THE MODERATING ROLE OF BPR AND TQM ON ICT BUSINESS VALUE

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Abstract

This paper empirically investigates and compares the moderating role 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 ICT investment, using data from 271 Greek firms. Initially multi-item BPR and TQM constructs have been developed based on the relevant literature and their validity and reliability has been tested with positive results. Then based on them moderated regression models with objective measures of business performance (as dependent variable) and ICT (as one of the independent variables) have been constructed, founded on the Cobb-Douglas production function and including all the fundamental independent variables. From these models it is concluded that both BPR and TQM have considerable moderating effects of similar magnitude on the relationship between ICT and firm value added. Therefore the contribution of ICT investment to firm value added can increase considerably if it is combined with BPR or TQM.

Keywords: ICT (or IS) business value, business performance, business process reengineering (BPR), total quality management (TQM)

1 INTRODUCTION

Even though earlier studies did not find evidence about a statistically significant association between ICT investment and business performance (e.g. Roach 1987, Strassman 1990, Brynjolfsson 1993, Loveman 1994, Strassman 1997), more recent studies have provided substantial evidence that ICT investment has a positive and statistically significant impact on business performance (e.g. Brynjolfsson & Hitt 1996, Stolarick 1999, Preslac 2003). So current research in this domain focuses on the identification and investigation of 'ICT complementary factors', which, if combined with ICT, can increase this positive impact and in general the business value that ICT generates (Melville et al 2004, Arvanitis 2005, Wan et al 2007). The most widely ICT complementary factor discussed in the literature is business process change; its potential as a moderator of ICT business value has been

emphasized by the relevant literature based on a rich argumentation (e.g. Hammer 1990, Brynjolfsson & Hitt 1996, Brynjolfsson & Hitt 1998, Brynjolfsson & Hitt 2000, Bresnahan et al 2002, OECD 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 remains a highly interesting topic for long time and most organizations today start BPR projects of various sizes and radicalness levels in order to close competitive gaps and achieve superior performance (Al-Mashari 2001). Recently the 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 instance, BPR has been ranked as the fifth most important issue that IS managers face in the most recent survey of the key IS management issues conducted by the Society for Information Management (SIM) of USA (www.simnet.org) (Luftman et al 2006). TQM constitutes another process change paragigm; it is defined by the 'International Organization for Standardization' (ISO) (http://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". 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 on the contrary TQM is incremental, evolutionary and continuous. Both of them rely to a large extent on ICT, as described in more detail in the section 2.

However, despite the abovementioned expectations of the relevant literature and the rich argumentation in support of them, the moderating role of BPR on ICT business value has only to a very small extent been empirically investigated using large datasets (Grover et al 1998, Devaraj & Kohli 2000), while the moderating effect of TQM on ICT business value has not been empirically investigated. Even these very few empirical studies of the moderating role of BPR, as described in the following section 2, are not based on theoretically sound models including all the fundamental variables; also, they are measuring the extent of BPR in a simplistic way using only one item (i.e. through one simple question), which may result in reduced measurement reliability. Therefore further empirical research is necessary concerning the moderating effects of those two different business process change paradigms on ICT business value in various sectoral and national contexts, based on sound theoretical foundations, large datasets, models including all fundamental variables, and also using appropriate multi-item constructs for measuring both BPR and TQM with high levels of reliability, in order to draw sound conclusions as to what extent the abovementioned expectations of the literature are realized. The results of this research will be useful to both the business and the ICT management community and to the research community.

This paper attempts to fill this research gap by presenting an empirical investigation and comparison of the moderating effect 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 are developed based on the BPR and TQM literature, and their validity and reliability is tested using the methods proposed by the relevant statistical literature (e.g. Chin 1998, Straub et al 2004, Kline 2005). Then based on them moderated regression models of firm value added including all the fundamental independent variables have been constructed, founded on the Cobb-Douglas production function, which constitutes a sound and mature theoretical foundation from the domain of microeconomics.

