Organizational and technological concepts that enable quality costs monitoring

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Abstract

The increasing competitiveness leads quality to become widely regarded as a key element for success in business. Through an empirical survey, we proved that companies that measure cost of quality have a significantly higher ROS. We looked at which technologies and organizational concepts enable monitoring quality costs.

Keywords: quality cost monitoring, organizational concepts, technological concepts

Introduction

The increasing competitiveness of markets leads quality to become widely regarded as a key element for success in business, especially in manufacturing industries. This is done by avoiding defects (Battini et al., 2012). As a result, quality and quality costs gain vital importance for a company to survive in a highly competitive market (Kirlioğlu and Çevik, 2013). Pires (2012) states that the economics of quality will become increasingly important in the future.

Measuring the cost of quality requires both technical knowledge and accounting know-how and is a joint effort of many, including quality control, accounting, engineering, production, marketing and service (Mwaura and Nyaboga, 2007). The identification of costs of quality is not straightforward, because there is no general agreement on a single broad definition of quality costs (Schiffauerova and Thomson, 2006b). Lari and Asllani (2013) in their literature research found many studies on quality costs but warn that due to the indeterminate nature of most indirect costs, effort has historically focused on the estimation of direct quality costs. Love and Irani (2003) point out that, only some quality cost components can be estimated with a certain degree of accuracy and objectivity. Consequently, the real quality cost values are possibly far superior to estimated costs if measured at all.

Setijono and Dahlgaard (2008) gave an overview of past and current definitions of quality costs. According to Schiffauerova and Thomson (2006) total quality costs represent the difference between the actual cost of a product or service and what the cost would be if the quality was perfect. According to Juran and Godfrey (1998), quality means freedom from deficiencies. Costs of quality are the costs, which occur because poor quality may or does exist (Hansen and Mowen, 2006). Campanella (1999) defined cost of quality as; (1) Prevention quality costs - are the sum of the cost incurred by investing in the prevention of non-conformances to requirements, (2) Appraisal Costs - appraising a product or service for conformance to requirements, and (3) Failure Costs - failing to meet requirements.

Companies that do not measure quality costs cannot even enhance their quality or reduce quality costs (Lopes and Capricho, 2007). This brings us to the first issue on quality cost measurement. The majority of research on quality cost is performed via case base method. Although those researches provide specific numbers as to the amount of quality costs, it does not provide the view how many companies do in fact have some quality measurement system. With a notable exception of Pires et al. (2013) who showed that of the 145 Portuguese companies considered in the analysis, 77 (53.1%) did measure quality related costs. Because of this low percentage of companies that do measure quality costs, Portuguese companies are not able to reap benefits (Souza and Collaziol, 2006; Yang, 2008; Omurgonulsen, 2009). Sower et al. (2007) only state that a small proportion of the industries systematically track quality costs.

This paper contributes to the literature on costs of quality in two ways. First it is a survey method which is rare, with a notable exception of Pires et al. (2013). Secondly, it is clear that most of the efforts in this area are focused on identifying quality cost elements, calculating the cost of quality, reducing the costs, and studying the relationship between the cost components. This paper contributes to the field of quality cost management by analyzing which technologies and organizational practices enable cost of quality calculations. It also proves, only speculations in literature, that measuring costs of quality enhances return on sales. This is proven via regression analysis. Reasons for including organizational practices and technology can be found in Al-Dujaili (2013) and Omachonu et al. (2004). Omachonu et al. (2004) researched quality costs in relation to materials and technology but indirectly undertook the analysis of the human factor. Al-Dujaili (2013), on the other hand, proved that obsolete technology largely increases scrap rate and all costs accompanied with poor quality.

