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An empirical investigation of the moderating effects of BPR and TQM on ICT business value

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Abstract

Purpose – The purpose of this paper is to empirically investigate and compare the moderating effects of the two basic business process change paradigms – business process reengineering (BPR) and total quality management (TQM) – on the business value generated for firms by their information and communication technologies (ICT) investment.

Design/methodology/approach – Using data collected through a survey of 271 Greek firms, moderated regression models founded on the Cobb-Douglas production function are estimated, which have as the dependent variable the firm value added (objective measure of business performance), and as independent variables the yearly labour expenses, the value of the non-computer capital, the value of the computer capital and BPR (TQM) measures.

Findings – From the above models it is concluded that both BPR and TQM have considerable positive moderating effects of a similar magnitude on the relationship between ICT investment and firm value added. Also, different BPR and TQM activities have different moderating effects on ICT business value; process simplification, process improvement and the creation of a horizontal interdepartmental process are the BPR activities with the largest moderating effects, while measurement of employee satisfaction and simplification of work methods for quality improvement are the TQM activities with the largest moderating effects.

Research limitations/applications – The basic limitation of this study is that it is based on data from Greek firms. Another limitation is that only one business performance measure, although quite important and theoretically fundamental (i.e. firm value added), is used.

Practical implications – Both BPR and TQM are important ICT "complementary factors", which, if combined with ICT, can increase the business value it generates. Therefore ICT should not be used simply as a tool for automating existing business processes, but for creating and supporting new business processes and practices, such BPR and TQM.

Originality/value – This study investigates and compares the moderating effects of the two main business process paradigms – BPR and TQM – based on reliable measurement of both through validated multi-item scales, and also on theoretically sound models, founded on the Cobb-Douglas production function.

Keywords Communication technologies, Information systems, Business performance, Business process re-engineering, Total quality management

Paper type Research paper

1. Introduction

The relationship between information and communication technologies (ICT) investment and business performance has been one of the most challenging and extensively researched topics in the information systems (IS) domain for long time.

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Earlier studies did not find evidence for a statistically significant association between ICT investment and business performance (e.g. Roach, 1987; Strassman, 1990; Brynjolfsson, 1993; Loveman, 1994; Strassman, 1997), but more recent studies have provided substantial evidence that ICT investment has a positive and statistically significant impact on various measures of business performance (e.g. Brynjolfsson and Hitt, 1996; Stolarick, 1999; Preslac, 2003). So current research in this area focuses on the identification and investigation of "ICT complementary factors", which, if combined with ICT, can increase its positive impact and in general the business value that ICT generates (Melville *et al.*, 2004; Arvanitis, 2005; Wan *et al.*, 2007). The most widely discussed ICT complementary factor in the literature is business process change; its potential as a positive moderator of ICT business value has been emphasised by the relevant literature based on a rich theoretical argumentation (e.g. Hammer, 1990; Brynjolfsson and Hitt, 1996, 1998, 2000; Bresnahan *et al.*, 2002; Organisation for Economic Co-operation and Development, 2004; Melville *et al.*, 2004).

Business process reengineering (BPR) and total quality management (TQM) constitute the two main paradigms of business process change. BPR is defined as "the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical measures of performance such as cost, quality, service, job satisfaction, and speed" (Hammer and Champy, 1993). It has remained a highly interesting topic for long time and most organizations start BPR projects of various sizes and levels of radicalness in order to close competitive gaps and achieve superior performance (Al-Mashari *et al.*, 2001). Recently, interest in ICT-based BPR has been renewed in the business world, as shown by the results of several relevant surveys conducted by professional societies or research institutions; for example, BPR has been ranked as the fifth most important issue that IS managers face in a recent survey of the key IS management issues conducted by the Society for Information Management (SIM) of the USA (see www.simnet.org) (Luftman *et al.*, 2006). TQM constitutes another process change paradigm; it is defined by the International Organisation for Standardisation (ISO) (www.iso.org/iso/home.htm) as "a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society". The principle of a "quality" organisation outperforming its competitors becomes gradually a basic foundation of the strategies and plans of an exponetially increasing number of firms around the globe; according to Soltani *et al.* (2008):

> From the *Business Week* and *The Economist* pages and from sources as Conference Board, EFQM, ISO, IPM, ESRC, AQAF and the Deming Institute, examples assail us of moves to TQM, to produce products and services that meet and exceed the needs and expectations of customers, to obtain a strategic orientation, to improve performance with the consequence of greater competitiveness.

It should be emphasised that there are significant differences between these two business process change approaches as we remark from their definitions: BPR is radical, revolutionary and follows an one-time approach, while in contrast TQM is incremental, evolutionary and continuous. However, both of them rely to a large extent on ICT, as described in more detail in section 2.

Despite the abovementioned high expectations of the relevant literature concerning the moderating effect of business process change on ICT business value, and the rich theoretical argumentation supporting these expectations, limited empirical

investigation of them has been conducted to understand to what extent they are realised in "real-life" firms. In particular, the moderating effect of BPR on ICT business value has only been empirically investigated to a very small extent using large samples of firms (Grover *et al.*, 1998; Devaraj and Kohli, 2000), while the moderating effect of TQM on ICT business value has not been investigated empirically. Even these very few empirical studies of the moderating role of BPR, as described in more detail in section 2, are not based on theoretically sound models including all the fundamental variables; also, they measure the extent of BPR in a simplistic way using only one item (i.e. through one simple question), even though it is widely accepted that it is a highly abstract and multidimensional concept, resulting in reduced measurement reliability. Furthermore, in these very few empirical studies there is a lack of empirical investigation and comparison of the moderating effects of particular basic BPR practices, even though such knowledge would be very useful for IS management practice. Therefore, further empirical research is necessary concerning the moderating effects of these two different business process change paradigms, i.e. BPR and TQM, on ICT business value in various sectoral and national contexts, based on sound theoretical foundations, large datasets and models including all fundamental variables, using appropriate multi-item constructs for measuring BPR and TQM, in order to draw sound conclusions as to what extent the abovementioned expectations of the literature are realised. Furthermore, it is necessary to examine empirically and compare the moderating effects of particular basic BPR and TQM practices in order to identify those practices that result in the highest increase in ICT business value.