In the following 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 the final 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 & Champy 1993, Davenport 1993, Brynjolfsson & Hitt 1996, Brynjolfsson & Hitt 1998, Gunasekaran & Nath 1997, Brynjolfsson & Hitt 2000, Bresnahan et al 2002, OECD 2004, Melville et al 2004, Pantazi & 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 90s "ICT Productivity Paradox" is that firms needed a period of learning how to utilize 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; they conclude that since modern ICTs can reduce dramatically communication and information processing cost and enable new electronic modes of office work, they can be 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 reorganization 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 finally 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, the moderating role of BPR on ICT business value has only to a very small extent been empirically investigated 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 from 313 senior ICT executives of USA large service and manufacturing firms (over half of them having more than 2500 employees) and based on them constructing moderated regression models. From them it was concluded 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 the client/server technologies. This study was based on subjective single-item measures of ICT-related process change and ICT-related productivity improvement (based on perceptions of firms' managers). Devaraj & Kohli (2000) have empirically investigated in the context of hospitals 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) and also the moderating role of BPR perceived effectiveness on these relationships. Using monthly data from USA 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). This study was based on a subjective single-item measure of BPR effectiveness (based on perceptions of hospitals' managers). It should also be noted that in the regression models of both these studies only independent variables associated with ICT capital and BPR have been 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, labor, etc, have not been

included. This omission of important independent variables, according to the relevant econometric modeling 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 describing how ICT can be used for supporting it, making it more efficient and increasing the business value it generates (Giffi et al 1990, Weston 1993, Flynn et al 1994, Forza 1995a and 1995b, Kock & McQueen 1997, Dewhurst et al 2003). 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 analyzing 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 and 1995b) from an empirical study in 34 industrial plants in Italy found that quality management practices can be significantly supported by eight 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, information exchange with customers and suppliers on quality; so he concluded that supporting these information flows through ICT can contribute to improving quality performance. 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 relationship, 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, resulting finally in higher quality, operational and financial performance. However, there is a lack of empirical investigations of the moderating effect of TQM on ICT business value.

Therefore, from the review of the relevant literature it is concluded that 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 sound theoretical foundations, including all fundamental independent variables, and using large datasets and appropriate multi-item constructs for measuring BPR and TQM, which are highly abstract and multidimensional concepts, with high levels of reliability.

3 RESEARCH HYPOTHESES, METHOD AND DATA

In this direction 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 the previous section 2, most of the existing business processes of firms have been designed in the past before the emergence of ICT; their design has been based on two assumptions: the dominant manual mode of office work and the high costs of communication and information processing at that time (Hammer 1990, Hammer & Champy 1993). These assumptions are not valid today due to the emergence of ICT, which enable new electronic modes of office work and reduce dramatically communication and information processing costs. For this reason automating those 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 enablers and facilitators of new enhanced business processes, which can lead to big increase of business performance (e.g. Hammer 1990, Hammer & Champy 1993, Brynjolfsson & Hitt 1996, Brynjolfsson & Hitt 1998, Gunasekaran & Nath 1997, Brynjolfsson & Hitt 2000, Bresnahan et al 2002, OECD 2004, Melville et al 2004, Pantazi & 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:

Hypothesis 1: 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 the 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 (Giffi et al 1990, Weston 1993, Flynn et al 1994, Forza 1995a and 1995b, Kock & 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, increasing thus the contribution of ICT investment to firm value added. Therefore our second hypothesis is:

Hypothesis 2: 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 two 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 extensively used in the past for estimating the contribution of firm inputs, including ICT capital (e.g. see Brynjolfsson & 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:

$$VA = e^{\beta_0} L^{\beta_1} K^{\beta_2} CK^{\beta_3} \qquad (3.1)$$

where VA is the yearly firm value added (= 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 (3.1) we obtain the following linear form of it:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK) \qquad (3.2)$$

In order to investigate the moderating effect of the above two business process change paradigms, BPR and TQM, on the contribution of ICT to firm output, we have added an 'interaction term' (Aiken & West 1996, Venkatraman 1989, Gujarati 2003), which is equal to the product of the corresponding business process change factor F (i.e. extent of BPR or extent of TQM) to ln(CK):

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK) + \beta_4 \ln(CK) \cdot F \qquad (3.3)$$