LITERATURE RESEARCH

Even though, there is little empirical confirmation that measuring quality costs improves performance of a company, Sansalvador and Brotons, (2013) state that this relationship is obvious. Also, Desai (2008) and Srivastava (2008) state that even a small reduction in quality costs will impact the overall financial goal of a company. Robles (2003) argues that, by reducing waste, the company can generate resources to leverage its quality-improvement system, and in this way boost the profitability of a company by a significant amount. The same opinion shares Al-Dujaili (2013). Carvalho and Paladini (2006) state that, systematic collection and analysis of quality costs enable the organization to verify the behavior of these costs over time, but their view is largely based on seminal work of Crosby (1979).

According to Schiffauerova and Thomson (2006b), improving quality is a way to enhance customer satisfaction, reduce manufacturing costs and, consequently increase productivity. However they warn that the reduction of quality costs is only possible if they are identified and measured, and that is not an easy task.

Srivastava (2008) has concluded in his research that quality-related costs directly affect the overall financial goal of a company, even though his research was focused on quality costs in supply chains.

Tye et al. (2011) in their case based research in Malaysia, have reported that effective implementation of measuring cost of quality would provide the opportunity for the manufacturing firms to identify and improve their product quality level, reduce scrap and rework, and improve their production yield as well as increase their sales volume. Similarly, in his Turkish case company Omurgonulsen (2009) successfully demonstrated that for manufacturing industry, conformance (prevention and appraisal) expenditures would be increasing over time in order to achieve reductions in non-conformance costs, especially those concerned with external failure costs.

It is also worth noting an opposing view by Robles (2003) who warns that information about cost of quality alone will not lead to improvements in quality and better performance. This brings us to the second problem of quality costs, that is, measurement issues.

Mandroli et al. (2006) defined defect rate as the quantity of defective items manufactured by a process at a station, and that is the data that most companies record. Villar and López (2007) state that companies can divide scrap rate into internal and external faults, internal beings the defaults observed in the company before the product reached the customer, and external, when the faulty product reached the customer. Battini et al. (2012); Kirlioğlu and Çevik (2013) state that collecting data from the production process is very difficult and warns that it is necessary to utilize reliable and consistent methods for both data collection and data analysis. Pires et al. (2013) state that it is jet unknown whether companies that report costs of quality include costs arising from activities undertaken to improve quality, or report only costs coming from failures. Yang (2008) warns that even if companies collect some data on quality issues it is largely underestimated. Hales et al. (2006) report on difficulties operations managers face in collecting quality costs data. They especially focused, through their action research on day-to-day problems operations managers face – such as simultaneous malfunction of several machines. They found that managers prioritize repairs on first-come-first- out sequencing schedule instead on relying on the cost of downtime of a machine. Lari and Asllani (2013) proposed a software program to monitor quality related data, but in their case analysis, they were fair enough to list all obstacles that initiative faced. Schiffauerova and Thomson (2006) and Setijono and Dahlgaard (2008) say that most industries are aware of the benefits of measuring cost of quality, but only a few of them are using it in their organization, because they do not know how to calculate and implement same. Exactly because of these measurement problems Yang (2008) noted that failure costs are usually under-estimated.

Finally, Omachonu et al. (2004) state also a practical research problem, and that is, that companies are reluctant to disclose these data to scientists.

Few case based analyses did in fact revile an estimate of quality costs. They are presented in the following table.

Table 1. Quality costs found in literature

<table>
<tr><th></th><th>(textile industry) Schiffauerova and Thomson (2006)</th><th>wood-processing Swedish manufacturing company Setijono and Dahlgaard (2008)</th><th>Cheah et al. (2011)</th><th>Omachonu et al. (2004)</th><th>Turkish manufacturing company Kirlioğlu and Çevik (2013)</th><th>footwear company Sansalvador and Brotons (2013)</th></tr>
<tr><td>Total prevention cost</td><td>12%</td><td>2,5%</td><td>16,8%</td><td></td><td rowspan="4">They provided also all those costs but in % of quality costs so comparison is impossible</td><td></td></tr>
<tr><td>Total appraisal cost</td><td>16%</td><td>15,5%</td><td>17,5%</td><td></td><td></td></tr>
<tr><td>Total internal failure cost</td><td>64%</td><td>53%</td><td rowspan="2">65,7%</td><td></td><td></td></tr>
<tr><td>Total external failure cost</td><td>8%</td><td>29%</td><td></td><td></td></tr>
<tr><td>Total cost of quality in relation to sales</td><td>7,56%.</td><td>4%</td><td>5,64% (additional 8.78% of sales are invisible quality costs)</td><td>3.67%</td><td>1,61%</td><td>5,5%</td></tr>
</table>

