UNIVERSITY OF THE AEGEAN

DEPARTMENT OF INFORMATION AND COMMUNICATION SYSTEMS ENGINEERING

FACTORS INCREASING THE PRODUCTIVITY OF INFORMATION AND COMMUNICATION TECHNOLOGIES INVESTMENTS OF THE GREEK FIRMS – THE EFFECT OF EXTERNAL ENVIRONMENT, STRATEGY AND STRATEGIC ALIGNMENT, SOFT ICT INVESTMENT AND NEW FORMS OF WORKPLACE ORGANIZATION

Doctoral Dissertation

BY

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To my family…

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ABSTRACT

One of the most important research topics in the area of information systems (IS) has been for many years the business value they generate. Initially, from the mid 1980s until the mid 1990s (Roach 1987, Strassman 1990, Brynjolfsson 1993, Strassman 1997), very little empirical evidence had been found of a positive statistically significant association between information and communication technology (ICT) investment and business performance, giving rise to the extensive debate on the 'ICT Productivity Paradox' (Brynjolfsson 1993). However, from the mid 1990s until today, there has been considerable empirical evidence of a positive statistically significant contribution of ICT investment to several measures of business performance (Brynjolfsson and Hitt 1996, Stolarick 1999, OECD 2003, OECD 2004, Loukis and Sapounas 2005), even though there are still studies with mixed or inconclusive results (e.g. Stiroh 1998, Carr 2003). After 2000 the main emphasis of the research in this area has been put on the identification of factors and conditions that can increase the business value generated by ICT. This research shows that the business value generated by the ICT 'hard' investment of organizations (i.e. in computer hardware, software, etc.) can significantly increase, if it is combined with appropriate 'soft investment' in new work practices, redesign of business processes, new human skills, innovations, etc. (e.g. Brynjolfsson et al 2002, Ramirez 2003, Loukis and Sapounas 2005, Arvanitis 2005, Hempell 2005).

This dissertation presents the results of the first empirical investigation of i) the impact of information and communication technologies (ICT) investment of firms on their business performance in Greece, and ii) the effect of a number of internal factors (associated with the interior of a firm) and external factors (associated with the external environment of a firm), which had not been previously empirically investigated, on this impact of ICT investment on business performance. Our study consists of four parts. In the first part we investigate the effect of both 'hard' ICT investment (in ICT hardware, software and networks) and 'soft' ICT investment (in ICT structures, human resources and skills) on firm output. It is based on data from big Greek industrial firms, which have been collected via a questionnaire-based survey conducted in cooperation with the Federation of

Greek Industries (FGI). Using these data, econometric models of output have been constructed based on the microeconomic production theory. Our analysis shows that the Cobb-Douglas production function can adequately describe the relation between output and inputs in the Greek context, in comparison to the more general transcendental production function. Using the Cobb-Douglas production function, it has been found that 'hard' ICT investment in Greece makes a positive and statistically significant contribution to firm output; however its output elasticity is lower than the one of the non-computer capital and much lower than that of the labour. Also, from the measures of the 'soft' ICT investment we examined, it has been found that the existence of a separate ICT department has a positive and statistically significant effect on firm output, which is of considerable magnitude of about two thirds of the effect of the hard ICT investment. This finding underlines the importance of this dimension of the soft ICT investment, as it can increase by two thirds on average the business value generated by the hard ICT investment. Finally, the possibility of an effect of firm size on the structural stability of the econometric models we employed was also investigated; it was found that for firms with total sales above about € 20 million the structure of the models is reasonably stable, and therefore the conclusions drawn from them are valid at least for the whole range of firm sizes that our data cover.

In the second part of our study we investigate the effect of two factors associated with the external environment of a firm: i) the 'generalized' competition it faces, which, according to M. Porter's 'Five Forces Model' of competition includes the bargaining power of its suppliers, the bargaining power of its buyers, the competitive rivalry from its competitors, the threat of new entrants and the threat of substitute products or services, and ii) the strategy the organization follows for responding to pressures of its external environment, on the business value generated by ICT investment. The study is based on firm-level data from Greek companies, which have been collected through a questionnaire-based survey in cooperation with ICAP, one of the largest business information and consulting companies of Greece. Using these data are constructed econometric models of output based on the Cobb-Douglas production function. From these models, it is concluded that higher level of bargaining power of suppliers causes a significant increase (41%) of the business value generated by ICT. Also, concerning strategy, it is concluded that following a strategy of frequent introduction of new innovative products and services causes a significant increase (31%) of the

business value generated by ICT. These findings mean that there are environment conditions and strategies resulting in higher ICT business value.

In the third part of our study, we examined the impact of four ICT strategic alignment mechanisms, which are associated with different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by ICT. The study is based on the above mentioned firm-level data from Greek companies. From the econometric models we estimated, based on the Cobb-Douglas production function, it is concluded that the ICT strategic alignment causes a statistically significant and large increase (of a level of 47%) of the business value generated by ICT. Furthermore, all the four ICT strategic alignment mechanisms we examined cause statistically significant increase of the business value generated by ICT. The bilateral relationship between the ICT Plan and the business/strategy plan and involvement of the organisational units of the firm (e.g. directorates, departments) in the IS and applications development projects are the mechanisms with the most increasing impact on the ICT business value (42% and 44% respectively).

Finally in the fourth part of our study, we conducted a comparative empirical study of the effect of ICT capital, human capital, organizational capital (adoption of new organizational practices) and knowledge capital, on labour productivity in Greece and Switzerland. It has been based on firm-level data from both countries collected through a common questionnaire, from samples of similar composition, from which econometric models of similar specification have been estimated for both countries. We found statistically significant positive effects for ICT capital, human capital and "employee voice" oriented organizational practices on labour productivity for both countries; on the contrary no effect (in the Greek case) or even a negative effect (in the Swiss case) has been found for "work design" oriented organizational changes. There are also considerable differences between the two countries. First, it has been concluded that Swiss firms are more efficient and mature in forming and using knowledge capital, than the Greek ones. Second, the effect of "employee voice" on labour productivity, which is significantly positive for both countries, is based on different types of practices. In Greece, positive and statistically significant effect on business performance has the decentralization of competences referring to the working conditions (work pace, work way, work sequence), while in

Switzerland the decentralization of competences having to do with the work content (contact to customers, solving of problems related to customers). The results of this comparative study provide evidence that the national context influences the effect of these ‘new’ production factors on labor productivity.

ΠΕΡΙΛΗΨΗ

Ένα από τα σημαντικότερα πεδία έρευνας στο χώρο των πληροφοριακών συστημάτων (ΠΣ) παραμένει για πολλά χρόνια η επιχειρησιακή τους αξία (business value), οριζόμενη ως η επίδραση της χρήσης τους στις επιδόσεις της επιχείρησης. Ειδικότερα, από τα μέσα της δεκαετίας του 1980 μέχρι τα μέσα της δεκαετίας του 1990 έχουμε ελάχιστες εμπειρικές ενδείξεις θετικής και στατιστικά σημαντικής σχέσης μεταξύ των επενδύσεων Τεχνολογιών Πληροφορικής και Επικοινωνιών (ΤΠΕ) καιτων επιδόσεων της επιχείρησης (Roach 1987, Strassman 1990, Brynjolfsson 1993, Strassman 1997), γεγονός το οποίο οδήγησε σε εκτεταμένες συζητήσεις σχετικά με το «Το Παράδοξο της Παραγωγικότητας των Επενδύσεων Πληροφορικής και Επικοινωνιών» (Brynjolfsson 1993). Ομως από τα μέσα της δεκαετίας του 1990 μέχρι και σήμερα, εμφανίζονται κάποια εμπειρικά αποτελέσματα που δειχνουν στατιστικά σημαντική συμβολή των επενδύσεων ΤΠΕ σε διάφορα μέτρα επιχειρησιακής απόδοσης (Brynjolfsson and Hitt 1996, Stolarick 1999, OECD 2003, OECD 2004, Loukis and Sapounas 2005), αν και συνεχίζουν να υπάρχουν μελέτες με μικτά ή αρνητικά αποτελέσματα (π.χ. Stiroh 1998, Carr 2003). Μετά το 2000 η έρευνα στον χώρο αυτό εστιάζεται στον προσδιορισμό συμπληρωματικών παραγόντων και συνθηκών που μπορούν να επαυξήσουν σημαντικά τις θετικές επιδράσεις των επενδύσεων ΤΠΕ στις επιδόσεις των επιχειρήσεων. Η έρευνα αυτή δείχνει ότι η επιχειρησιακή αξία από τις «σκληρές» (hard) επενδύσεις ΤΠΕ (σε υλικό, λογισμικό, κ.λ.π.) μπορεί να αυξηθεί σημαντικά, εάν αυτές συνδυαστούν με κατάλληλες «εύκαμπτες» (soft) επενδύσεις ΤΠΕ, οι οποίες αφορούν νέες πρακτικές εργασίας, ανασχεδιασμό των επιχειρησιακών διαδικασιών, νέες ανθρώπινες δεξιότητες, καινοτομίες κ.λπ. (π.χ. Brynjolfsson et al 2002, Ramirez 2003, Loukis and Sapounas 2005, Arvanitis 2005, Hempell 2005).