The extent of BPR and TQM constitute highly abstract and multidimensional concepts, which cannot be measured by only one item, so it was decided to measure them as multi-item constructs using multi-

item scales. In particular, the extent of BPR is measured through a nine-item scale, which has been developed based on a review of the relevant BPR literature (Davenport 1993, Hammer and Champy 1993, Gunasekaran and Nath 1997, Al-Mashari and Zairi 2000), and is shown in the Appendix. The extent of TQM is measured through a seven-item scale, which has also been developed based on a review of the relevant TQM literature (Saraph et al 1989, Flynn et al 1994, NIST 1995, Ahire et al 1996, EFQM 1998, Martinez-Lorente et al 2004), and is shown in the Appendix. The validity and reliability of those multi-item scales is assessed using the methods proposed by the relevant statistical literature (e.g. Chin 1998, Straub et al 2004, Kline 2005).

The above hypotheses 1 and 2 were tested by estimating initially model (3.2) and then model (3.3) for F equal to the extent of BPR (calculated as the average of the above nine BPR items) and then 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. For the estimation of the above regression models we used data collected through a survey among Greek companies, which was conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. The questions of this survey concerning the financial data of the company and the extent of its BPR and TQM activities that have been used in this study are shown in Appendix. The sample of the survey was randomly selected from the database of ICAP and included 304 Greek firms (103 small, 103 medium and 98 large ones) from the 27 most important sectors of 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. Initially the questionnaire was sent by mail to the 304 firms of the first sample; the ones who refused to participate were replaced by 'similar' companies (i.e. from the same size and industry group) from the second sample; in the rare cases that the similar companies of the second group were exhausted, the similar companies of the third sample were used. In this way we managed to have a balanced sample concerning company size and industry. Finally were received complete questionnaires from 271 companies (88 small, 105 medium and 78 large ones).

4 DATA ANALYSIS AND RESULTS

4.1 BPR and TQM construct validity and reliability assessment

Initially we tested the construct validity of the above BPR and TQM multi-item constructs, focusing on its two most important dimensions: convergent and discriminant validity. Convergent validity of the BPR and the TQM constructs was tested through confirmatory factor analysis (Straub et al 2005, Kline 2005). In particular, we hypothesized each of them to be a latent factor reflected by its items (i.e. BPR reflected by its corresponding 9 items and TQM reflected by its corresponding 7 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 1 and 2 respectively.

	BPR	**TQM**
Chi-Square	89.65	25.2
RMSEA	.101	.059
Incremental Fit		
NFI	.939	.978
RFI	.909	.964
IFI	.955	.989
TLI	.932	.982

CFI	.955	.989

Table 1. Goodness-of-fit indexes for the BPR and TQM models

BPR		TQM	
Indicator	Loading	Indicator	Loading
BPR_1	.722	TQM_1	.592
BPR_2	.698	TQM_2	.673
BPR_3	.783	TQM_3	.824
BPR_4	.694	TQM_4	.804
BPR_5	.706	TQM_5	.798
BPR_6	.781	TQM_6	752
BPR_7	.751	TQM_7	.825
BPR_8	.729		
BPR_9	.676		

Table 2. Item loadings of the BPR and TQM constructs.

From Table 1 we can see that for both models the incremental fit indexes are within the limits recommended by Gefen et al (2000) (≥ 0.9); RMSEA for the TQM model is within the limits recommended by Browne and Cudeck (1993) (≤ 0.08), while for the BPR model it is a little higher. The item loadings of these two constructs shown in Table 2 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.

Next 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 9 BPR items and the 7 TQM items). The results show that there is 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, as we can see in Table 3. These results indicate the discriminant validity of the two constructs.

