Flowchart	1 2 3 4 5
Network Plan (CPM/PERT)	1 2 3 4 5
Internal Audit	1 2 3 4 5
Benchmarking	1 2 3 4 5
Electronic Control of documentation	1 2 3 4 5
FMEA	1 2 3 4 5
Sampling and acceptance methods	1 2 3 4 5
Analysis and processing of data (complaints, conflicts, etc.)	1 2 3 4 5
Value analysis	1 2 3 4 5
Study of precision, accuracy and stability of the process	1 2 3 4 5
Reliability analysis	1 2 3 4 5
	1 2 3 4 5
	1 2 3 4 5

*(1 - not used, 5 - full range of applications that significantly improves quality). If you use some other methods and techniques to improve quality, that is not listed in the table, enter here a name and mark in the above fields blank.

8. Product design according to user demands.

i. Excellent coordination of employees from different organizational units in the product development process	1 2 3 4 5	Product development services exclusively does research and development Product development, special attention is paid to standardization, simplification and co-operation
ii. The quality of new products is a priority	1 2 3 4 5	The priority is the price of the product
iii. Product development is not thinking about the possibilities of production and cooperation	1 2 3 4 5	In product development, special attention is paid to standardization, simplification and co-operation