Η παρούσα διδακτορική διατριβή παρουσιάζει τα αποτελέσματα της πρώτης εμπειρικής μελέτης α) της επίδρασης των επενδύσεων ΤΠΕ στην απόδοση των επιχειρήσεων, και β) των επιπτώσεων μίας σειράς ‘εσωτερικών παραγόντων’ (που σχετίζονται με το εσωτερικό της επιχειρισης) καθώς επίσης και ‘εξωτερικών παραγόντων’ (που σχετίζονται με το εξωτερικό της περιβάλλον) στην παραπάνω επίδραση. Η εμπειρική μας μελέτη αποτελείται από τέσσερα μέρη. Στο πρώτο μέρος εξετάσθηκε η επίδραση των «σκληρών»

επενδύσεων ΤΠΕ (σε υλικό ΤΠΕ, λογισμικό και δίκτυα) και των «εύκαμπτων» επενδύσεων ΤΠΕ (σε ανθρώπινους πόρους ΤΠΕ και δεξιότητες) στην απόδοση της επιχείρησης. Η εμπειρική αυτή μελέτη βασίζεται σε δεδομένα, τα οποία έχουν συλλεχθεί από διεξαχθείσα έρευνα σε συνεργασία με τον Σύνδεσμο Ελλήνων Βιομηχανιών (ΣΕΒ) με χρήση δομημένου ερωτηματολογίου. Με βάση τα παραπάνω δεδομένα, κατασκευάσαμε οικονομετρικά υποδείγματα της απόδοσης της επιχείρησης, βασισμένα στην Μικροοικονομική θεωρία παραγωγής. Η ανάλυση των δεδομένων έδειξε ότι η συνάρτηση παραγωγής Cobb-Douglas μπορεί να περιγράψει επαρκώς την σχέση μεταξύ εξόδου (output) και εισόδων (inputs) επιχείρησης στην χώρα μας, σε σύγκριση με την γενικευμένη Transendental συνάρτηση παραγωγής. Χρησιμοποιώντας στην συνέχεια την συνάρτηση παραγωγής Cobb-Douglas προέκυψε ότι οι «σκληρές» επενδύσεις ΤΠΕ στην Ελλάδα δημιουργούν μία θετική και στατιστικά σημαντική συνεισφορά στην απόδοση της επιχείρησης. Όμως η ελαστικότητά τους σε σχέση με την απόδοση της επιχείρησης είναι χαμηλότερη από την αντίστοιχη του υπολοίπου κεφαλαίου ΤΠΕ και ακόμη χαμηλότερη από την αντίστοιχη της εργασίας. Επίσης, από τις μεταβλητές των «εύκαμπτων» επενδύσεων ΤΠΕ που εξετάσαμε, βρέθηκε ότι η ύπαρξη αυτόνομης οργανωτικής μονάδας ΤΠΕ στην επιχείρηση έχει μία θετική και στατιστικά σημαντική επίδραση στην απόδοση της επιχείρησης, η οποία έχει σημαντικό μέγεθος ίσο με τα δύο τρίτα περίπου της επίδρασης των «σκληρών» επενδύσεων ΤΠΕ. Το συμπέρασμα αυτό είναι ενδεικτικό της σημασίας αυτής της διάστασης των «εύκαμπτων» επενδύσεων ΤΠΕ (σε δημουργία δομών ΤΠΕ στη επιχείρηση), η οποία μπορεί να αυξήσει περίπου κατά δύο τρίτα την επιχειρησιακή αξία που δημιουργούν οι επενδύσεις ΤΠΕ. Τέλος ερευνήθηκε το ενδεχόμενο της επίδρασης του μεγέθους της επιχείρησης στη διαρθρωτική σταθερότητα των εκτιμηθέντων οικονομετρικών υποδειγμάτων. Προέκυψε το συμπέρασμα ότι για επιχειρήσεις με συνολικές πωλήσεις πάνω από 20 εκατομμύρια ευρώ η διάρθρωση των υποδειγμάτων διατηρείται σταθερή, και επομένως τα συμπεράσματα που απορρέουν από τα υποδείγματα είναι έγκυρα, τουλάχιστον για ολόκληρο το έυρος μεγεθών των επιχειρήσεων που τα δεδομένα μας καλύπτει.

Στο δεύτερο μέρος της διδακτορικής διατριβής εξετάσθηκε η επίδραση δύο παραγόντων που σχετίζονται με το εξωτερικό περιβάλλον της επιχείρησης: α) του «γενικευμένου» ανταγωνισμού που αντιμετωπίζει μια επιχείρηση, όπως αυτός περιγράφεται από το μοντέλο των «πέντε δυνάμεων» του Porter (που περιλαμβάνει την διαπραγματευτική δύναμη των προμηθευτών, την διαπραγματευτική δύναμη των αγοραστών, την ένταση των ανταγωνιστικών

πιέσεων από τους ανταγωνιστές, την απειλή νέων εισόδων και την απειλή από υποκατάστατα) και β) της στρατηγικής που μια επιχείρηση ακολουθεί για να αντιμετωπίσει τις πιέσεις του εξωτερικού της περιβάλλοντος, στην επιχειρηματική αξία που δημιουργούν οι επενδύσεις ΤΠΕ. Η εμπειρική αυτή μελέτη βασίζεται σε δεδομένα, τα οποία έχουν συλλεχθεί από έρευνα σε Ελληνικές επιχειρήσεις με χρήση δομημένου ερωτηματολογίου, σε συνεργασία με την επιχείρηση ICAP Α.Ε., μία από τις μεγαλύτερες επιχειρήσεις παροχής επιχειρησιακών δεδομένων και συμβουλευτικών επιχειρήσεων στην Ελλάδα. Με βάση τα παραπάνω δεδομένα κατασκευάσαμε οικονομετρικά υποδείγματα της απόδοσης της επιχείρησης, βασισμένα στην μικροοικονομική θεωρία παραγωγής, και ειδικότερα στη συνάρτηση παραγωγής Cobb-Douglas. Από τα παραπάνω υποδείγματα, όσον αφορά τις παραπάνω διαστάσεις του γενικευμένου ανταγωνισμού προέκυψε το συμπέρασμα ότι η ένταση της διαπραγματευτικής δύναμης των προμηθευτών αυξάνει σημαντικά (κατά 41%) την συνεισφορά των ΤΠΕ στην απόδοση των επιχειρήσεων. Επίσης, όσον αφορά τη στρατηγική προέκυψε το συμπέρασμα ότι η υϊοθέτηση μίας στρατηγικής συχνής εισαγωγής νέων καινοτομικών προϊόντων και υπηρεσιών αυξάνει σημαντικά (κατά 31%) τη συνεισφορά των ΤΠΕ στην απόδοση των επιχειρήσεων. Τα αποτελέσματα αυτά δείχνουν ότι υπάρχουν συνθήκες εξωτερικού περιβάλλοντος και στρατηγικές που οδηγούν στην δημιουργία υψηλότερης επιχειρηματικής αξίας από τις επενδύσεις ΤΠΕ

Στο τρίτο μέρος της διδακτορικής διατριβής εξετάσθηκε η επίδραση τεσσάρων μηχανισμών στρατηγικής ευθυγράμμισης ΤΠΕ, οι οποίοι αφορούν διαφορετικά ιεραρχικά επίπεδα της επιχείρησης, και καλύπτουν τόσο την διαμόρφωση όσο και την υλοποίηση της στρατηγικής, στην επιχειρηματική αξία που δημιουργούν οι επενδύσεις ΤΠΕ. Η μελέτη βασίζεται στα προαναφερθέντα δεδομένα, τα οποία έχουν συλλεχθεί από τις Ελληνικές επιχειρήσει, σε συνεργασία με την επιχείρηση ICAP Α.Ε. Από τα οικονομετρικά υποδείγματα που κατασκευάσαμε, βασισμένα στην συνάρτηση παραγωγής Cobb-Douglas, προέκυψε το συμπέρασμα ότι η στρατηγική ευθυγράμμιση των ΤΠΕ αυξάνει (κατά 47%) τη συνεισφορά των ΤΠΕ στην απόδοση των επιχειρήσεων. Επιπλέον, όλοι οι τέσσερις μηχανισμοί στρατηγικής ευθυγράμμισης ΤΠΕ που εξετάσθηκαν αυξάνουν τη συνεισφορά των ΤΠΕ στην απόδοση των επιχειρήσεων. Η αμφίδρομη σύνδεση του σχεδίου ΤΠΕ με το επιχειρησιακό/στρατηγικό σχέδιο και η συμμετοχή των οργανωτικών μονάδων της επιχείρησης στα διάφορα έργα (projects) ΤΠΕ έχουν την μεγαλύτερη επαυξητική επίπτωση (κατά 42% και 44% αντίστοιχα) στη συμβολή των επενδύσεων ΤΠΕ στην απόδοση της επιχείρησης