BPR and TQM activities	F1	F2
BPR1: Creation of new horizontal (inter-departmental) processes (that cross more than one departments)	0.725	0.319
BPR2: Creation of new inter-departmental units/workgroups (e.g. customer or product-focused)	0.686	0.363
BPR3: 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
BPR4: Simplification of processes	0.718	0.141
BPR5: Improvement of processes	0.697	0.295
BPR6: Abolition of processes	0.791	0.195
BPR7: Redesign of processes so that they become customer-focused	0.789	0.148
BPR8: Job enrichment - increase of decision making competences-authorization for employees involved in some processes	0.725	0.230
BPR9: Decrease of supervision and number of supervisors in some processes	0.711	0.120

TQM1: Use of statistical control methods	0.069	0.729
TQM2: Permanent quality improvement teams	0.297	0.713
TQM3: Systematic measurement-monitoring of customer satisfaction	0.188	0.835
TQM4: Cooperation with suppliers for quality improvement	0.197	0.789
TQM5: Work simplification for quality improvement	0.306	0.766
TQM6: Systematic measurement-monitoring of employee satisfaction	0.263	0.731
TQM7: Continuous quality improvement	0.301	0.781

Table 3. Factor analysis of BPR and TQM measurement items

Finally the reliability of the above BPR and TQM constructs was tested by calculating their Cronbach's Alpha coefficients; both of them (0.914 for the BPR construct and 0.906 for the TQM construct) exceed the minimum acceptable level of 0.7 recommended by the relevant literature (Gefen et al 2000, Straub et al 2004), confirming thus the reliability of the two constructs.

4.2 Investigation of the moderating effects of BPR and TQM on ICT business value

Having confirmed the validity and reliability of the BPR and TQM constructs, based on them we proceeded to the investigation of the moderating effects of BPR and TQM on ICT business value, which is quantified as the contribution of firm ICT investment to firm value added, by estimating regression models (3.2) and (3.3). In these models were additionally included two dummy variables controlling for firm size: D_Large (it is equal to 1 for large firms having more than 250 employees and 0 for all other firms) and D_Medium (it is 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 4 we can see the results from the estimation of the model of equation (3.2). 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.

Dependent variable : ln (VA)				
Independent variable	Coefficient	Standard Error	Standardized 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

Table 4. Regression model for the impact of labour, non-computer capital and computer capital on firm value added

In Table 5 we can see the results from the estimation of the model of equation (3.3) 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. This result indicates that the extent of BPR moderates positively the contribution of ICT investment to firm value added and provides support for hypothesis 1. In particular, this model indicates that the contribution of ln(CK) to ln(VA) is equal to (0.202 + 0.013*BPR)*ln(CK), so if the extent of BPR takes its lowest value being equal to 1 (corresponding to not performing at all any of the nine considered BPR activities shown in the Appendix) 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), which equals to the output elasticity of the computer capital (see Brynjolfsson et al 1996, Nicholson 1998), will increase by (0.267/0.215)-1=0.242, i.e. by 24.2%, in comparison with the case of having ICT investment without any BPR at all.

Dependent variable : ln (VA)				
Independent variable	Coefficient	Standard Error	Standardized 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)*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	0.012

Table 5. 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

In Table 6 we can see the results from the estimation of the model of equation (3.3) for F equal to the extent of TQM measured by the average of the abovementioned seven TQM items. We remark that the coefficients of labour, non-computer capital and computer capital again remain all positive and statistically significant, and also that the coefficient of the interaction term between computer capital and TQM is positive and statistically significant. This result indicates that the extent of TQM moderates positively the contribution of ICT investment to firm value added and provides support for hypothesis 2. In particular, this model indicates that the contribution of ln(CK) to ln(VA) is equal to (0.201 + 0.014*TQM)*ln(CK), so if the extent of TQM takes its lowest value being equal to 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 being equal to five (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. 26%) in comparison with the case of having ICT investment without any TQM at all.

Dependent variable : ln (VA)				
Independent variable	Coefficient	Standard Error	Standardized 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)*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

Table 6. 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 5 and 6 (0.013 and 0.014 respectively) is much lower than their standard errors (0.006 and 0.005 respectively).

5 CONCLUSIONS, LIMITATIONS & FURTHER RESEARCH DIRECTIONS

This paper presented an empirical investigation and comparison of the moderating role of the two basic process change paradigms, 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 issue. It has been based on firm-level data from 271 Greek firms, which have been collected through a survey conducted in cooperation with ICAP, one of the largest business information and consulting companies of Greece. Initially, in order to achieve a reliable measurement of BPR and TQM, since they constitute highly abstract and multidimensional concepts, multi-item constructs have been developed based on the relevant literature; their validity and reliability has been tested using the 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) have been constructed, founded on the Cobb-Douglas production function and including all the fundamental independent variables. From these models it has been concluded that both BPR and TQM have considerable positive moderating effects of similar magnitude on the relationship between ICT investment and firm value added. These 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). It should be noted that the findings of this study confirm the theoretical expectations and arguments of the relevant literature, which have been 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.