This paper contributes to filling these research gaps. It presents an empirical investigation and comparison of the moderating effects of BPR and TQM on the business value generated by ICT, which is quantified in an objective manner as the contribution of ICT investment to firm value added, using firm-level data from 271 Greek firms. Initially multi-item BPR and TQM constructs were developed based on an extensive review of the relevant BPR and TQM literature, and their validity and reliability was tested using the methods proposed by the relevant statistical literature (e.g. Chin, 1998; Straub *et al.*, 2004; Kline, 2005) with positive results. Based on those constructs, moderated regression models of firm value added were constructed, founded on the Cobb-Douglas production function (Nicholson, 1998), which constitutes a sound and mature theoretical foundation from the domain of microeconomics, and including all the fundamental independent variables. Finally, in a similar manner, the moderating effects of the particular basic BPR and TQM activities were also examined and compared by constructing the corresponding moderated regression models of firm value added. We believe that the results of this study are useful to a wide audience, including all researchers, practitioners, firms, consulting companies, professional societies and educational institutions interested in ICT business value maximisation.

In section 2 previous relevant research is briefly reviewed. Then in section 3 the research hypotheses, method and data are described. The data analysis and the results of this study are presented in section 4, while in section 5 the conclusions and limitations of this study are discussed and further research directions are proposed.

2. Review of previous research

There is considerable literature arguing that ICT can be used for enabling big transformations of existing business processes, which can result in high levels of business benefits and significant increase of business performance (e.g. Hammer, 1990;

Hammer and Champy, 1993; Davenport, 1993; Brynjolfsson and Hitt, 1996, 1998; Gunasekaran and Nath, 1997; Brynjolfsson and Hitt, 2000; Bresnahan et al, 2002; Organisation for Economic Co-operation and Development, 2004; Melville *et al.*, 2004; Pantazi and Georgopoulos, 2006). Michael Hammer (1990), one of the founders of BPR, in his highly influential paper "Re-engineering work: don't automate, obliterate" states that "Instead of embedding outdated processes in silicon and software, we should obliterate them and start over. We should 'reengineer' our businesses: use the power of modern information technology to radically redesign our business processes in order to achieve dramatic improvements in their performance". In the same direction, Brynjolfsson and Hitt (1996) argue that one of the explanations of the widely discussed in the 1990s "ICT productivity paradox" is that firms needed a period of learning how to utilise and exploit ICT and how to make the appropriate process adjustments before they could reap the full benefits that ICTs can offer. In a more recent work they argue that, since most of the existing business processes have been designed in the past before the emergence of ICT, they reflect the high costs of communication and information processing and the dominant manual mode of office work at that time; so they conclude that taking into account that modern ICTs can reduce dramatically communication and information processing cost and enable new electronic modes of office work, they can be strong enablers and facilitators of new enhanced business processes, which can lead to big productivity increase (Brynjolfsson and Hitt, 2000). Bresnahan *et al.* (2002) conclude that the three most important elements of modern economy are ICT, workplace reorganisation and new products and services, which are closely associated and exhibit high levels of complementarity. There is also considerable literature reporting case studies of firms that have successfully used ICTs for reengineering their processes and achieving significant benefits and higher business performance (e.g. Davenport and Nohria, 1994; O'Neill and Sohal, 1999; Hunter *et al.*, 2000; Attaran, 2003).

However, despite the above theoretical arguments, the moderating role of BPR on ICT business value has only been investigated empirically to a very small extent using large datasets. Grover *et al.* (1998) have investigated empirically whether the perceived extent of ICT-related process change has a moderating effect on the relationship between ICT diffusion and perceived ICT-related productivity improvement, using data collected through a survey of 313 senior ICT executives of USA large service and manufacturing firms (over half of them having more than 2,500 employees) and based on them constructing moderated regression models. Their main conclusion was that ICT diffusion has a positive impact on the perceived ICT-related productivity improvement, and that the perceived extent of ICT-related process change moderates this relationship only for client/server technologies. It should be noted that this study used subjective single-item measures of ICT-related process change and ICT-related productivity improvement, which are based on perceptions of firms' managers. Devaraj and Kohli (2000) investigated empirically in the context of health care organisations the effect of the expenses made for a particular decision support system on four measures of hospitals' performance (net patient revenue per day, net patient revenue per admission, mortality rate and customer satisfaction) as well as the moderating role of BPR perceived effectiveness on these relationships. Using monthly data from US hospitals, they constructed moderated regression models of these four performance variables. From these models it has been concluded that the expenses for this particular decision support system have a positive impact on all these four performance variables, and that BPR perceived effectiveness moderates three of these

relationships (with the exception of the one concerning the mortality rate). It should be noted that this study used a subjective single-item measure of BPR effectiveness, which is based on perceptions of hospitals' managers. Another common characteristic of both these studies is that in their regression models, only independent variables associated with ICT capital and BPR were included. However, other fundamental independent variables, which according to basic microeconomic theory (e.g. Nicholson, 1998) affect substantially business performance, such as independent variables associated with non-ICT capital, labour, etc, were not included. This omission of important independent variables, according to the relevant econometric modelling literature (e.g. Greene, 2003; Gujarati, 2003), may cause significant inaccuracies and introduce biases in the estimated coefficients of the constructed regression models.

Concerning TQM, there is considerable literature arguing that ICT can be used to support it, making it more efficient and increasing the business value it generates (Giffi *et al.*, 1990; Weston, 1993; Flynn *et al.*, 1994; Forza, 1995a, b; Kock and McQueen, 1997; Dewhurst *et al.*, 2003; Martinez-Lorente *et al.*, 2004). Giffi *et al.* (1990) argue that computers play a critical role in quality management, since they can significantly support statistical process control, reduce the effort required by production personnel for collecting and analysing quality data and also shorten the reaction time between the collection of process data and the implementation of corrective actions that might be required, having the potential to increase in these ways the efficiency and the business benefits of quality management. In the same line, Forza (1995a, b), in an empirical study in 34 industrial plants in Italy, found that quality management practices can be significantly supported by basic quality information flows:

- quality performance feedback to managers and superintendents;
- visible and timely feedback on quality (e.g. defects rate, machines breakdown frequencies, etc.);
- information on internal quality inspections and audits;
- information on machines (e.g. maintenance, operation, setup, etc.);
- information for the identification of causes of non-quality;
- documentation on production procedures; and
- information exchange with customers and suppliers on quality.