Τέλος στο τέταρτο μέρος της διδακτορικής διατριβής πραγματοποιήθηκε συγκριτική εμπειρική μελέτη της επίδρασης του κεφαλαίου ΤΠΕ, του ανθρώπινου κεφαλαίου, του «οργανωσιακού κεφαλαίου» (=των νέων μορφών οργάνωσης της εργασίας) καθώς επίσης και του γνωσιακού κεφαλαίου στην παραγωγικότητα της εργασίας στην Ελλάδα και την Ελβετία. Η μελέτη αυτή βασίστηκε σε αντίστοιχα δεδομένα που συλλέχθηκαν με κοινό ερωτηματολόγιο και από παρόμοια δείγματα επιχειρήσεων στην Ελβετία και στην Ελλάδα, από τα οποία οικονομετρικά υποδείγματα με τις ίδιες μεταβλητές κατασκευάστηκαν για τις δυο χώρες. Από αυτά προέκυψαν στατιστικά σημαντική θετική συμβολή για το «κεφάλαιο ΤΠΕ», το «ανθρώπινο κεφάλαιο», και για τις νέες μορφές οργάνωσης της εργασίας, που σχετίζονται με την ενίσχυση του ρόλου του εργαζομένου (employee voice) στην παραγωγικότητα της εργασίας και για τις δύο χώρες. Αντίθετα για τις νέες μορφές οργάνωσης της εργασίας που σχετίζονται με το σχεδιασμό της εργασίας (work design) δεν προέκυψε στατιστικά σημαντική επίδραση στην παραγωγικότητα της εργασίας (για τις Ελληνικές επιχειρήσεις) ή ακόμη και αρνητική επίδραση (για τις Ελβετικές επιχειρήσεις). Επίσης, προέκυψαν σημαντικές διαφορές μεταξύ των δύο χωρών όσον αφορά τις επιδράσεις των παραπάνω ‘μορφών κεφαλαίου’, οι οποίες χαρακτηρίζουν. Πρώτον, οι Ελβετικές επιχειρήσεις προέκυψε ότι είναι περισσότερο ώριμες και αποτελεσματικές στην δημιουργία και χρήση του «γνωσιακού κεφαλαίου» από τις Ελληνικές. Δεύτερον, είναι διαφορετικές στις δύο χώρες οι μορφές ενίσχυσης του ρόλου του εργαζομένου (employee voice) που έχουν θετική επίδραση στην παραγωγικότητα της εργασίας: συγκεκριμένα στην Ελλάδα αφορούν παραχώρηση περισσότερων αρμοδιοτήτων σους εργαζομένους, σχετικά με τις συνθήκες εκτέλεσης εργασιών (ρυθμός εργασίας, τρόπος εκτέλεσης εργασιών, ροή των εργασιών), ενώ στην Ελβετία αφορούν παραχώρηση περισσότερων αρμοδιοτήτων σους εργαζομένους σχετικά με το περιεχόμενο των εργασιών (επαφή με πελάτες, επίλυση προβλημάτων πελατών) και σχετίζονται περισσότερο με ανάληψη πρωτοβουλίας από εργαζόμενους όσον αφορά τους πελάτες. Τα αποτελέσματα αυτής της συγκριτικής εμπειρικής μελέτης οδηγούν στο συμπέρασμα ότι το ‘εθνικό περιβάλλον’ (national context) επιρεάζει την σχέση των παραπάνω ‘νέων παραγωγικών συντελεστών’ με την απόδοση των επιχειρήσεων.

CHAPTER 1:
INTRODUCTION

1.1 Introduction

One of the most important research subjects in the area of information systems (IS) has been for many years the business value they generate and its main determinants. Businesses have been making significant investments in information and communication technologies (ICT) in the last 25 years. According to OECD (2003) the investment in ICT in its member countries has risen from less than 15% of the total non-residential investment in the early 1980s, to between 15% and 30% in 2001. However, in the same report it is mentioned that there are marked differences in the diffusion of ICT across OECD countries: in some of them ICT investment is particularly high, e.g. in USA it is about 28% of the total non-residential investment, while in some others it is much lower (although it constitutes a considerable percentage of the total non-residential investment). Given the high level of ICT investment it is of critical importance to investigate the benefits and the value they create, and also their impact on business performance. For this reason the study of the relation between ICT investment and business performance has been extensively researched for long time.

This research can be divided into two periods. The first period of this research, from the mid 1980s until the mid 1990s, contrary to theoretical arguments and professional beliefs, provided very little empirical evidence of a positive and statistically significant relation between ICT investment and business performance (Roach 1987, Strassman 1990, Yosri 1992, Loveman 1994, Hitt & Brynjolfsson 1996, Rai & Patnayakuni R. & Patnayakuni N. 1996, Rai & Patnayakuni R. & Patnayakuni N. 1997, Strassman 1997). These early results posed critical questions concerning the productivity of the huge investments in ICT: do they really contribute to the productivity of firms, or not? And if they do, how much they contribute? This problematic is usually referred to as the *'ICT Productivity Paradox'* (Brynjolfsson 1993). The Productivity Paradox summed up in R. Solow's statement that *'you can see the computer age everywhere but in the productivity statistics'* (Solow 1987), alarmed managers, puzzled researchers, because firms were spending huge amounts of money for ICT.

On the contrary, the second period of this research, from the mid 1990s until today, provided empirical evidence of positive and statistically significant relation between ICT investment and some measures of business performance, such as output, labour productivity, etc. (Lichtenberg 1995, Brynjolfsson & Hitt 1996, Gurbaxani & Melville & Kraemer 1998, Lehr & Lichtenberg 1999, Gilchrist & Gurbaxani & Towne 2001, Devaraj & Kohli 2003). However there are still studies reporting ICT investment falling short of expectations (Hartman 2002). An important conclusion drawn in this period is that the benefits from ICT investments can increase significantly if they are combined with some complementary actions and 'co-investments' aiming at the development of new work practices, business processes, organisational structures, skills, etc. (Black & Lynch 1997, Francalanci & Galal 1998, Tallon & Kraemer & Gurbaxani 2000, Devaraj & Kohli 2000, Brynjolfsson & Hitt 2000, Brynjolfsson & Hitt & Yang 2000, Ramirez 2003, Arvanitis 2003, OECD 2003).

However, most of the empirical studies on the impact of ICT investment on business performance in both periods have been conducted in the context of only a few countries, which are characterised by high levels of economic development and ICT diffusion, and have been based mainly on data from quite big firms. Therefore the results of these studies are conditional on the characteristics of the particular contexts. OECD, in its recent report on this subject, warns that the impact of ICT investment can differ markedly across countries due to differences in 'the regulatory framework, the availability of appropriate skills, the ability to change organisational set-ups as well as the strength of accompanying innovations in ICT applications' (OECD 2003). Also Melville, Kraemer and Gurbaxani (2004) in their recent literature review stressed that one of the most important deficiencies of the research conducted in this area is its 'emphasis on U.S. firms' and 'lack of cross-country studies', so its 'results are conditional on the characteristics of the U.S. business environment'. Therefore it is necessary to investigate the above research questions also in contexts of other countries, which are characterised by different levels of economic development, ICT diffusion and ICT skills, different sizes of firms and different regulatory frameworks and business culture. Also it is necessary to investigate further the effect of internal and external factors on the contribution of ICT on business performance.

1.2 Literature Review

As mentioned in the 'Introduction', ICT business value has been for long time a major research topic in the area of IS. Extensive research has been conducted on this topic, aiming mainly at the assessment and understanding of the impact of ICT investment on business performance, and also at the identification of factors affecting the magnitude of this impact. Many empirical studies in these two directions are reported in the relevant literature, which differ in the level of analysis (there are studies at the national economy level, at sectoral level, at firm level and at business process level), the dependent variables (various business performance measures are examined), the independent variables, the methodology, the data and the context. This research can be divided into the next four periods:

1.2.1 First Period (mid 1980s - mid 1990s)

In this first period of this research, from the mid 1980s until the mid 1990s, little empirical evidence has been found of a positive and statistically significant relation between ICT investment and business performance. Most of the studies of this period found zero or even negative impact of ICT investment on productivity.

One of the first studies in this area was conducted by Roach (1987), who measured the productivity of information workers against that of production workers; he found that during the 1970s through the mid 1980s the productivity of production workers increased by 16.9%, while the productivity of information workers decreased by 6.9%, despite the big ICT investments that had been made during this period.

Strassman (1990 and 1994) investigated if firms have benefited from IT investment in three distinct years. In an analysis of scatter diagrams for over 530 firms, the author found no evidence of a relationship between IT and profits, or IT and productivity in 1985, 1990 and 1994. He interpreted these results as evidence that incremental benefits are not possible by simply investing in IT. Rather, investments in IT must be applied to value added organizational processes to have a real effect on performance of firms. He also concludes that evaluating IT related firm benefits is complicated, as IT supports managerial work, a process that is difficult to measure.

Weill (1992) investigated the performance effects of IT investment in 33 valve manufacturing firms between 1982 and 1987. IT investment data within the categories of strategic IT (used for competitive advantage and market share gains), informational IT (used to improve management and administrative information) and transactional IT (used as a labor substitute for routine tasks were gathered from annual surveys of firm executives. Hierarchical regression estimates of a linear model indicated that transactional IT is positively associated with multiple measures of financial performance including returns-on-assets (ROA) and sales per employee. Strategic IT was found to be weakly associated with firm performance in the short term, but unrelated in the long run. Informational IT appeared to have no impact on performance. Weill argued IT is not homogenous in its use. Rather, IT is purchased and implemented according to a specific management plan. In addition, the author concluded that other factors may be influencing the IT-performance relationship. He tested one such moderator of IT value – conversion effectiveness – which represents the quality of a firm's management and their commitment to IT. Regression results indicated that conversion effectiveness significantly improved the value of strategic IT, supporting expectations that there are management related factors that influence IT's effect on firm performance.

Yosri (1992), based on data from large food firms, found that ICT investment is not associated with sales growth, market share gain, new market penetration, productivity and various measures of quality improvement.

Dos Santos et al. (1993) examined the effect of IT usage on the performance of firms; however, rather than using an internal measure of performance like sales or cost, the authors employed an external assessment of value. Specifically, they completed an event study that analyzed the effect of innovative IT investment announcements on the charge in firm market value. Analysis results demonstrated that for 97 firms between 1981 and 1988, these announcements were responsible for a positive increase in stock price. While this suggested that innovative uses of IT can provide excess returns, the same is not true for non-It investments; no significant change in market value was found for similar non-IT announcements.