In our research we will concentrate only on last row that is, cost of quality as a percentage of sales. We present our results after describing the methodology used.

RESEARCH METHODOLOGY

Data collection

Research data was collected through a survey. The European Manufacturing Survey (EMS), coordinated by the Fraunhofer Institute for Systems and Innovation Research – ISI, is the largest European survey of manufacturing activities (ISI, 2015). EMS questionnaire is very extensive (8 condensed pages). The survey’s questions concern manufacturing strategies, the application of innovative organizational and technological concepts in production, cooperation issues, production off-shoring, servitisation, and questions of personnel deployment and qualification. In addition, data on performance indicators such as productivity, flexibility, quality and returns is collected. The survey is conducted among manufacturing companies (NACE Revision 2 codes from 10 to 32) having at least 20 employees. The main objectives of EMS project are to find out more about the use of production and information technologies, new organizational approaches in manufacturing and the implementation of best management practices (Palcic et al. 2015). The underlying idea of the question design is to have a common part of questions constantly over several survey rounds, to modify other common questions in the respective survey round corresponding to current problems and topics from the field of innovations in production and to give space for some country or project specific topics. The Survey is conducted on a three-year basis and new concepts are added to the questionnaire, while obsolete concepts were excluded. The survey round in 2012 had extensive changes especially in the technology part.

In order to collect valid data permitting international comparisons, the EMS consortium employs various procedures recommended by the Survey Research Center to avoid problems arising from different languages and national peculiarities in terminology. First, the basic questionnaire is developed in English and then translated including backwards translation. Second, in each participating country pre-tests are conducted. Third, identical data harmonization processes is applied (Bikfalvi et al, 2014).

Data from EMS is mainly used for research projects on behalf of the EU, but also for scholarly articles. However, the dominant current research streams using EMS data is in area of servitization, energy efficiency and relocation (Lerch, 2014).

The questionnaire was sent to Chief Executive Officer of the manufacturing company in March 2012, but the filing was done by several persons, usually by operations management and accounting. After two weeks companies are called by telephone and asked to fill in the questionnaire or to name the reasons why they cannot respond to the questionnaire. The questionnaire was sent to all manufacturing companies (NACE 10-32) in Croatia with over 20 employees (population was 1541 companies so no sampling was needed) and obtained 120 fully filled questionnaires which represent an 8% response rate. Non response base was tested with χ^2 test between early and late responders and there was no significant difference between responders.

Representativeness of the sample was checked by size and industry and it shows generalizability for Croatian manufacturing.

The analysis is done using three independent regression analyses because the aim is to find influence of each technology/organizational concept on a dichotomous depended variable "do the calculate cost of quality". Therefore, the regression analysis is most appropriate. Then, non-significant technologies and organizational concepts are excluded and in our results we present only technologies and organizational concept that have significant impact on measurement of quality costs. Third regression analysis has return on sales as a dependent variable (categorical variable ranging from 0- negative ROS, to 4- ROS>10%), and independent variables are selected organizational concepts and technologies.

Control variables size of the company, the complexity of the product, and process type are used. It is believed that larger companies have more resources to invest into technology so size should consider as an important factor. Secondly, the complexity of the product might need more advanced technologies so this variable is also used as a control variable. Process type was researched because it is actually connected with business strategy. MTS is generally associated with low cost strategy, while ETO, MTO with differentiation. Those control variables are also contextual factors if we look from Contingency theory perspective.