Dewhurst *et al.* (2003), through a multiple case study of 14 Spanish companies, found that ICTs can effectively support TQM in improving customer and supplier relationships, increasing process control, facilitating teamwork, facilitating inter-departmental information flow, improving design process and skills, applying preventive maintenance, introducing ISO 9000, measuring quality costs and improving the decision process in quality departments, finally resulting in higher quality and operational and financial performance. Martinez-Lorente *et al.* (2004), from an empirical study based on survey data from 442 Spanish industrial companies, found that some measures of perceived ICT usage have a direct effect on perceived measures of operational and quality performance. However, despite the above literature arguing that ICT can be used for supporting and enhancing TQM and increasing its business value, there is a lack of empirical investigations of the moderating effect of TQM on ICT business value.

To summarise, from the review of the relevant literature it is concluded that the moderating effect of BPR on ICT business value has only been investigated empirically

to a very small extent, while the moderating effect of TQM on ICT business value has not been investigated empirically. Further empirical research is required concerning the moderating effects of these two main business process change paradigms – BPR and TQM – on ICT business value in various national and sectoral contexts, based on large datasets, sound theoretical foundations and models including all fundamental independent variables. Also, since the highly abstract and multidimensional BPR and TQM concepts have been measured in the previous research in a simplistic way using only one item, it is necessary to develop, validate and use in future relevant research appropriate multi-item constructs for measuring BPR and TQM in a highly reliable manner, so that our conclusions are more valid and reliable.

3. Research hypotheses, method and data

Aiming to contribute to filling these research gaps, the research objective of this study is to empirically investigate and compare the moderation effects of BPR and TQM on the business value generated by ICT, which is quantified in an objective manner as the contribution of firm ICT investment to firm value added. So our first research hypothesis concerns the moderation effect of BPR on the relationship between ICT investment and firm value added. As mentioned in section 2, most of the existing business processes of firms were designed in the past before the emergence of ICT, and their design was based on two assumptions:

(1) the dominant manual mode of office work; and

(2) the high costs of communication and information processing at that time (Hammer, 1990; Hammer and Champy, 1993).

These assumptions are not valid today due to the emergence of ICT, which enables new electronic modes of office work and dramatically reduces communication and information processing costs. For this reason automating existing business processes using ICT will result in a suboptimal level of business benefits from ICT; the optimal level of benefits from ICT will be achieved only if it is combined with a redesign of business processes based on the "new assumptions" that ICT have generated: the low costs of communication and information processing and the new electronic mode of office work. In this direction there is considerable literature, as mentioned in section 2, arguing that ICT can be the enabler and facilitator of new enhanced business processes, which can lead to a large increase in business performance (e.g. Hammer, 1990; Hammer and Champy, 1993; Brynjolfsson and Hitt, 1996, 1998; Gunasekaran and Nath, 1997; Brynjolfsson and Hitt, 2000; Bresnahan *et al.*, 2002; Organisation for Economic Co-operation and Development, 2004; Melville *et al.*, 2004; Pantazi and Georgopoulos, 2006). For the above reasons we expect that the combination of ICT investment with BPR will result in more beneficial ways of using ICT and in more valuable applications, and will thus increase the contribution of ICT investment to firm value added. Therefore our first hypothesis is:

H1. The extent of BPR moderates positively the contribution of ICT investment to firm value added.

The second hypothesis concerns the moderation effect of TQM on the relationship between ICT investment and firm value added. TQM practices are data-intensive, so they can be significantly supported and enhanced through the use of ICTs. In particular, the use of ICT can significantly support and enhance basic TQM practices,

such as statistical process control, preventive maintenance, cooperation with customers and suppliers on quality, teamwork, design of products, introduction of ISO 9000, collection and analysis of quality data, inter-departmental information flow, etc., and increase the business benefits these practices offer. In this direction there is considerable literature, as mentioned in section 2, describing how ICT can be used for supporting TQM and making it more efficient, so that a higher level of business benefits can be achieved from it (Giffi *et al.*, 1990; Weston, 1993; Flynn *et al.*, 1994; Forza, 1995a, b; Kock and McQueen, 1997; Dewhurst *et al.*, 2003). For these reasons we expect that the combination of ICT investment with TQM will result in more beneficial ways of using ICT and in more valuable applications, thus increasing the contribution of ICT investment to firm value added. Therefore our second hypothesis is:

H2. The extent of TQM moderates positively the contribution of ICT investment to firm value added.

The basic theoretical foundation we used for testing the above hypotheses was the Cobb-Douglas production function (Nicholson, 1998). It constitutes a sound and mature foundation from the area of microeconomics, which includes all fundamental variables that affect firm output, and has been used extensively in the past to estimate the contribution of firm inputs, including ICT capital (see, for example, Brynjolfsson and Hitt, 1996; Stolarick, 1999; Preslac, 2003), to firm output. In particular, we have used an extended form of the Cobb-Douglas production function, in which the capital is divided into computer capital and non-computer capital:

$$VA = e^{\beta_0} L^{\beta_1} K^{\beta_2} CK^{\beta_3}, \tag{1}$$

where VA is the yearly firm value added (i.e. the yearly sales revenue minus yearly expenses for buying materials and services), and L, K and CK are the yearly labour expenses, the value of the non-computer capital and the value of the computer capital, respectively. By log-transforming equation (1) we obtain the following linear form of it:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK). \tag{2}$$

In order to investigate the moderating effects of these two basic business process change paradigms, BPR and TQM, on the contribution of ICT to firm output, we have added an "interaction term" (Venkatraman, 1989; Aiken and West, 1996; Gujarati, 2003), which is equal to the product of $\ln(CK)$, to the corresponding business process change factor F measuring the extent of BPR or TQM, respectively:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK) + \beta_4 \ln(CK) \cdot F. \tag{3.3}$$

The extent of BPR and TQM constitute highly abstract and multidimensional concepts, which cannot be measured reliably by only one item, so it was decided to measure them as multi-item constructs (see, for example, Byrne, 2001; Kline, 2005). In particular, the extent of BPR is measured through a nine-item scale, with each of these nine items BPR_i ($i = 1, \ldots, 9$) measuring the extent of having performed one basic BPR activity in the last five years, developed through a review of the relevant BPR literature (e.g. Davenport, 1993; Hammer and Champy, 1993; Gunasekaran and Nath, 1997; Al-Mashari and Zairi, 2000). Similarly, the extent of TQM is measured through a seven-item scale, with each of these seven items TQM_i ($i = 1, \ldots, 7$) measuring the extent of performing one basic TQM activity, also developed through a review of the relevant TQM literature (e.g. Saraph *et al.*, 1989; Flynn *et al.*, 1994; National Institute of

Standards and Technology, 1995; Ahire *et al.*, 1996; European Foundation for Quality Management, 1998; Martinez-Lorente *et al.*, 2004). These BPR and TQM multi-item scales are shown in the Appendix. Their validity and reliability was assessed using the methods proposed by the relevant statistical literature (e.g. Chin, 1998; Straub *et al.*, 2004; Kline, 2005) as described in section 4.2.