Brynjolfsson (1993), based on a review of the relevant literature of this first period, summarises the 'ICT Productivity Paradox' issue as follows: 'Delivered computing power in the U.S. has increased by more than two

orders of magnitude since 1970, yet productivity, especially in the service sector, seems to have stagnated'; also, in the same paper he remarks that the Productivity Paradox may be, at least to some extent, due to mismeasurement of outputs and inputs, mismanagement of ICT, redistribution of ICT benefits to the consumers (via an increase of consumer surplus) and also due to lags in learning, adjustment and restructuring of firms, which are necessary in order to reap the full benefits from ICT investments.

Loveman (1994) investigated the impact of IT investment in 60 business units, within 20 manufacturing firms between 1978 and 1984. Secondary data from the Management Productivity and Information technology (MPIT) database were utilized in the study. Production function estimates provided no evidence of a net marginal benefit from investment in IT, but non-IT inputs were found to positively contribute to firm output. Complementary organizational factors were highlighted as one possible explanation for the research results. Loveman concluded that the results can be interpreted as management failure to implement the necessary organizational change that should accompany IT investment. As IT is used to produce information with no intrinsic value, in order to add value, the information must be integrated with a structure that is capable of exploiting it effectively. The absence of any significant productivity effect indicates a failure to, "... build organizations that effectively integrate IT with business strategy, human resource management and efficient resource allocation. A key objective in organizational design therefore, "... must be to put in place mechanisms that can better value IT."

Using the same MPIT database Barua, Kriebel and Mukhopadhyay (1995) utilized an innovative model that estimates the impact of IT investment at the intermediate and output levels of a firm. Ordinary least squares estimation of a linear model suggested that intermediate level business processes, such as those that involve inventory turnover, can benefit from the use of IT. However, the authors found no evidence that the benefits of IT extend to firm performance as measured by ROA. While the theoretical foundation for the model is limited, the results indicate that IT can enable process efficiency improvements. A shortfall of the study, as highlighted by the authors, is the lack of data on the type of IT and managerial strategies utilized by firms. The inclusion of such information, the authors argue,

would lead to a more thorough understanding of the firm impacts of IT investment.

1.2.2 Second Period (mid 1990s until today)

The studies of Brynjolfsson and Hitt (1996) and Lichtenberg (1995) can be regarded as the starting point of a second period of research in this area, from the mid 1990s until today, which has provided empirical evidence of positive and statistically significant relation between ICT investment and business performance. Brynjolfsson and Hitt (1996) using an extensive data set on ICT spending by large U.S. firms compiled by the International Data Group (IDG) and constructing econometric models founded on a Cobb Douglas production function framework found that the contributions of computer capital and ICT staff labour expenses to firm output are not only positive and statistically significant, but also much higher than the contributions of the non-computer capital and the non-IS labour expenses respectively. The authors concluded their study by arguing for the existence of several organizational factors that can influence the payoff from IT. First, the estimates of IT elasticity were found to differ across industries. This indicated that the use and return to IT investment may be dependent upon the type of the firm utilizing the technology. Second, duplicating the analysis after splitting the IT stock variable into different usage categories indicates that the returns to IT vary by the type of computer equipment utilized. As the results suggest, the decision by management to use a mix of centralized and decentralized forms of IT can result in a higher IT payoff than a majority usage of any one type. Finally, the authors argued that complementary changes in organizational processes influence the relationship between IT and business performance. These can include the adoption of new organizational structures, inventory methods and IT focused reengineering programs.

Lichtenberg (1995) used two databases in their examination of the returns of to IT investment; IDG and Information Week. Ordinary least squares estimates of a Cobb Douglas production function indicate that IT positively and significantly contributes to firm output, supporting the earlier results of Brynjolfsson and Hitt (1996). The author also presented evidence that IT investment can generate excess returns. To gine an indication of how IT can benefit firms, Lichtenberg investigate the contribution of employees who

perform the IT function. Rough estimates indicated that one skilled IS employee is as valuable as up to six non-IS workers. It appears the combination of IT and the hiring of skilled workers may provide a positive benefit to firms.

Lehr and Lichtenberg (1998) investigated the returns to IT investment in six separate years between 1977 through 1993. This study used a merged dataset combining data from the U.S. Bureau of the Census and the Computer Intelligence Corporation (CI). The CI database is unique and contains annual data on IT capital stock value and counts of IT hardware for over 400 Fortune 100 firms between 1987 and 1994. While this time frame covers only a portion of the Lehr and Lichtenberg study, it is a valued component due to its up-to-date and depth of coverage (Ramirez, et al. 2000). Deriving a common measure of IT stock across the Census and CI datasets, the authors estimate a series of Cobb-Douglas production functions to examine the returns to overall IT stock and to individual types of IT hardware. The results demonstrate that computers not only contribute to value added output, but that the returns to IT capital are higher than those for non-IT assets. In addition, there is evidence that he returns to IT vary by type of IT utilized. The returns generated by end-user technologies, specifically Pc's and terminals, are much larger than those for computer capital associated with centralized computing. As the authors conclude, it appears that "...raw computing power matters less than how computers are used".

Rai, Patnayakuni R. and Patnayakuni N. (1996, 1997) found that the total IS budget makes a positive contribution to firm output and labor productivity, but not to the return on assets and the return on equity; also they found that different components of the IS budget have different effects on the various business performance measures.

Dewan and Min (1997) estimated the impact of ICT investments on firms, by using the IDG dataset and multiple econometric models. Estimations of CEs, Tranlog and CEs-Translog specifications provide consistent and confirmatory evidence of a positive relation between ICT investment and firm output. A comparison of the estimated results of each model with the constraints of Cobb-Douglas production function is appropriate and reasonable for estimating output elasticities and returns on investment. Finally, the authors test and find that IT capital is a net substitute for both ordinary capital and labor. It appears that firms are substituting IT for other

inputs to production in order to "...capitalize on the vastly superior price and performance improvements in IT relative to these other inputs".

Gurbaxani, Melville and Kraemer (1998), examined the returns of different forms of IT hardware using the CI database. Between 1987 and 1994, estimates of a Cobb-Douglas production function indicate that mainframe and PC hardware were positively associated with the output of over 400 Fortune 1000 firms. In addition, the degree to which employees are networked positively influences firm productivity, indicating that distributing forms of computing are paying off for firms.

Bharadwaj (2000) takes an innovative look at IT investment and its relationship to firm performance. He argued conceptually that IT represents an organizational capability, a firm's ability to, "...mobilize and deploy IT resources in combination or co-present with other resources and capabilities". Firms who are successful at creating such capabilities benefit from improved financial performance relative to competing firms, due to the heterogeneity of IT resources and skills (Barney 1991, Grant 1991, Mata, et al. 1995). Using matched sample methods, Bharadwaj compared the financial performance of 56 IT leading firms against a control group of non-leading firms between 1991 and 1994. The Information Week Data used to create the IT leading group was developed annually by a panel of experts, who identified and ranked firms according to how effective and efficient they are at using IT. The results indicate that distinct IT capabilities can enable superior financial performance, including an increase in profit ratios (ROA, return-on-sales) and a reduction in costs (costs of goods sold, total operating expense). However, contrary to Bharadwaj 's expectations, selling and administrative expenses appear to be higher in IT leading firms.

Devaraj and Kohli (2000) provide evidence of positive effect of ICT capital and labour on two important output performance measures in the health care industry (net patient revenue per day and net patient revenue per admission).

Gilchrist, Gurbaxani and Towne (2001) utilize CI data to examine the effect of ICT on the performance of manufacturing firms between 1987 and 1994; their analysis shows that ICT contribute to productivity, and this contribution is higher than what would be expected given the share of ICT capital in the overall capital investment; also they found that the contribution of decentralised computing (e.g. PC technology) is higher than the contribution of centralised computing (e.g. mainframe technology). In addition, after examining the influence of individual IT hardware

components, the authors found that the greatest impact appears to come from the application of PC technology rather than more centralized IT hardware like mainframe computers.

Devaraj and Kohli (2003) from a longitudinal study in hospitals conclude that the main driver of the impact of ICT on financial and non-financial performance is not the investment in technology, but the actual usage of technology. The positive evidence found in this second period concerning the impact of ICT investment on several measures of business performance reflects the improvements in ICT management, and also the adjustments and the restructuring that had taken place at the firm level between the mid 1980s and the mid 1990s, which enabled a higher level of value and benefits from ICT; also it reflects the significant improvements in research methodology (e.g. in data collection and analysis). However, even in this second period there are studies leading to conclusions in the opposite direction (e.g. Stiroh, 1998; Hartman, 2002), which indicate that there might be some additional variables that influence the effect of ICT on business performance, such as various characteristics of the sectoral and the national context of the firm, new organizational practices, re-engineering of business processes, new human skills, etc.

1.2.3 Third Period: ICT Investment Complements

In this direction during this second period considerable research has been conducted also in order to identify complementary actions and factors, which if combined with ICT investment, will maximise its contribution to business performance (usually referred to as 'ICT complements'). In this direction Black and Lynch (1997) examine the effect of ICT and new human resource management practices associated with total quality management, performance benchmarking and recruitment policies on productivity in USA manufacturing firms between 1987 and 1993. Their analysis indicates that these new human resource management practices make a positive contribution to productivity; also they found the investment in ICT and the usage of ICT by non-managers (e.g. workers) contribute positively to productivity. However, in this study the ICT investment and the above new human resource management practices are considered as separate independent variables, and their interaction and complementarity is not examined.