The results of this study are interesting for both the research community and the business and ICT management community. For the former (research community) it offers a contribution to the very limited empirical literature on the moderating effect of business process change on ICT business value, based on a reliable measurement of BPR and TQM and on theoretically sound models based on the Cobb-Douglas production function and including all the fundamental independent variables. Also the multi-item BPR and TQM constructs we developed and tested in this study with positive results, and in general the whole approach we adopted in it, can be useful for future empirical research concerning impacts and complementarities of BPR and TQM. Moreover, this multi-item BPR and TQM measurement approach that we developed in this study allows the empirical investigation of differing impacts and complementarities of different types of BPR and TQM activities. For the latter (business and ICT management community) this study has significant ICT management implications, providing useful directions for increasing the value and the benefits that organizations 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 have usually been designed in the past before the emergence of ICT and have been based on the two 'old assumptions': the dominant manual mode of office work and 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 ICT have generated: 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 assets in more valuable applications, so it will increase the benefits and business value generated by ICT investment.

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. lower level of economic development, smaller firm size, smaller size of domestic market, lower level of competition and lower ICT penetration and Internet usage in comparison with the other member-states of the European Union). Another limitation is that only one business performance measure has been used (firm value added). So further empirical research is required concerning the moderation effects of BPR and TQM on ICT business value in various national and sectoral contexts,

using various financial and non-financial measures of business performance and business value. Also it would be interesting to investigate empirically the moderating effects of different types of BPR and TQM activities (e.g. of each of the nine BPR activities that have been used for developing the BPR construct and of each of the seven TQM activities that have been used for developing the TQM construct) on ICT business value The above future research directions can also be extended one level backwards, by additionally investigating 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 ICT investment, the extent of BPR and TQM, and on the relationships among them and with business performance.

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References

Ahire, S. L., Golhar, D. Y. and Waller, M. A. 1996. 'Development and Validation of TQM Imementation Cnstructs'. *Decision Sciences,* 27 (1): 23-56.

Aiken, L. S. and West, S. G. 1996. '*Multiple Regression: Testing and Interpreting Interactions*'. Newbury Park, CA: Sage

Al-Mashari, M. and Zairi, M. 2000. 'Revisiting BPR: A Holistic Review of Practice and Development'. *Business Process Management Journal*, 6(1): 10-42.

Al-Mashari, M., Irani, Z. and Zairi, M. 2001. 'Process Reengineering: A Survey of International Experience'. *Business Process Management Journal*, 7(5): 437-453.

Arvanitis, S. 2005. 'Computerization, Workplace Organization, Skilled Labour and Firm Productivity: Evidence for the Swiss Business Sector'. *Economics of Innovation and New Technology*, 14(4): 225-249.

Attaran, M. 2003. 'Information Technology and Business Process Redesign'. *Business Process Management Journal,* 9(4): 440-458.

Bresnahan, T., Brynjolfsson, E., Hitt, L. M. 2002. 'Technology, Workplace Organization and the Demand for Skilled Labor: Firm-level Evidence'. *Quarterly Journal of Economics,* 117: 339-376

Browne, M. W., Cudeck, R. 1993. '*Alternative Ways of Assessing Model Fit'*. In Testing Structural Equation Models, eds. K. A. Bollen and S. Long, Newbury Park, CA: Sage Publications, Inc.

Brynjolfsson, E. 1993. 'The Productivity Paradox of Information Technology: Review and Assessment'. *Communications of the ACM*, 36(12): 67-77.

Brynjolfsson, E., Hitt, L. M. 1996. 'Firm Level Evidence on the Returns to Information Systems Spending'. *Management Science,* 42(4): 541-558.