It is also useful for IS management practice to examine the moderating effect of each of these nine basic BPR activities and then compare them in order to identify those that result in the highest increase of ICT business value; since each of them leads to different types of applications and in general different ways of using ICT, we expect that they have different moderating effects on ICT business value. Therefore our following hypotheses are:

H1.1. The extent of process simplification positively moderates the contribution of ICT investment to firm value added.

H1.2. The extent of process improvement positively moderates the contribution of ICT investment to firm value added.

H1.3. The extent of horizontal interdepartmental process creation positively moderates the contribution of ICT investment to firm value added.

H1.4. The extent of process abolition positively moderates the contribution of ICT investment to firm value added.

H1.5. The extent of process customer-centric redesign positively moderates the contribution of ICT investment to firm value added.

H1.6. The extent of horizontal interdepartmental workgroups creation positively moderates the contribution of ICT investment to firm value added.

H1.7. The extent of process coordinator roles creation positively moderates the contribution of ICT investment to firm value added.

H1.8. The extent of job enrichment, increase of decision making competences and authorisation in some processes positively moderates the contribution of ICT investment to firm value added.

H1.9. The extent of supervision decreases positively moderates the contribution of ICT investment to firm value added.

Similarly, it is useful to examine the moderating effect of each of the above seven basic TQM activities so that by comparison we can identify the ones resulting in the highest increase of ICT business value; each of these TQM activities leads to different types of applications and in general different ways of using ICT, so we expect that they have different moderating effects on ICT business value. Therefore our following hypotheses are:

H2.1. The extent of using statistical quality control methods moderates positively the contribution of ICT investment to firm value added.

H2.2. The extent of operating permanent quality improvement teams moderates positively the contribution of ICT investment to firm value added.

H2.3. The extent of systematic measurement of customer satisfaction moderates positively the contribution of ICT investment to firm value added.

H2.4. The extent of cooperating with suppliers for quality improvement moderates positively the contribution of ICT investment to firm value added.

H2.5. The extent of work simplification for quality improvement moderates positively the contribution of ICT investment to firm value added.

H2.6. The extent of systematic measurement of employee satisfaction moderates positively the contribution of ICT investment to firm value added.

H2.7. The extent of continuous quality improvement moderates positively the contribution of ICT investment to firm value added.

H1 and *H2* were tested by estimating initially equation (2) and then equation (3), first for F equal to the extent of BPR (calculated as the average of the above nine BPR items) and second for F equal to the extent of TQM (calculated as the average of the above seven TQM items), and examining the statistical significance of the corresponding interaction terms. Similarly, *H1.1-H1.9* and *H2.1-H2.7* were tested by estimating equation (3) for F equal to each of the above BPR and TQM items (i.e. to the extent of performing each of these basic BPR or TQM activities), so $9 + 7 = 16$ times in total. In all these 19 models we performed the tests of the basic assumptions of the "classical" linear regression model suggested by the relevant econometrics literature (Gujarati, 2003; Greene, 2003). In particular, the assumptions of error normality and homoscediasticity were tested by inspecting the residuals' histograms, while the existence of error autocorrelation was tested through the Durbin-Watson test; the existence of multicollinearity was tested by examining the independent variables correlation matrix, the condition index (CI) and the variance inflation factor (VIF) of each independent variable.

For the estimation of the above regression models we used data that were collected through a survey among Greek companies, which was conducted in cooperation with ICAP, one of the largest business information and consulting companies in Greece. The questions in this survey concerning the financial data of the company and the extent of its BPR and TQM activities that were used in this study are shown in the Appendix. The sample of the survey was randomly selected from the database of ICAP and included 304 Greek firms of all sizes (103 small, 103 medium and 98 large) from the 27 most important sectors in the Greek economy. Two similar samples were also created with the same percentages of small, medium and large firms, and also with the same percentages of firms from the above 27 sectors. This questionnaire was initially sent by mail to the managing directors of the 304 firms of the first sample; the recipients were asked to fill in the questionnaire and return it by fax or mail within one month. For most of the firms of this first sample several telephone calls were required in order to have the questionnaire filled in completely and correctly; those who despite our telephone calls refused to participate were replaced by "similar" companies (i.e. of the same size and from the industry group) from the second sample, while in the rare cases that these similar companies of the second group were exhausted, similar companies from the third sample were used. In this way we managed to have a balanced sample concerning company size and industry. Finally complete questionnaires were received from 271 companies (88 small, 105 medium and 78 large). We also examined whether there was any non-response bias. According to the relevant literature (Armstrong and Overton, 1977; Chapman, 1992; Kearns and Lederer, 2000) the best method for assessing non-response bias is to gather data (i.e. receive answered questionnaires)

from a significantly large and random sample of non-respondents and compare them with the corresponding data provided by the respondents; however, this method is rarely feasible, so a good alternative method, which according to the relevant literature gives reliable results, is to compare the variables' means of the early respondents with those of the late respondents; if there are no statistically significant differences, then it is highly likely that non-response bias does not exist. Following this method we divided the answered questionnaires we received into two groups: those we received within the first month (first group), and those we received later (second group). Then we tested for all variables whether there are statistically significant differences between the means of these two groups. Since we did not find any statistically significant differences it is highly likely that non-response bias does not exist.