However, in all our regression analyses control factors showed no significance, that is, results are valid for any size of company, any type of manufacturing process, and the like.

Results

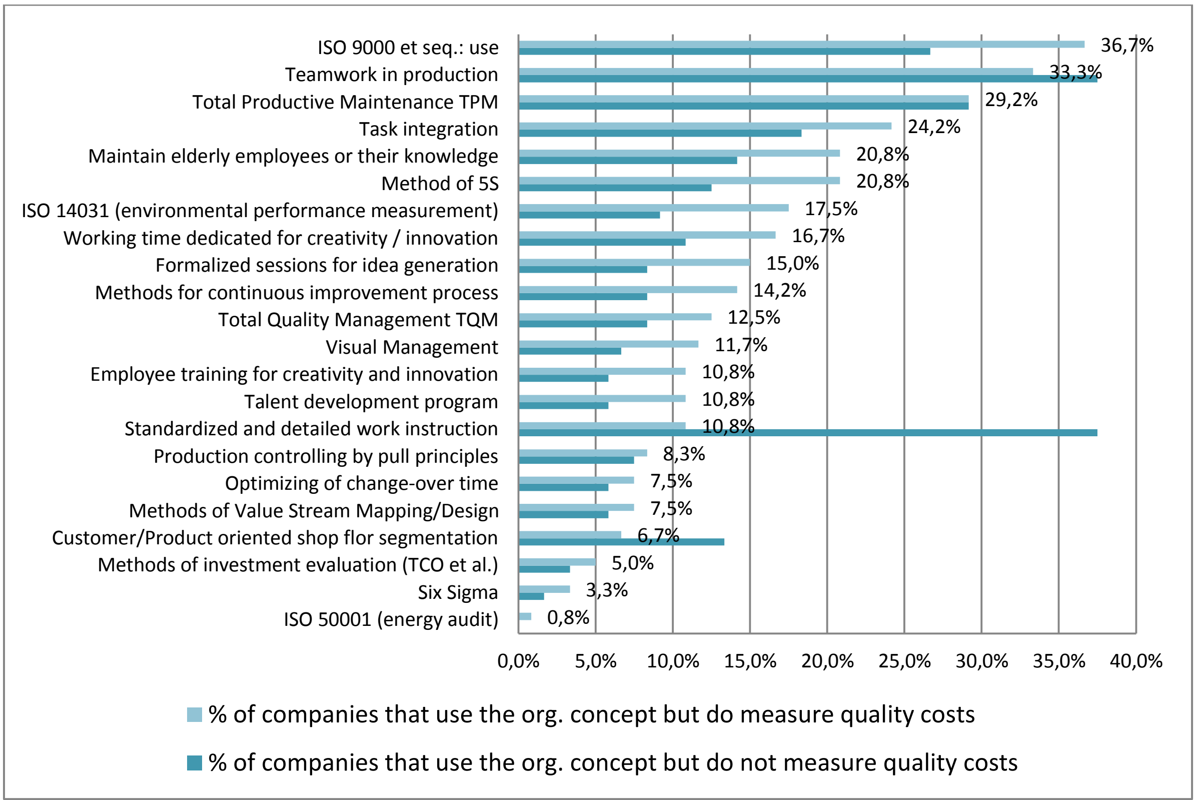

Figure 1. % of companies that use organizational concepts and do they measure quality costs

From Figure 1, we can see that dominantly used organizational concepts are: ISO 9000, Teamwork in production, Total Productive Maintenance TPM, Task integration, Maintain elderly employees or their knowledge, Method of 5S. Those concepts are almost equally present whether the company records quality costs or not. However, Chi Square analysis proved difference in proportions for concepts: ISO 9000, Method of 5S, Standardized and detailed work instruction, ISO 14031 (environmental performance measurement) and Formalized sessions for idea generation. The above mentioned organizational concepts are significantly more used by companies that also record quality costs.