Brynjolfsson, E., Hitt, L. M. 1998. 'Beyond the Productivity Paradox – Computers are the Catalyst for Bigger Changes'. *Communications of the ACM,* 41(8): 49-55.

Brynjolfsson, E., Hitt, L. M. 2000. 'Beyond Computation: Information Technology, Organizational Transformation and Business Performance'. *Journal of Economic Perspectives,* 14(4): 23-48.

Byrne, B. M. 2001. '*Structural Equation Modeling With AMOS: Basic Concepts, Applications and Programming*', Lawrence Erlbaum Associates, New Jersey.

Chin, W. W. 1998. 'Issues and Opinion on Structural Equation Modeling'. Management *Information Systems Quarterly*, 22(1): 7-16.

Davenport, T. 1993. '*Process Innovation*: *Re-engineering Work through Information Technology'*. Harvard Business School Press, Boston, USA.

Davenport, T. and Nohria, N. 1994. 'Case Management and the Integration of Labor'. *Sloan Management Review*, 31: 11-27.
Devaraj, S., and Kohli, R. 2000. 'Information Technology Payoff in the Health-Care Industry: A Longitudinal Study'. *Journal of Management Information Systems*, 16 (4): 41-65.
Dewhurst, F. W., Martinez-Lorente, A. R. and Sanchez-Rodriguez, C. 2003. 'An Initial Assessment of the Influence of IT on TQM: A Multiple Case Study'. *International Journal of Operations & Production Management*, 23(4): 348-374.
EFQM. 1998. 'Self Assessment 1998 – Guidelines for Companies'. *European Foundation for Quality Management*, Brussels, Belgium.
Flynn, B. B., Shroeder, R. G. and Sakakibara, S. 1994. 'A Framework for Quality Management Research and an Associated Measurement Instrument'. *Journal of Operations Management*, 11(4): 339-366.
Forza, C. 1995a. 'Quality Information Systems and Quality Management: A Reference Model and Associated Measures for Empirical Research'. *Industrial Management and Data Syatems*, 95(2): 6-14.
Forza, C. 1995b. 'The Impact of Information Systems on Quality Performance – An Empirical Study'. *International Journal of Operations and Production Management*, 55(6): 69-83.
Gefen, D., Straub, D. and Boudreau, M. 2000. 'Structural Equation Modelling and Regression: Guidelines for Research Practice'. *Communications of the Association for Information Systems*, 4: 1-78.
Greene, W. H. 2003. '*Econometric Analysis*- 5th edition'. Prentice Hall Inc.
Giffi, C., Roth, A. V. and Seal, G. M. 1990. '*Competing in World Class Manufacturing*'. Business One Irwin, Homewood, Illinois, IL.
Grover, V., Teng, J., Segars, A. H., Fiedler, K. 1998. 'The Influence of Information Technology Diffusion and Business Process Change on Perceived Productivity: the IS Executive's Perspective'. *Information and Management*, 34: 141-159.
Gujarati, D. N. 2003. '*Basic Econometrics – 4th edition'*. Mc-Graw Hill Higher Education.
Gunasekaran, A and Nath, B. 1997. 'The Role of Information Technology in Business Process Reengineering'. *International Journal of Production Economics*, 50: 91-104.
Hammer, M. 1990. 'Re-engineering Work: Don't automate, Obliterate'. *Harvard Business Review*, 68(4): 104-112.
Hammer, M. and Champy, J. 1993. '*Re-engineering the Corporation: A Manifesto for Business Revolution*'. Harper Press, New York, USA.
Hunter, L. W., Bernhardt, A., Hughes, K L. and Skuratowitz, E. 2000. '*It' Not Just the ATMs: Firm Strategies, Work Restructuring and Workers' Earnings in Retail Banking'*. Wharton School, USA.
Kline, R. B. 2005. '*Principles and Practice of Structural Equation Modelling'*, Guilford Press, NewYork, NY.
Kock, N. F. J. and McQueen, R. J. 1997. 'Using Groupware in Quality Management Programs'. *Information Systems Management*, 14(2): 56-62.
Loveman, G. 1994. '*Information Technology and the Corporation in the 1990s'*. MIT Press, Cambridge, MA, USA.
Luftman, J., Kempaiah, R. and Nash, E. 2006. 'Key Issues for IT Executives 2005'. *MIS Quarterly Executive*, 5(2): 81-100.
Martinez-Lorente, A. R., Sanchez-Rodriguez, C. and Dewhurst, F. W. 2004. 'The Effect of Information Technologies on TQM: An Initial Analysis'. *International Journal of Production Economics*, 89: 79-93.
Melville, N., Kraemer, K. and Gurbaxani, V. 2004. 'Information Technology and Organizational Performance: An integrative Model of IT Business Value'. *MIS Quarterly*, 28(2): 283-322.
Nicholson, W. 1998. 'Microeconomic Theory: Basic Principles and Extensions', 7th edition. *The Dryden Press*, Orlando, Florida.
NIST. 1995. 'Award Criteria – Malcolm Baldrige National Quality Award', *US National Institute of Standards and Technology*, Gaitherburg, MD.