4. Data analysis and results

4.1 Descriptives

In Table I we can see the basic descriptives (mean and standard deviation) of the nine BPR and the seven TQM items (variables), which show the average extent of the adoption and use of the corresponding activities. We remark that process improvement, process customer-centric redesign and process simplification are the most extensively adopted BPR activities by Greek firms, having on average a moderate to large extent of adoption; in contrast, supervision decrease, interdepartmental workgroup creation and process coordinator role creation are the least adopted BPR activities, having on average a small to moderate extent of adoption. From these results we can conclude that the departmental "silo mentality" remains strong in Greek firms, as the extent of horizontal (interdepartmental) process creation is less than moderate, while even lower is the extent of creation of interdepartmental workgroups and process coordinator roles. On the other hand continuous quality improvement, cooperation with suppliers for improving the quality of purchased materials and measurement of

Activity	Description	Mean	SD
BRP activities			
BPR_1	Process simplification	3.33	1.01
BPR_2	Process improvement	3.64	0.90
BPR_3	Horizontal (interdepartmental) process creation	2.94	1.20
BPR_4	Process abolition	2.70	1.06
BPR_5	Process customer-centric redesign	3.42	1.02
BPR_6	Interdepartmental workgroup creation	2.60	1.17
BPR_7	Process coordinator role creation	2.62	1.15
BPR_8	Job enrichment – increase in decision making competences	2.91	1.04
BPR_9	Supervision decrease	2.38	1.03
TQM activities			
TQM_1	Use of statistical quality control	2.90	1.35
TQM_2	Permanent quality improvement teams	2.75	1.42
TQM_3	Measurement of customer satisfaction	3.38	1.29
TQM_4	Cooperation with suppliers for quality improvement	3.44	1.22
TQM_5	Work simplification for quality improvement	3.25	1.12
TQM_6	Systematic measurement of employees' satisfaction	2.79	1.18
TQM_7	Continuous quality improvement	3.79	1.14

Table I. Descriptives of the BPR and TQM items (variables)

customer satisfaction are the most extensively adopted TQM activities by Greek firms, with a moderate to large average extent of adoption. In contrast, permanent quality improvement teams and systematic measurement of employees' satisfaction are the least adopted TQM activities, having on average a small to moderate extent of adoption. These results show that Greek companies place more emphasis on "outward looking" TQM (focused on their relationships with customers and suppliers) than on "inward looking" TQM (e.g. use of statistical quality control, permanent quality improvement teams, etc.).

4.2 BPR and TQM construct validity and reliability assessment

Initially, we assessed the construct validity of the above BPR and TQM multi-item constructs, which is defined as the extent to which the items selected for a latent construct constitute, considered together and compared to other latent constructs, a reasonable operationalisation of it (Straub *et al.*, 2004); its main dimensions are the convergent and the discriminant validity. The convergent validity of the BPR and the TQM constructs was tested through confirmatory factor analysis (Straub *et al.*, 2004; Kline, 2005). In particular, we hypothesized each of them to be a latent factor reflected by its items (i.e. the BPR latent factor being reflected by its corresponding nine items and the TQM latent factor being reflected by its corresponding seven items) and we estimated the corresponding two models using the AMOS 6 software (Byrne, 2001); their goodness-of-fit indices and item loadings are shown in Tables II and III, respectively.

Table II.
Goodness-of-fit indexes for the BPR and TQM models

	BPR	TQM
χ^2	89.65	25.2
RMSEA	0.101	0.059
Incremental fit indices		
NFI	0.939	0.978
RFI	0.909	0.964
IFI	0.955	0.989
TLI	0.932	0.982
CFI	0.955	0.989

Table III.
Item loadings of the BPR and TQM constructs

BPR		TQM	
Indicator	Loading	Indicator	Loading
BPR_1	0.722	TQM_1	0.600
BPR_2	0.698	TQM_2	0.673
BPR_3	0.783	TQM_3	0.824
BPR_4	0.694	TQM_4	0.804
BPR_5	0.706	TQM_5	0.798
BPR_6	0.781	TQM_6	0.752
BPR_7	0.751	TQM_7	0.825
BPR_8	0.729	–	–
BPR_9	0.676	–	–

From Table II we can see that for both models the incremental fit indexes are within the limits recommended by Gefen *et al.* (2000) (≥ 0.9), while RMSEA for the TQM model is within the limits recommended by Browne and Cudeck (1993) (≤ 0.08) but for the BPR model it is a little higher. The item loadings of these two constructs (shown in Table III) are all statistically significant and exceed the 0.6 minimum acceptable level suggested by Chin (1998). Taking into account all the above results we conclude that both constructs are characterised by convergent validity.

The discriminant validity of the BPR and TQM constructs was tested by performing factor analysis with Varimax rotation using the SPSS 15.0 software. In particular, we examined the factors structure behind the 16 items of these two constructs (i.e. the nine BPR items and the seven TQM items). The results are shown in Table IV and reveal one factor, F1, characterized by high loadings of the BPR items and much lower loadings of the TQM items, and another factor, F2, characterized by high loadings of the TQM items and much lower loadings of the BPR items; these results indicate discriminant validity for the two constructs.

Next, we assessed the reliability of the above BPR and TQM constructs, which is defined as the extent to which the items selected for a latent construct constitute, taken together, an error-prone operationalisation of it (Straub *et al.*, 2004). For this purpose

BPR and TQM activities	F1	F2
BPR_1: Simplification of processes	0.718	0.141
BPR_2: Improvement of processes	0.697	0.295
BPR_3: Creation of new horizontal (inter-departmental) processes (that cross more than one departments)	0.725	0.319
BPR_4: Abolition of processes	0.791	0.195
BPR_5: Redesign of processes so that they become customer-focused	0.789	0.148
BPR_6: Creation of new inter-departmental workgroups (e.g. customer or product-focused)	0.686	0.363
BPR_7: Creation of new horizontal coordination roles (process coordinators) for monitoring and coordinating the efficient and faster execution of processes crossing more than one department.	0.761	0.246
BPR_8: Job enrichment – increase of decision making competences and authorisation for employees involved in some processes	0.725	0.230
BPR_9: Decrease of supervision and number of supervisors in some processes	0.711	0.120
TQM_1: Use of statistical control methods	0.069	0.729
TQM_2: Permanent quality improvement teams	0.297	0.713
TQM_3: Systematic measurement/monitoring of customer satisfaction	0.188	0.835
TQM_4: Cooperation with suppliers for quality improvement	0.197	0.789
TQM_5: Work simplification for quality improvement	0.306	0.766
TQM_6: Systematic measurement-monitoring of employee satisfaction	0.263	0.731
TQM_7: Continuous quality improvement	0.301	0.781

Table IV.
Factor analysis of BPR and TQM measurement items

we calculated their Cronbach's α coefficients as recommended by the relevant literature (Gefen *et al.*, 2000; Straub *et al.*, 2004; Kline, 2005); both exceeded the minimum acceptable level of 0.7 (0.914 for the BPR construct and 0.906 for the TQM construct), thus confirming the reliability of the two constructs.

We also assessed the content validity of the BPR and TQM constructs, which is defined as the extent to which the items selected for a latent construct capture the essence and the whole content of the construct (Straub *et al.*, 2004). In this direction a first version of both constructs was developed based on an extensive review of the relevant literature, as described in section 3. Then it was reviewed by six experts – three from ICAP, and three from the University of the Aegean. Based on their comments and recommendations the final version of the questionnaire was developed.