Francalanci & Galal (1998), based on data from insurance companies, examine the effect of ICT investment, employees composition and the interaction between them on firm productivity; they conclude that increase in ICT spending combined with changes in employees composition (more 'information and knowledge workers') results in higher overall productivity.

Devaraj and Kohli (2000) in their abovementioned study concluded also that the combination of ICT investment with business processes reengineering increases the positive effect on output.

Brynjolfsson, Hitt and Yang (2000) found that the combination of decentralisation practices (allocation of more decision authority, self managed teams, increase of worker responsibilities) with ICT has a disproportionately large positive effect on firm market value.

Tallon, Kraemer and Gurbaxani (2000), based on a survey of business executives, found that the strategic alignment of ICT investment with business strategy results in higher business value from the ICT investment; also they found that systematic post-implementation review and evaluation of the IS projects enhances the business value they generate.

Brynjolfsson and Hitt (2000) review existing evidence on how ICT investments are linked to higher productivity and organizational transformation and conclude that '..both case studies and econometric work point to organisational complements, such as new business processes, new skills and new organisational and industry structures as a major driver of the contribution of information technology. These complementary investments, and the resulting assets, may be as much as an order of magnitude larger than the investments in the computer technology itself'.

Ramirez (2003) investigated empirically the impact of ICT and three sets of organisational work practices: employee involvement, total quality management and reengineering; his results indicate that ICT is a key enabler of employee involvement and total quality management, and also that their combination with ICT contributes positively to the performance of firms.

Arvanitis (2005), based on data from Swiss firms, constructed three composite indices for ICT capital, new organisational practices and human capital respectively, and examined their impact on labour productivity and their complementarity. His results indicate that ICT capital, new organisational practices and human capital all contribute positively to labour productivity, and also provide evidence of complementarity between

ICT capital and human capital: the combined use of ICT and human capital results in additional labour productivity increase beyond the individual effects of these two factors.

Hempell (2005), based on firm-level panel data from services firms covering a five years' period, concluded that ICT investments are closely linked to complementary innovations and at the same time they are more productive in firms with experience in innovations.

Melville, Gurbaxani and Kraemer (2007) found that external environment factors also affect the productive impact of ICT capital. In particular, using data from publicly traded USA firms they found that the marginal product of ICT capital is lower in industries characterised by higher concentration, while the opposite happens with the traditional capital; also they did not find evidence that the marginal product of ICT capital is affected by the level of industry dynamism, but they found strong evidence that the marginal product of traditional capital is lower in industries with higher dynamism.

1.2.4 Fourth Period: Business value generated by particular types of IS

In addition to the above 'generic' firm level ICT business value research, during this second period, recently there is a growing research interest in investigating the business value generated by particular types of IS, such as e-business systems and Enterprise Resource Planning (ERP) systems.

One of the first studies, concerning the business value of e-business systems, was conducted by Zhu (2004), who grounded in the IT business-value literature and enhanced by the resource-based theory of the firm to develop a research framework in which both the main effects and the interaction effects of e-commerce and IT on firm performance were tested. Within this theoretical framework, he formulated several hypotheses. Then he developed a multidimensional e-commerce capability construct, and after establishing its validity and reliability, tested the hypotheses with empirical data from 114 companies in the retail industry. Controlling for variations of firm size and sub-industry effects, his empirical analysis found a strong positive interaction effect between IT infrastructure and e-commerce capability. This suggests that their complementarity positively contributes to firm performance in terms of sales per employee, inventory turnover, and cost reduction. The results are consistent with the resource-based theory,

and provide empirical evidence to the complementary synergy between front-end e-commerce capability and back-end IT infrastructure.

Zhu & Kramer (2005) grounded in the innovation diffusion literature and the resource-based theory to develop an integrative research model for assessing the diffusion and consequence of e-business at the firm level. Unlike the typical focus on adoption as found in the literature, they focused on post-adoption stages, that is, actual usage and value creation. The model thus moved beyond dichotomous "adoption versus non-adoption" and accounted for the "missing link"—actual usage—as a critical stage of value creation. The model linked technological, organizational, and environmental factors to e-business use and value, based on which a series of hypotheses are developed. The theoretical model was tested, by using structural equation modelling on a dataset of 624 firms across 10 countries in the retail industry. To probe deeper into whether e-business use and value are influenced by economic environments, two sub-samples from developed and developing countries are compared. The study found that technology competence, firm size, financial commitment, competitive pressure, and regulatory support are important antecedents of e-business use. In addition, the study found that, while both front-end and back-end capabilities contribute to e-business value, back-end integration has a much stronger impact. While front-end functionalities are becoming commodities, e-businesses are more differentiated by back-end integration. This is consistent with the resource-based theory because back-end integration possesses the value-creating characteristics of resources (e.g., firm specific, difficult to imitate), which are strengthened by the Internet-enabled connectivity.

Soto-Acosta and Merono-Cerdan (2008) developed a conceptual model, grounded in the resource-based theory, for assessing e-business value creation. This model posited three relationships: Internet resources and e-business value, Internet resources and e-business capabilities, and e-business capabilities and e-business value. To test hypotheses, a sample comprising 1010 Spanish firms was employed. The results show that, as hypothesized, Internet resources per se are not positively associated with e-business value. Furthermore, although Internet resources are not positively related to e-business value, they are found to play a critical role in creating e-business capabilities. In addition, the results confirm that e-business capabilities are key drivers of e-business value.

The main empirical studies that have been conducted, concerning the business value of the ERP systems, examine the impact of ERP adoption on various financial and non-financial measures of performance, most of them at the organization level. In the first of these studies Poston & Grabski (2001) examined the effect of ERP systems on firm performance over a 3-year period by comparing basic financial performance indices of 50 ERP adopters before ERP implementation and for three years after it. The results show a statistically significant decrease only in the ratio of cost of goods sold (COGS) to revenues three years after the ERP system implementation (but not in the first or second year after implementation). On the other hand they found no significant improvement in the ratio of selling, general and administrative expenses (SG&A) to revenues and also in the residual income. Also there was a significant reduction in the ratio of employees to revenues for each of the three years after the ERP implement. Hence, they suggested a contradiction: while ERP systems appear to yield efficiency gains in some areas, e.g. in reducing cost-to-revenue, they cause some increases elsewhere, so they leave residual income unaffected.

Hitt et al (2002) using multiyear multi-firm ERP implementation and financial data concluded that firms that invest in ERP tend to show higher business performance in several financial performance indices, though there is a slowdown in business performance and productivity shortly after the implementation. Concerning stock value they found that financial markets reward the adopters with higher market valuation as measured by Tobin's q. Another interesting conclusion is that higher level of ERP (i.e. implementation of more ERP modules) is associated with higher business performance, but only up to an optimal level, while exceeding this level results in declining benefits; this provides some evidences that the broadest ERP implementation faces diseconomies of scale.

Hunton et al (2003) examined the longitudinal impact of ERP adoption on firm performance by matching and comparing 62 firms that have adopted ERP systems with peers that had not adopted ERP systems. Results indicated that return on assets (ROA), return on investment (ROI), and asset turnover (ATO) were significantly better over a 3-year period for adopters as compared to the non-adopters. Also, they found that these significant differences arise because the financial performance decreased over time for the non – adopters, while it remained steady for the adopters. Another interesting finding of this study was a significant interaction between firm

size and financial health for ERP adopters with respect to ROA, ROI, and return on sales (ROS); in particular, a positive (negative) relationship was found between financial health and performance for small (large) firms.

In order to examine the effect of adoption of ERP systems on a firm's long-term financial performance Nicolaou (2004) compares financial data of 247 firms adopting ERP systems with a matched control group of firms before and after adoption. The results show that firms adopting enterprise systems exhibit higher differential financial performance (i.e. in comparison with 'similar' firms non-adopters) only after two years of continued ERP use, while in the year of completion and the following one there is negative differential impact (i.e. show lower financial performance than 'similar' firms non-adopters). Another interesting finding of this study is that implementing a system from a larger vendor, having system-led objectives, and implementing some particular types of modules increase the positive impact of ERP systems on financial performance in comparison to firms following a different implementation strategy.

Two years later, Nicolaou & Bhattacharya (2006) examined the effects of various types of ERP system changes (e.g. enhancements, upgrades, abandonments, switches) in firms that have previously adopted ERP systems on the impact of ERP on long-term financial performance. Two research hypotheses have been developed in this study, which posit that both the nature and the timing of system changes affect the extent of ERP post – implementation success. The empirical results provide support to these hypotheses: ERP-adopting firms, which initiate early enhancements in the form of either add-ons or upgrades, exhibit higher differential financial performance in comparison to other ERP-adopting firms' differential performance. These changes seem to resolve implementation problems, based on the experience gained during the first period of usage, so they affect positively the subsequent level of ERP success. On the contrary it was found that late enhancements and both early and late abandonments lead to differential performance deterioration in comparison to other ERP-adopting.

Hendricks et al. (2006) examined the effect of firms' investments in Enterprise Resource Planning (ERP), Supply Chain Management (SCM), and Customer Relationship Management (CRM) systems on long-term stock price performance and various profitability measures, such as return on assets and return on sales. Their results provide evidence that the adoption ERP systems leads to significant improvements in the profitability, which are

stronger in the case of early adopters of ERP systems, but not in the stock returns. Also, the adopters of SCM systems experience positive stock returns as well as improvements in profitability. On the contrary, there was no evidence of improvements in stock returns or profitability for firms that have invested in CRM.