Table 2. Mean values of selected performance indicators

Record of quality costs	Inputs [Million Euro]	Depreciation of machines/equip. [Mill. Euro]	Share of staff costs of turnover [%]	Degree of capacity utilization [%]	consumed material as percentage of revenues	Turnover in [Million Euro]	Return on sales before tax	Product complexity
NO	11,5663	,8875	26,13	35,59	71,30	19,681	1,05	1,96
YES	9,6778	,9404	21,06	48,39	45,90	16,077	1,67	2,22
Total	10,6421	,9146	23,64	41,87	58,86	17,931	1,36	2,09

The T-test showed that there is statistical difference in return on sales between companies that do monitor quality cost and those that do not, proving the benefits of quality cost measurement presented in the literature research.

Table 3. Results of regression analyses and Pearsons correlations (sig. in parenthesis)

Technology (independent variables)	Persons corr. on Dependent Variable: Record of quality costs	Organizational concept (independent variables)	Pearsons corr. on Dependent Variable: Record of quality costs
Industrial robots/ handling systems: use	0,071 (0,231)	Methods of Value Stream Mapping/Design	0,059 (0,27)
Automated Warehouse Management Systems	**0,285 (0,001)**	**Customer/Product oriented shop floor segmentation**	**-0,167 (0,041)**
Technologies for safe human-machine cooperation	0,076 (0,214)	Production controlling by pull principles	0,032 (0,369)
Multi-modal programming methods	0,004 (0,485)	Optimizing of change-over time	0,059 (0,27)
Processing alloy construction materials	0,008 (0,469)	Total Productive Maintenance TPM	0,024 (0,402)
Processing composite materials	0,098 (0,155)	Total Quality Management TQM	0,118 (0,109)
Manufacturing micromechanical components	no record	**Method of 5S**	**0,203 (0,017)**
Nanotechnological production processes	0,101 (0,148)	Standardized and detailed work instruction	-0,054 (0,289)
Supply chain management with suppliers/customers	**0,243 (0,005)**	Task integration	0,145 (0,066)
VR / simulation in production reconfiguration	**0,254 (0,004)**	**Methods for continuous improvement process**	**0,158 (0,049)**
VR / simulation in product design	**0,267 (0,002)**	Teamwork in production	-0,075 (0,218)
Product Lifecycle Management-System	**0,303 (0,001)**	Visual Management	0,145 (0,065)
Idea management systems	0,121 (0,104)	**ISO 9000**	**0,263 (0,003)**
Dry processing/minimum lubrication	0,15 (0,059)	Six Sigma	0,084 (0,19)
Control system for shut down of machines	**0,171 (0,037)**	**ISO 14031 (environmental performance measurement)**	**0,212 (0,013)**
Recuperation of kinetic and process energy	0,065 (0,251)	ISO 50001 (energy audit)	0,098 (0,155)
Combined cold, heat and power (Bi-/Trigeneration)	0,074 (0,222)	Methods of investment evaluation (TCO et al.)	0,069 (0,237)
Power generation by renewable energy	-0,053 (0,292)	**Formalized sessions for idea generation**	**0,178 (0,032)**
Heat generation by renewable energy	-0,028 (0,387)	**Maintain elderly employees or their knowledge**	**0,164 (0,043)**
		Working time dedicated for creativity / innovation	0,151 (0,058)
		Talent development program	0,15 (0,059)
		Employee training for creativity and innovation	0,15 (0,059)
R	0,387	0,425	
R Square	0,149	0,18	
F	3,655	3,204	
Sig.	0,004	0,004	

For purpose of generality we presented all researched technological and organizational concepts regressed on the dichotomous variable do they measure cost of quality. Bolded are only significant technologies and organizational concepts. Then the next regression was performed, with only significant independent variables. The reported R, R Square, F and Sig. are for those models with only significant variables. Both models are significant meaning that these technologies and organizational concepts do in fact increase the measurement of quality costs.