4.3 Moderating effects of BPR and TQM on ICT business value

Having confirmed the validity and reliability of the BPR and TQM constructs, we used them for the investigation of the moderating effects of BPR and TQM on ICT business value, which has been quantified as the contribution of firm ICT investment to firm value added, by estimating regression equations (2) and (3). In these models we included two additional dummy variables controlling for firm size:

(1) *D*_Large (equal to 1 for large firms having more than 250 employees and 0 for all other firms); and

(2) *D*_Medium (equal to 1 for medium firms having more than 50 and less than or equal to 250 employees and 0 for all other firms).

In Table V we can see the results from the estimation of the model of equation (2). We can see that the coefficients of labour, non-computer capital and computer capital are all positive and statistically significant, so we conclude that all these three inputs make a positive contribution to firm value added.

In Table VI we see the results from the estimation of the model of equation (3) for F equal to the extent of BPR measured by the average of the abovementioned nine BPR items. We remark that the coefficients of labour, non-computer capital and computer capital remain all positive and statistically significant, and also that the coefficient of the interaction term between computer capital and BPR is positive and statistically significant as well. This result indicates that the extent of BPR moderates positively the contribution of ICT investment to firm value added and provides support for *H1*. In particular, this model indicates that the contribution of ln(CK) to ln(VA), which is equal to the output elasticity of the computer capital (see Brynjolfsson and Hitt, 1996; Nicholson, 1998), is equal to $(0.202 + 0.013 \times \mathrm{BPR}) \ln(CK)$, so if the extent of BPR

Independent variable	Coefficient	Standard error	Standardised coefficient	Significance
Constant	4.204	0.685		0.000
ln(*L*)	0.474	0.054	0.454	0.000
ln(*K*)	0.083	0.034	0.105	0.015
ln(*CK*)	0.248	0.043	0.275	0.000
*D*_Large	0.773	0.226	0.194	0.001
*D*_Medium	0.397	0.157	0.108	0.012

Note: Dependent variable: ln(*VA*)

Table V.
Regression model for the impact of labour, non-computer capital and computer capital on firm value added

takes its lowest value being equal to 1 (corresponding to not performing at all any of the nine basic BPR activities) this contribution is equal to $0.215\ln(CK)$; however, if BPR takes its highest value being equal to five (corresponding to a very large extent of performing all these BPR activities) this contribution will be higher and equal to $0.267\ln(CK)$. Therefore, if ICT investment is combined with extensive BPR, the contribution of $\ln(CK)$ to $\ln(VA)$, will increase by $(0.267/0.215) - 1 = 0.242$, i.e. by 24.2 per cent, in comparison with the case of having ICT investment without any BPR at all.

Table VII shows the results from the estimation of the model of equation (3) for F equal to the extent of TQM measured by the average of the above-mentioned seven TQM items. We note that the coefficients of labour, non-computer capital and computer capital again all remain positive and statistically significant, and also that the coefficient of the interaction term between computer capital and TQM is positive and statistically significant as well. This result indicates that the extent of TQM moderates positively the contribution of ICT investment to firm value added and provides support for *H2*. In particular, this model indicates that the contribution of $\ln(CK)$ to $\ln(VA)$ is equal to $(0.201 + 0.014TQM)\ln(CK)$, so if the extent of TQM takes its lowest value, i.e. 1 (corresponding to not performing at all any of the seven considered TQM activities shown in the Appendix), this contribution is equal to $0.215\ln(CK)$; however, if TQM takes its highest value, i.e. 5 (corresponding to a very large extent of performing all these TQM activities), this contribution will be higher and equal to $0.271\ln(CK)$. In conclusion, if ICT investment is combined with extensive TQM, the contribution of $\ln(CK)$ to $\ln(VA)$, which equals to the output elasticity of the computer capital as mentioned above, is going to increase by $(0.271/0.215) - 1 = 0.26$ (i.e. by 26 per cent) in comparison with the case of having ICT investment without any TQM at all.

Independent variable	Coefficient	Standard error	Standardised coefficient	Significance
Constant	4.350	0.685		0.000
$\ln(L)$	0.479	0.054	0.458	0.000
$\ln(K)$	0.077	0.034	0.097	0.023
$\ln(CK)$	0.202	0.049	0.224	0.000
$\ln(CK) \times$ BPR	0.013	0.006	0.085	0.051
*D*_Large	0.750	0.225	0.188	0.001
*D*_Medium	0.365	0.157	0.099	0.021

Note: Dependent variable: $\ln(VA)$

Table VI. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and extent of BPR on firm value added

Independent variable	Coefficient	Standard error	Standardised coefficient	Significance
Constant	4.214	0.675		0.000
$\ln(L)$	0.488	0.054	0.467	0.000
$\ln(K)$	0.070	0.033	0.090	0.036
$\ln(CK)$	0.201	0.046	0.223	0.000
$\ln(CK) \times$ TQM	0.014	0.005	0.104	0.006
*D*_Large	0.771	0.222	0.193	0.001
*D*_Medium	0.373	0.155	0.101	0.017

Note: Dependent variable: $\ln(VA)$

Table VII. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and extent of TQM on firm value added

A comparison between the moderating effects of BPR and TQM on the contribution of ICT investment to firm value added leads to the conclusions that they are of similar magnitude, since the small difference between the coefficients of the corresponding interaction terms in the models of Tables V and VI (0.013 and 0.014, respectively) is much lower than their standard errors (0.006 and 0.005, respectively). It should also be noted that our conclusions about the moderating effect of BPR on ICT business value are consistent with those of the two previous empirical studies that have been conducted on this topic (Grover *et al.*, 1998; Devaraj and Kohli, 2000).

4.4 Moderating effects of basic BPR and TQM activities on ICT business value

Finally, we investigated the moderating effect on ICT business value of the each of these nine basic BPR activities and seven basic TQM activities, which were determined based on a review of the relevant literature as described in section 3. For this purpose we estimated the model of equation (3) for F equal to each of these BPR and TQM items. In this way we estimated $9 + 7 = 16$ moderated regression models, each of them corresponding to one of these basic BPR and TQM activities and showing whether and to what extent it moderates the contribution of $\ln(CK)$ to $\ln(VA)$. In all these 16 estimated models the coefficients of labour, non-computer capital and computer capital remain positive and statistically significant, confirming the conclusion drawn from the models of Tables V-VII that all these three inputs make a positive contribution to firm value added.