1.3 Motivation

Taking into account the above literature review on ICT business value, one of the most important research topics in the IS domain, the motivations in this research are the following:

- The above research has focused on the *'hard'* ICT investment, namely on the investment in ICT hardware, software and networks, while the effect of the *'soft'* ICT investment, defined as the investment in ICT human resources, skills and organization, on business performance has been researched to a very limited extent; so the effect of this 'soft complement' of the 'hard' ICT investment on business performance remains unexplored, even though the relevant literature has emphasized its importance for the effective exploitation and use of the 'hard' ICT investment in accordance with the needs and the strategy of the particular firm (e.g. Stratopoulos & Dehning, 2000; Melville, Kraemer & Gurbaxani, 2004). Therefore, further research is required concerning the effect of the 'soft' ICT investment on business performance, which has received limited research attention as mentioned above; this 'soft' ICT investment is often neglected by the Greek firms (Sirigos, 2001) and we believe that this might happen also in other similar national contexts.
- The research conducted on the impact of ICT investment on business performance has concluded that the magnitude of the business value ICT generate for an organization is affected to a large extent by a number of 'internal factors', which are related to the internal functions of the organization, such as new work practices, new business processes, new human skills, innovation, new IS management structures, etc. (e.g. Brynjolfsson, Hitt and Yang 2000, Ramirez 2003, Arvanitis 2003 and 2005, Hempell 2005). However, limited research has been conducted on the effect of *'external' factors*, which are related to the external environment of the organization, on the

business value generated by its ICT investment. Therefore, it is necessary to investigate the effect of external factors as well on the business value generated by ICT, in order to find out whether there are external conditions resulting to systematically higher or lower ICT business value, and also to understand the underlying reasons, so that organizations can take them into account in planning their ICT investment.

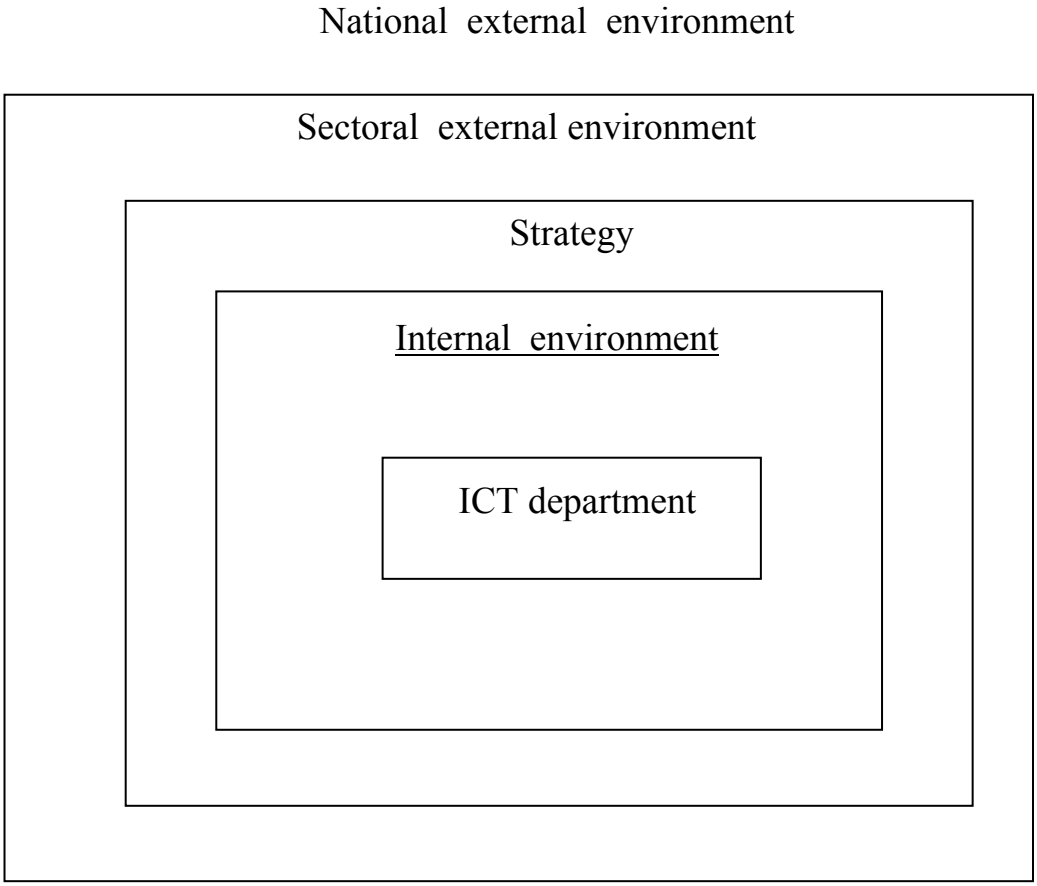
- Previous research has adressed to some extent the impact of *ICT strategic alignment* on business performance. However, most of the relatively few empirical studies that have been conducted about the contribution of strategic alignment to some measures/dimensions of business performance, are based on managers' subjective perceptions of business performance or contribution of IS to business performance, as dependent variables, and not on objective measures of them; only one of these studies (Byrd et al, 2006) is based on objective measures of business performance and ICT contribution to it, though using partial models. Another characteristic of these previous studies is that they focus on ICT strategic alignment only in the formulation of strategy at the executive level, though the relevant literature has repeatedly and consistently underlined the need of extending ICT strategic alignment throughout the hierarchy, so that it covers the middle and the lower hierarchical levels, and also the whole strategy lifecycle, including both formulation and implementation phases (e.g. Chan and Huff 1992, Luftman et all 1999, Luftman 2000, Allen and Wilson 2003, Rantham et al 2004, Campbell et al 2005, Bleistein et al 2006a, Bleistein et al 2006b, Gutierrez et all 2006). Therefore, it is necessary to investigate the effect of different mechanisms of strategic alignment, which concern different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by ICT investment.
- Previous research on the impact of ICT capital on firm performance, has produced some first evidence that the contribution of ICT investments can increase significantly if they are combined with human capital and new organizational practices (e.g. Devaraj and Kohli 2000, Brynjolfsson and Hitt 2000). However, between the conclusions of these studies there are some similarities, but also several differences as well, which might be (at least to some extent)

due to differences in sample composition (the samples of these studies are from different sectors and industries), in national context (different countries), in variables and models specification and also in the nature of the investigations (cross-sectional versus longitudinal). Therefore, further empirical research is required concerning the impact of ICT capital, human capital, new organizational practices on firm performance. More empirical studies need to be conducted, covering different sectors and industries (in order to understand better the effect of sector and industry characteristics on the above impacts), and also several different national contexts, including not only highly developed countries but also less developed countries as well (in order to understand better the effect of national context on the above impacts). Also, comparative studies, based on common variables and models, and also samples of similar composition, are required.

Most of the previous research on the effect of ICT investment on business performance has been based mainly on empirical studies conducted in the context of a few countries, which are characterised by high levels of economic development and ICT penetration, although OECD warns that the impact of ICT investment can differ significantly across countries (OECD, 2003; OECD, 2004). Therefore, it is necessary to investigate the above research questions also in contexts of other countries, which are characterised by different levels of economic development, ICT diffusion and ICT skills, different sizes of firms and different regulatory frameworks and business culture. In particular, it is quite interesting to study the abovementioned research issues in Greece, given its significant differences from the highly developed countries in which most of the empirical studies on this subject have been conducted. Greece does not belong to the highly developed countries, though it has made considerable economic progress in the last decade and has become a full member of the European Economic and Monetary Union. It is characterised by smaller size of internal market, smaller average firm size and lower level of ICT diffusion; according to the European Information Technology Observatory (EITO – www.eito.gr) the per capita ICT expenditure in Greece during 2003 was 689 Euro, while in the highly developed countries it was much higher, e.g. in USA it was 2430 Euro, in Sweden it was 2369 Euro, etc.

1.4 Research Scope and Objectives

This dissertation aims to expand knowledge on ICT business value and factors affecting it. As described in the previous research has focused on the effect of internal environment factors on ICT business value, so we aim to investigate the effect on ICT business value of other types of factors, which have not been studied before: i) factors associated with the ICT department (soft ICT investment in ICT structures, personnel and skills), ii) factors associated with strategy (ICT strategic alignment and business strategy), iii) factors associated with the sectoral external environment (generalised competition), and iv) factors associated with the national external environment. These basic directions of the present dissertation are visualized below.



In particular, the basic objectives of this dissertation are the following:

- To investigate and compare the effect of hard ICT investment (i.e. investment in ICT hardware, software and networks) on business performance, and soft ICT investment (i.e. investment in ICT

structures, human resources and skills) on business value of ICT technologies.

- To examine the effect of strategy and external environment on the impact of ICT investment on business value.
- To analyse the effect of different mechanisms of strategic alignment on business ICT value.
- To compare the effect of ICT capital, human capital, organizational capital (i.e. new organizational practices) and knowledge capital on labour productivity in Greece and Switzerland, based on similar samples, variables and research models, and therefore to draw some conclusions on the effect of the national external contaxt on the productive impact of these 'new' types of capital.