Table 4. Results of the regression of return on sales as dependent and selected technology and organizational concepts as independent variables

Technological and organizational concepts	Return on sales before tax
Record of quality costs	**0,244 (0,011)**
Customer/Product oriented shop floor segmentation	0,025 (0,408)
Method of 5S	**0,199 (0,031)**
Methods for continuous improvement process	0,035 (0,372)
ISO 9000 et seq.: use	0,095 (0,188)
ISO 14031 (environmental performance measurement)	-0,072 (0,251)
Formalized sessions for idea generation	0,129 (0,115)
Maintain elderly employees or their knowledge	0,044 (0,342)
Supply chain management with suppliers/customers	0,015 (0,446)
VR / simulation in production reconfiguration	-0,115 (0,142)
VR / simulation in product design	0,124 (0,123)
Product Lifecycle Management-System	0,052 (0,315)
Control system for shut down of machines	0,11 (0,152)
R	**0,455**
R Square	**0,207**
F	**1,505**
Sig.	**0,135**

In parentheses are significances. The bolded ones are significant.

When our significant concepts were regressed on return on sales only recording quality costs and method 5S proved significant. Already in the literature research we showed research that hypothesized this relationship so this was some kind of expected. The interesting concept is concept 5S and this concept significantly increase return on sales. Therefore we undertook additional literature research to see why this is so.

5S

Ablanedo-Rosas et al. (2010) name Toyota and Boing using 5S methodology for improving their quality and safety. 5S is borrowed from lean management, keeping the workplace clean. 5S is a tool to help make problems visible and can be part of the process of visual control of a well-planned lean system (Hirano 1995). Ablanedo-Rosas et al. (2010) wrote an extensive list of authors who proved that 5S is a precondition for lean management, six sigma or total production maintenance. The 5S implementation requires commitment from both the top management and everyone in the organization. The 5S practice requires significant investment in time and if properly implemented it has a huge impact on organizational performance (Liker and Hoseus, 2008).

There is also a problem why ISO 9000 did not come as significant. Hoyle (2001) states that collection and analysis of data about quality costs have become an integrated part of the ISO 9001 item on analysis of data and there is an emphasis on the management of these costs. By contrast, results from Pires et al. (2013) seem to suggest that ISO 9001 certification does not foster the use of quality-related indicators, both in terms of the quality management system, and its processes. Same states Montgomery (2001) who says that these standards do not take quality costs directly into account and that economic aspect of this issue has been widely investigated by international researchers, in several books and scientific papers.

CONCLUSION

We empirically proved that measuring quality costs significantly positively influences returns on sales. This is not done previously because literature research on quality costs are dominantly performed through case based methods. We show via regression analyses that dominant technologies that enable quality costs measurements are: Automated Warehouse Management Systems, Supply chain management with suppliers/customers, VR / simulation in production reconfiguration, VR / simulation in product design, Product Lifecycle Management-System and Control system for shut down of machines. Organizational concepts that enable quality cost measurement are: Method of 5S, Methods for continuous improvement process, ISO 9000, ISO 14031 (environmental performance measurement), Formalized sessions for idea generation and Maintain elderly employees or their knowledge. Finally, regression analysis of return on sales on selected significant technologies and organizational concepts show that only measurement of quality costs and Method 5S have a significant positive impact on return on sales. The finding that measurement of quality costs is well documented in the literature, therefore expected. Method 5S is also important and that finding is in line with Ablanedo-Rosas et al. (2010) and Liker and Hoseus (2008). Interestingly, ISO 9000 did not come as important and that is in line with findings of Hoyle (2001), Pires et al. (2013) and Montgomery (2001).

LIMITATIONS

This study shows only that measurement of quality has positive impacts on return on sales but this study does not identify categories of quality based costs. Future direction is to investigate collection, measurement and monitoring of quality costs, which kinds of costs are considered in the calculations, and whether those are formal or informal approaches.

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