However, only in five of the nine BPR-related models is the interaction term statistically significant, which is shown in the upper part of Table VIII (for each model we show the coefficients of $\ln(L)$, $\ln(K)$, $\ln(CK)$ and the interaction term, and also the ICT contribution increase coefficient explained later in this section); we see that they correspond to BPR_1 (process simplification), BPR_2 (process improvement), BPR_3 (creation of new interdepartmental horizontal processes), BPR_4 (process abolition) and BPR_6 (creation of new interdepartmental horizontal workgroups). Therefore it can be concluded that only these five BPR activities positively moderate the contribution of of ICT investment to firm value added, while the remaining four BPR activities do not

	$\ln(L)$ coefficient	$\ln(K)$ coefficient	$\ln(CK)$ coefficient	Interaction term coefficient	ICT contribution increase coefficient (per cent)
BPR activity					
BPR_1	0.479^{***}	0.081^{**}	0.190^{***}	0.013^{**}	26
BPR_2	0.480^{***}	0.081^{**}	0.191^{***}	0.013^{**}	25
BPR_3	0.480^{***}	0.074^{**}	0.211^{***}	0.010^{**}	18
BPR_4	0.472^{***}	0.076^{**}	0.216^{***}	0.009^{*}	16
BPR_6	0.477^{***}	0.075^{**}	0.221^{***}	0.009^{*}	16
TQM activity					
TQM_2	0.483^{***}	0.076^{**}	0.224^{***}	0.007^{**}	12
TQM_3	0.484^{***}	0.076^{**}	0.221^{***}	0.008^{**}	14
TQM_4	0.478^{***}	0.073^{**}	0.222^{***}	0.008^{**}	14
TQM_5	0.481^{***}	0.072^{**}	0.212^{***}	0.012^{*}	21
TQM_6	0.494^{***}	0.074^{**}	0.209^{***}	0.015^{*}	27

Table VIII.
Regression models for the impact of labour, non-computer capital, computer capital and interaction between computer capital and extent of each of the basic BPR and TQM activities on firm value added

Notes: Only models with statistically significant interaction are shown. ***, **, * denote statistical significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively

have such a moderating effect. These results provide support for *H1.1*, *H1.2*, *H1.3*, *H1.4*, and *H1.6*, but do not provide support for *H1.5*, *H1.7*, *H1.8* and *H1.9*.

Also, only in five of the seven TQM-related models is the interaction term statistically significant, which is shown in the lower part of Table VIII; we can see that they correspond to TQM_2 (permanent quality improvement teams), TQM_3 (systematic measurement of customer satisfaction), TQM_4 (cooperation with suppliers for quality improvement), TQM_5 (working method simplification for quality improvement) and TQM_6 (systematic measurement of employee satisfaction). So it is concluded that only these five TQM activities positively moderate the contribution of ICT investment to firm value added, while the remaining two TQM activities do not have such a moderating effect. These results provide support for *H2.2-H2.6*, but do not provide support for *H2.1* and *H2.7*.

Finally, we assessed the magnitude of the moderating effect of each of the above five BPR and five TQM activities on ICT business value by calculating the increase it can cause to the contribution of $\ln(CK)$ to $\ln(VA)$ (i.e. to the output elasticity of the computer capital) if combined with ICT investment, in the same way we used in the previous moderated regression models of Tables V and VII as described in section 4.3. For instance, concerning BPR_1 (simplification of processes) the contribution of $\ln(CK)$ to $\ln(VA)$ equals $(0.190 + 0.013\text{BPR\_1})\ln(CK)$. If the extent of implementing BPR_1 takes its lowest value (equal to 1) this contribution equals $0.203\ln(CK)$; on the other hand if the extent of implementing BPR_1 takes its highest possible value (equal to 5), the contribution will become equal to $0.255\ln(CK)$. Therefore if ICT investment is combined with extensive process simplification, its contribution will increase by $0.255/0.203 - 1 = 0.26$ (i.e. by 26 per cent) in comparison to the case of not going under process simplification at all. In a similar manner for each of these five BPR and five TQM moderating activities, we calculated the percentage increase they could cause to the contribution of $\ln(CK)$ to $\ln(VA)$ if combined with ICT investment; this coefficient is shown in the fifth column of Table VIII.

We note that the BPR activities with the largest positive moderating effect on ICT business value are process simplification and process improvement, followed by the creation of new interdepartmental horizontal processes. This means that the simplification and improvement of business processes leads to the development of highly valuable applications that enable and support improved versions of them (e.g. by enabling and supporting new sequences of steps, parallelisation of these steps, execution of these steps in different remote geographic locations, offering more information to the employees responsible for them so that they can make better decisions, etc., according to Davenport (1993) and Hammer and Champy (1993)) and also their simplification (e.g. through the automated execution of some of steps by computers), which generates high levels of business value. Also, the creation of new interdepartmental horizontal processes leads to the development of appropriate valuable applications, which are based on internal networks, connect the departments involved and support their coordination, resulting in the generation of high levels of business value. It should be noted that process simplification and improvement are among the most extensively adopted BPR activities (section 4.1, Table I), while the creation of new interdepartmental horizontal processes is not.

Also, from the fifth column of Table VIII we note that the TQM activities that positively moderate the impact of ICT on business performance most are the systematic measurement of employees' satisfaction and work method simplification for quality improvement. This means that the systematic measurement of employees'

satisfaction leads to the development of a group of highly valuable applications in this direction, which enable employees (usually via the enterprise's intranet) to express their opinions on current work methods and processes, to make suggestions for possible improvements, to fill in questionnaires concerning their satisfaction, etc., which generate high levels of business value. Also, the simplification of work methods for quality improvement leads to the development of applications that support this simplification, through the automated execution of some steps by computers, the provision of additional information or alarms to the employees who perform various tasks so that they become easier and simpler, etc., which generates high levels of business value. It should be noted that work method simplification for quality improvement is on of the the most extensively adopted TQM activities (section 4.1, Table I), while the systematic measurement of employee satisfaction is not.