The above research allows us to improve ICT investment decision-making and management. In particular, the knowledge gained from it will allow managers to take into account the complementarity between the ICT investments and the above factors, and also the potential impacts generated from their coordinated adoption, in order to increase the business value generated for their firms from their ICT investment.

1.5 Methodology and Data

1.5.1 Methodology

As mentioned above, the first objective of this thesis is to examine the effect of hard ICT investment (i.e. investment in ICT hardware, software and networks) on business performance in the Greek industry. The firm output has been selected as the basic business performance measure and dependent variable. This measure is directly related to the production function: the production function (F) relates the firm output (Q) to firm inputs X_i i, 1,..,n: $Q=F(X_1, X_2,...,X_n)$ (Nicholson, 2004). In most empirical studies, including those of the published literature on the productive impact of ICT investments, the specification of the production function that has been used is that of the so-called Cobb-Douglas form (e.g. Linchtenberg, 1995; Brynjolfsson and Hitt, 1996; Gurbaxani, Melville and Kraemer, 1998):

$$Q = A \cdot X_1^{\alpha_1} \cdot X_2^{\alpha_2} \cdot ..... \cdot X_n^{\alpha_n} \qquad (1)$$

This form of the production function has certain advantages; for example it is homogeneous and also it is linear, for constant returns to scale (i.e. if

$\alpha_1+\alpha_2+.....+\alpha_n=1$). In its simplest version for n=2, X_1 = capital (C), and X_2 = labour (L). However, as far as microeconomics is concerned, with such a specification, there are certain limitations:

(i) the marginal products ($\frac{\partial Q}{\partial X_i}$) fall from the beginning;

(ii) the elasticities are necessarily constant;

(iii) the elasticities of substitution between X_i, X_j are constant and equal to 1.

For these reasons we also investigated whether a more general form of a production function would be more appropriate for addressing the above research questions in the Greek national context, fitting better to our data than the Cobb-Douglas production function. Among the several generalizations of the Cobb-Douglas form (see for instance Intriligator et al, 1995) we selected to examine the so-called Transcendental production function (TPF), which has more practical application in other types of studies than the other generalizations. For the case of the two basic inputs, labour and capital, the transcendental production function is defined as follows:

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{(\alpha_3 L + \alpha_4 K)} \qquad (2)$$

where X_1 = labour (L) and X_2 = capital (K).

In order to avoid problems associated with non-linear estimation, we assume that the stochastic disturbances enter into the Cobb Douglass and the Transcendental production function equations in the following way:

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{u_1} \qquad (1')$$

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{(\alpha_3 L + \alpha_4 K)} e^{u_2} \qquad (2')$$

with u_1, u_2 obeying the conditions of the Gauss-Markov theorem. Then log-transforming (1') and (2') we have:

$$log(Q) = log(A) + \alpha_1 log(L) + \alpha_2 log(K) + u_1 \qquad (1'')$$

$$log(Q) = log(A) + \alpha_1 log(L) + \alpha_2 log(K) + \alpha_3 L + \alpha_4 K + u_2 \qquad (2'')$$

These equations are both linear and can be estimated by Ordinary Least Squares (OLS).

In this thesis, the capital input is broken down into two components: one related exclusively to ICT, referred to as computer capital (CK), and one for

the rest of the capital input, referred to as non-computer capital or simply capital (K). Such a separation has been successfully used in the past in many relevant studies of the business impact of ICT investments on firm output (e.g. see Brynjolfsson & Hitt 1996, OECD 2003, OECD 2004, Melville, Kraemer & Gurbaxani 2004).

The above model, and in general all the econometric models to be estimated in this study, will be single equation linear models of the form: $\vec{Y} = X\vec{\beta} + \vec{U}$ where $\vec{Y}$ is a (NX1) vector of the observations of the dependent variable, X is a (NXK) matrix of the observations of the independent variables, $\vec{\beta}$ is a (KX1) vector of model parameters and $\vec{U}$ is a (NX1) vector of stochastic disturbances.

In this framework the null of any test of hypothesis to be performed in this study regarding $\vec{\beta}$ may be stated in the following way:

$$H_0: R\vec{\beta} = \vec{r} \qquad (3)$$

where **R** is a (qXK) matrix of known constants (with q<K), which are related to the character of the linear equations hypothesized between the model parameters (usually referred to as 'linear restrictions'), $\vec{r}$ is a (qX1) vector of known constants, and $\vec{\beta}$ is the (KX1) vector of model parameters. For the purposes of this work the test statistic used for H_0: $R\vec{\beta} = \vec{r}$ is the one proposed by the relevant econometric literature (Johnston and Dinardo, 1997; Gujarati, 2003):

$$F = \frac{\dfrac{(\hat{U}_R'\hat{U}_R - \hat{U}_{UR}'\hat{U}_{UR})}{q}}{\dfrac{\hat{U}_{UR}'\hat{U}_{UR}}{(N-K)}} \qquad (4)$$

where $\hat{U}_{UR}$, $\hat{U}_R$ are the observed residuals of the so-called unrestricted regression model (i.e. the initial regression model without any linear restrictions) and restricted regression model (i.e. the regression model with the linear restrictions, the validity of which is to be tested) respectively, q is the number of linear restrictions, K is the number of estimated parameters in the unrestricted model and primes denote transposition. This statistic follows the F distribution with q,(N-K) degrees of freedom. The above

statistic can be equivalently expressed in terms of the corresponding coefficients of determination (R^2_{UR} and R^2_R respectively) as:

$$F=[(R^2_{UR}-R^2_R)/q]/[(1-R^2_{UR})/(N-K)] \qquad (5)$$

Within this framework we can test any linear restrictions between the model parameters, including the particular form of the production function (i.e. Cobb-Douglas or transcendental).

1.5.2 Data

The dataset created for this dissertation has two sources. *The first data source*, we used in our preliminary study was a survey we conducted among Greek industrial firms in cooperation with the Federation of Greek Industries (FGI) (http://www.sev.org.gr/online/index.aspx). For this purpose a survey questionnaire was designed, which, amongst others, included questions concerning the yearly sales revenue, the computer capital (including hardware, software and networks), the non-computer capital and the yearly labour expenses of the firm; also it included questions about the soft ICT investment: the existence or not of a separate ICT department in the firm, the number of ICT employees and the extent of ICT training provided to the users. The FGI selected the 250 biggest firms from various sectors among its members, sent to them by mail the above questionnaire accompanied by a cover letter explaining them the objectives of this survey, and then contacted them by phone in order to inform them orally about the survey. The recipients were asked to fill in the questionnaire and return it by fax or mail within one month. After one month all the recipients were contacted by phone once again who had not responded. Finally were received filled questionnaires from 137 firms, so the response rate was 54.8%. The respondents were big firms for the Greek context: their average sales revenue for the year 2002 was *about* € 68 million, ranking between € 10 thousands and € 1.5 billion, however they were much smaller than the big firms that most studies on this subject (e.g. in U.S.A. or other highly developed countries) were based on. In order to examine whether there is non-response bias we compared variables' means of the early respondents with the ones of the late respondents; this approach is a good alternative to the desirable approach of gathering data from a random sample of non-respondents and comparing them with the corresponding data provided by the respondents through the questionnaires they filled, since the latter approach is very often not feasible (Chapman, 1992; Dooley & Linder,

2003). No statistically significant differences have been found between the early and the late respondents concerning the means of all the variables used in this study, we can conclude that non-response bias does not exist.

The second data source, we used in the second part in our research was a survey we conducted among Greek companies, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', in cooperation with ICAP, one of the largest business information and consulting companies of Greece. This survey was based on a structured questionnaire, which pre-tested by three experts highly experienced in such surveys and questionnaires, from ICAP, and also by two postgraduate students from the University of Aegean with experience in information systems research. Based on their remarks the final version of the questionnaire was developed, which included questions about the basic financial data of the company for the year 2004 (sales revenue, expenses for materials and services, labour expenses, value of capital, value of computer capital, etc.), and also questions about innovative activity, new forms of work organization, new forms of human resources management, redesign of processes and organizational practices, quality, usage of various kinds of IS and IS management practices and processes. Three samples of 300 Greek firms each were randomly selected from the database of ICAP (all these three samples included firms from the same industries and sizes), which includes financial and other business information for approximately 135,000 Greek firms, and consisted of 304 Greek companies from the 27 most important sectors of Greek economy; there was equal representation in the sample of the small, the medium and the large companies (according to the relevant definitions of the European Union): in particular, 103 of these companies were small (with more than 10 and less than 50 employees), 103 were medium (with more than or equal to 50 and less than 250 employees) and 98 were large (with more than or equal to 250 employees). Initially the questionnaire was sent by post to the firms of the first sample; after three weeks the firms who had not responded were contacted by phone. Firms that definitely refused to participate in this survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample, while in a few cases that exhausted the firms of the second sample we had to proceed to the third sample. Following the above procedure, which aimed to maintain the proportions of the industry and size classes, we received answered questionnaires from 281 companies (99 small, 98 medium and 84 large ones), so the response rate was 92.4%; their average number of

employees is 493 and their average sales revenue in 2004 was 183.7 million Euro. In general there are big difficulties in collecting such data, because many companies regard them as confidential. In Table 1 we can see the structure of the final data set we used by industry and firm size class.