Organisation for Economic Co-operation and Development (OECD). 2004. '*The Economic Impact of ICT – Measurement. Evidence and Implications,* Paris, France.
O'Neill, P., and Sohal, A. S. 1999. 'Business Process Reengineering: A Review of Recent Literature'. *Technovation*, 19: 571-581.
Pantazi, M. A. and Georgopoulos, N. 2006. 'Investigating the Impact of Business-Process-Competent Information Systems on Business Performance'. *Managing Service Quality*, 16(4): 421-434.
Preslac, A. R. 2003. 'A Firm Level Study of Information Technology Productivity by Industry Using Financial and Market Based Measures'. *Journal of Information Technology Impact*, 3(2): 77-90.
Roach, S. 1987. 'America's Technology Dilemma: A Profile of the Information Economy'. *Morgan Stanley Special Economic Study*, New York, USA.
Saraph, J. V., Benson, P. G. and Schroeder, R. G. 1989. 'An Instrument for Measuring the Critical Factors of Quality Management'. *Decision Sciences,* 20(4): 810-829.
Stolarick, K. 1999. 'IT Spending and Firm Productivity: Additional Evidence from the Manufacturing Sector'. *Center for Economic Studies, U.S. Census Bureau*, Working Paper 99-10.
Straub, D., Boudreau, M. and Gefen, D. 2004. 'Validation Guidelines for IS Positivist Research'. *Communications of the Association for Information Systems*, 13: 380-427.
Strassman, P. 1990. 'The Business Value of Computers: An Executive's Guide'. *The Information Economic Press*, New Canaan, Connecticut, USA.
Strassman, P. 1997. '*The Squandered Computer'*. The Information Economic Press, New Canaan, Connecticut.
Venkatraman, N.1989. 'The Concept of Fit in Strategy Research: Towards Verbal and Statistical Correspondence'. *Academy of Management Review*, 14(3): 423-444.
Wan, Z, Fang, Y. and Wade, M. 2007. 'A Ten-Year Odyssey of the 'IS Productivity Paradox' - A Citation Analysis (1996-2006)'. *The Americas Conference on Information Systems (AMCIS) 2007,* Keystone, Colorado, USA.
Weston, F. C. J. 1993. 'Weighting 'Soft' and 'Hard' Benefits of Information Technology'. *Manufacturing Systems,* 11(7): 120-121.

APPENDIX: *Survey Questions*

- 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 5 years?

BPR ACTIVITIES	1	2	3	4	5
Creation of new horizontal (inter-departmental) processes (that cross					

more than one departments)					
Creation of new inter-departmental units/workgroups (e.g. customer or product-focused)					
Creation of new horizontal coordination roles (process coordinators) for monitoring and coordinating the efficient and faster execution of processes crossing more than one department.					
Simplification of processes					
Improvement of processes					
Abolition of processes					
Redesign of processes so that they become customer-focused					
Job enrichment - increase of decision making competences 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					
Permanent quality improvement teams					
Systematic measurement-monitoring of customer satisfaction					
Cooperation with suppliers for quality improvement					
Work simplification for quality improvement					
Systematic measurement-monitoring of employee satisfaction					
Continuous quality improvement					