5. Conclusions, limitations and further research directions

In the previous sections of this paper we have presented an empirical investigation and comparison of the moderating role of the two basic process change paradigms – i.e. BPR and TQM – on the business value generated for firms by their ICT investments, which aims to contribute to filling the existing research gap on this highly important topic for IS management practice. This study is based on firm-level data from 271 Greek firms, which was collected through a survey conducted in cooperation with ICAP, one of the largest business information and consulting companies in Greece. Initially, in order to achieve a reliable measurement of BPR and TQM, which constitute highly abstract and multidimensional concepts, multi-item constructs were developed based on the relevant literature; their validity and reliability was tested using methods proposed by the relevant statistical literature, with positive results. Then, based on those constructs, moderated regression models with objective measures of business performance (firm value added) and ICT (value of firm ICT hardware-software and networks) were constructed, founded on a sound and mature foundation from the area of microeconomics – i.e. the Cobb-Douglas production function – and including all the fundamental independent variables. The results show that both BPR and TQM have considerable positive moderating effects of a similar magnitude on the relationship between ICT investment and firm value added. Our BPR-related findings are consistent with the results of the two previous empirical studies of the moderating effect of BPR on ICT business value (Grover *et al.*, 1998; Devaraj and Kohli, 2000). The findings of this study confirm the theoretical expectations and arguments of the relevant literature, mentioned in the Introduction, that BPR constitutes an important "ICT complementary factor", which, if combined with ICT, can increase the positive impact and in general the business value that ICT generates.

Also, the moderating effect on ICT business value of the each of these basic BPR and TQM activities, which have been determined based on a review of the relevant literature, has been investigated through the estimation of the corresponding moderated regression models. Our results show that these activities differ considerably as to their moderating effect on ICT business value. Process simplification and improvement as well as interdepartmental horizontal process creation are the BPR activities that result in the highest increase in the contribution of ICT investments to firm value added. On the other, hand the systematic measurement of employee satisfaction and the simplification of working tasks for quality improvement are the TQM activities resulting in the highest increase in the contribution of ICT investments to firm value added.

This study contributes to the very limited empirical literature on the moderating effect of business process change on ICT business value. Its main contributions are:

- It investigates empirically the moderating effect of TQM (which constitutes a basic paradigm of business process change) on ICT business change, and compares it with the corresponding effect of the other basic paradigm of business process (BPR). Such an empirical investigation has not been reported in the previous relevant literature.
- It is based on a reliable measurement of BPR and TQM through validated multi-item scales. The scales that we develop and test in the present study with positive results, and in general the whole approach we adopt, could be useful for future empirical research concerning the antecedents, impacts and complementarities of BPR and TQM.
- It is based on theoretically sound models, which are founded on the Cobb-Douglas production function and include all the fundamental independent variables, and also on objective measures of business performance and the ICT business value.
- It investigates the moderating effects of particular basic BPR and TQM activities on ICT business value and identifies those that can result in the highest increase of the contribution of ICT investments to firm value added.

The present study has significant implications for business and ICT management, providing useful directions for increasing the value and the benefits that businesses gain from their ICT investments. In particular, it shows that ICT should not be used simply as a tool for automating existing business processes, which were usually designed in the past before the emergence of ICT and are based on the two "old assumptions":

(1) the dominant manual mode of office work; and

(2) the high costs of communication and information processing at that time.

On the contrary, ICT should be used in an innovative manner for creating and supporting new business processes and practices, such as those proposed by the BPR and TQM literature, based on the "new assumptions" that ICTs have generated, i.e. the low costs of communication and information processing and the new electronic mode of office work. Such an innovative approach will result in more beneficial ways of using ICT capital in more valuable applications, so it will increase the benefits and business value generated by ICT investment. Also, IS management should take into account that the various basic BPR activities proposed by the relevant literature have quite different moderating effects on ICT business value. The highest contribution of ICT investment to firm value added is achieved when it is combined with BPR activities concerning the simplification of existing complex processes, the improvement of problematic or costly processed and the abandoning of a departmental "silo mentality" through the creation of interdepartmental horizontal processes that cross more than one department, since the existence of ICT can enable and support such changes, resulting in high levels of business value. Concerning TQM, the highest contribution of ICT investment to firm value added is achieved when it is combined with the systematic measurement of employee satisfaction and the simplification of working tasks for quality improvement.

The basic limitation of this study is that it is based on data from Greek firms, so its results might, at least to some extent, reflect the characteristics of the Greek national economic and cultural context (e.g. smaller firm size, smaller size of the domestic market, lower level of competition, and lower ICT penetration and internet usage in comparison with other member states of the European Union). Another limitation is that only one business performance measure is used, although one that is quite important and theoretically fundamental (i.e. firm value added). So, further empirical research is required concerning the moderating effects of BPR and TQM on ICT business value in various national and sectoral contexts, using more financial and non-financial measures of business performance. These future research directions should also be extended one level backwards, by additionally investigating empirically the basic antecedents of BPR and TQM, i.e. internal and external factors affecting the extent of BPR and TQM. In this direction it would be quite interesting to investigate empirically the effect of environmental factors (e.g. price and non-price competition, environmental dynamism, etc.) and business strategy (e.g. cost leadership, differentiation, focus, etc.) on the extent of BPR and TQM, on ICT investment, on the relationships between them and business performance and also on the moderating effect of BPR and TQM on ICT business value.

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Appendix

- Yearly total sales revenue (without VAT): _____ Euro

- Yearly total expenses for buying materials and services (without VAT): _____ Euro

- Number of employees: _____

- Value of assets at the end of the year (without VAT): _____Euro

- Value of ICT equipment (hardware, software and networks) at the end of the year (without VAT): _____ Euro

Answer the following two groups of questions in a scale 1 – 5, where 1 = Not at all, 2 = To a small extent, 3 = To a moderate extent, 4 = To a large extent, 5 = To a very large extent, by clicking the appropriate box in the right of each question

- To what extent have you performed the following business process reengineering (BPR) activities in the last five years?

BPR ACTIVITIES	1	2	3	4	5
Process simplification					
Process improvement					
Creation of new interdepartmental (horizontal) processes that cross more than one departments					
Process abolition					
Process redesign in order to become more customer-focused					
Creation of new interdepartmental (horizontal) workgroups (customer or product-focused)					
Creation of process coordinator role (responsible for the monitoring, and the fast completion of a horizontal process)					
Job enrichment – increase of decision making competences and authorization for employees involved in some processes					
Decrease of supervision and number of supervisors in some processes					

- To what extent does your company perform the following quality management activities?

QUALITY MANAGEMENT ACTIVITIES	1	2	3	4	5
Use of statistical quality control methods					
Operation of permanent quality improvement teams					
Systematic measurement of customer satisfaction					
Cooperation with suppliers for quality improvement					
Working method simplification for quality improvement					
Systematic measurement of employee satisfaction					
Continuous quality improvement					

Figure A1.
Survey questions

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