Table 1: Composition of the data sets by industries and firm size classes

	N	Percentage
Industry:		
Food, beverage	25	8,9
Textiles	6	2,1
Clothing, leather	7	2,5
Wood processing	3	1,1
Paper	3	1,1
Printing	12	4,3
Chemicals	12	4,3
Plastics, rubber	6	2,1
Glass, stone, clay	9	3,2
Metal	6	2,1
Metal working	7	2,5
Machinery	1	,4
Electrical machinery	2	,7
Electronics, instruments	3	1,1
Vehicles	3	1,1
Other manufacturing	5	1,8
Energy	3	1,1
Construction	14	5,0
Wholesale trade	56	19,9
Retail trade	21	7,5
Hotels, catering	27	9,6
Transport, Telecommunication	15	5,3
Banks, insurances	6	2,1
Real estate, leasing	2	,7
Business services	17	6,0
Personal services	10	3,5
Firm size:		
20-49 employees	99	35,2
50-249 employees	98	34,9
250 employees and more	84	29,9
Total	281	100.0

1.6 Contribution

This dissertation makes the following contributions to ICT business value research:

- It examines empirically the effect on business performance not only of the 'hard' ICT investment, but also of the *'soft'* ICT investment as well, which has received limited research attention as mentioned above; this 'soft' ICT investment is often neglected by the Greek firms (Sirigos, 2001) and we believe that this might happen also in other similar national contexts (at least to some extent). Also it is interesting that it is the first time that a comparison is made between the effects of these two types of ICT investment (hard and soft) on business performance, and also with the effects of the two 'basic' production inputs: the labour and the 'non-ICT' investment ("traditional" assets).
- A second contribution is the empirical investigation of the effect of two external environment related factors, the 'generalized' competition an organization faces, as it is conceptualised by the well established 'Five Forces Framework' of M. Porter (Porter 1980), and the strategies an organization follows in response to its external environment, on the business value generated by its ICT investment.
- Third, we have examined the impact of ICT strategic alignment on business performance, through an empirical study of the effect of different mechanisms of strategic alignment, which concern different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by ICT investment.
- Fourth, we have conducted a cross-national comparative study, based on firm-level data in order to examine the effect of ICT capital, human capital and new organizational practices on labour productivity in Greece and Switzerland, and also the impact of national contexts on the above relations.
- Fifth, it is the first study of the effect of ICT investments on business performance in Greece. This is quite interesting taking into account the differences of Greece from the highly developed countries in which most of the empirical studies on this subject have been conducted. Greece does not belong to the highly developed countries,

though it has made considerable economic progress in the last decade and has become a member of the European Economic and Monetary Union. It is characterised by smaller size of internal market, different culture, smaller firm size, and lower level of ICT penetration and Internet usage. However, the findings of this research are interesting not only for Greece, but also for many other countries, which are not highly developed and have similar characteristics.

- Sixth, through a questionnaire-based survey among Greek firms, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', in cooperation with ICAP (one of the largest business information and consulting companies of Greece) we created a unique research dataset. It includes data from 280 Greek firms concerning business performance, ICT investment ('hard' and 'soft'), non-ICT investment, labour employment, adoption of new organisational forms, strategic alignment and innovation. No similar database combining these data components exists in Greece. Our data allow the empirical investigation of many critical research questions concerning ICT business value.

- Another contribution of this dissertation is that it investigates which is the most appropriate form of production function to be used as a basis for addressing the above research questions in the Greek national context. While most of the previous relevant research has been based on production functions of the so-called "Cobb-Douglas" form, in this study we investigate whether a more general "Transcendental" production function would be more appropriate; this issue has never been examined in the previous relevant research. Finally, it examines for first time in such studies the effect of the firm size on the structural stability of the constructed econometric models, and therefore on the validity of the conclusions drawn from them, using a method based on the 'recursive residuals'.

Based on the results and contributions of this dissertation the following publications have been produced:

Journal papers

- Loukis, E., Sapounas, I. and Milionis, A. (2009), "The effect of hard and soft information and communication technologies investment on

manufacturing business performance in Greece - A preliminary econometric study", Telematics and Informatics, 26(2), pp.193-210.

- Loukis, E., Sapounas, I., Aivalis, K. (2008), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", Journal of Enterprise Information Management, 21 (1), pp. 24-38.

Research book chapters

- Loukis, E. Sapounas, I. and Aivalis, K. (2009), "Enterprise Systems Strategic Alignment and Business Value", chapter in: Handbook of Research on Enterprise Systems, Idea Group Inc, pp. 152-168.

Conference papers

- Loukis, E., Sapounas, I. (2005), "The Impact of Information Systems Investment and Management on Business Performance in Greece", in the Proceedings of 13th European Conference on Information Systems (ECIS 2005), Regensburg, Germany, May 26-28.

- Loukis, E., Sapounas, I., Aivalis, K. (2006), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", in the Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS 2006), Alikante, Spain, July 6-7.

- Sapounas, I., Loukis, E., Milionis, A. (2007), "The Effect of Information Systems Investment and Management on Manufacturing Business Performance in Greece. A preliminary econometric study", in the Proceedings of the 4th International Conference in Applied Financial Economics (QASS 2007), Samos, Greece, July 12-14.

CHAPTER 2:

THE EFFECT OF HARD AND SOFT INFORMATION AND COMMUNICATION TECHNOLOGIES INVESTMENT ON BUSINESS PERFORMANCE IN GREECE

2.1 Review of previous relevant research

As mentioned in the 'Literature Review', significant investments have been made by businesses in ICT in the last 25 years (OECD, 2003; OECD, 2004), so it is of critical importance to investigate the benefits and the value they create and their effect on business performance. For this reason extensive research has been conducted in order to investigate the relation between ICT investment and business performance. One important gap of this research is that it has focused on the 'hard' ICT investment, namely on the investment in ICT hardware, software and networks; limited research has been conducted on the effect of the 'soft' ICT investment, defined as the investment in ICT human resources, skills and organization, on business performance, although it has been recognised in the relevant literature as an important 'soft complement' of the 'hard' ICT investment, which enables its effective exploitation and use in accordance with the needs and the strategy of the particular firm. The abovementioned study of Brynjolfsson and Hitt (1996) examined directly the effect of one of the dimensions of the soft ICT investment, the ICT labour, on business performance; in their econometric models they included one ICT labour term and found that it has a positive statistically significant effect on the output and its marginal product is higher that the one of the non-ICT labour.

Stratopoulos and Dehning (2000) dealt indirectly with the effect of some perspectives of the soft ICT investment on financial performance. From an empirical investigation using a matched pair approach they concluded that it is not only the ICT investment, but it is the 'successful' use and management of ICT inputs that improves financial performance. They reached this conclusion by comparing several measures of financial performance of 100 companies, which have been selected as being 'successful users' of ICT based on four criteria-dimensions (percentage of revenue spent on ICT, suitability of IS for meeting business needs, evaluation of effectiveness of ICT use and profitability growth rate, with the

financial performances of 100 similar companies, which are 'less successful users' of ICT; however, they do not examine separately the effect of each of the above four criteria-dimensions (and especially of each of the two criteria-dimensions which are associated with the soft ICT investment: the 'evaluation of effectiveness of ICT use' and the 'suitability of IS for meeting business needs') on financial performance.

Bharadwaj (2000) also dealt indirectly with the effect of some perspectives of the soft ICT investment on a variety of profit and cost-based performance measures. Adopting a resource-based perspective and using a matched pair approach, he found that superior 'ICT resources', which consist of 'ICT physical infrastructure', 'human ICT resources' (technical and managerial ICT skills) and 'ICT-enabled intangibles' (knowledge assets, customer orientation, synergy between organizational divisions), result in superior performance in these performance measures; however, he does not examine the effect of each of these three components of the 'ICT resources' of a firm (e.g. of the 'human ICT resources') separately on business performance. Therefore further research is required concerning the effect of both the 'hard' investment and the 'soft' ICT investment (appropriately measured, so that all its dimensions are taken into account) on business performance, based on theoretically sound and complete models. From a quantitative study conducted in the Greek industry it has been found that this soft dimension of ICT investment is often neglected by the Greek industrial firms (Sirigos, 2001), and we believe that this might happen, at least to some extent, also in other similar national contexts.

Most of the research on the effect of ICT investment on business performance in both these periods has been based mainly on empirical studies conducted in the context of a few countries, which are characterised by high levels of economic development and ICT penetration, and also on data from large firms; so the conclusions of this research are conditional on the characteristics of these particular national contexts, as mentioned in 'Introduction'. OECD warns that the impact of ICT investment can differ significantly across countries, due to differences in 'the regulatory framework, the availability of appropriate skills, the ability to change organisational set-ups as well as the strength of accompanying innovations in ICT applications' (OECD, 2003).

Also in a more recent report of OECD on the same subject it is argued that 'ICT is a network technology; the more people and firms that use the

network, the more benefits it generates', therefore, taking into account that a few highly developed countries have the highest rates of ICT uptake, 'it is likely that the largest economic impacts of ICT should also be found in these countries' (OECD, 2004). Therefore it is necessary to investigate the effect of ICT investment on business performance also in other national contexts of countries, which are characterised by different levels of economic development, ICT diffusion and ICT skills, and also by different sizes of firms, legal frameworks and business culture.

2.2 Research hypotheses, method and data

Taking into account the above research gaps, the first objective of this part of our study is to examine the effect of hard ICT investment (i.e. investment in ICT hardware, software and networks) on business performance in the Greek industry. The firm output (total sales revenue) has been selected as the basic business performance measure and dependent variable. This measure is directly related to the production function: the production function (F) relates the firm output (Q) to firm inputs X_i i, 1,..,n: $Q=F(X_1, X_2,...,X_n)$ (Nicholson, 2004). In most empirical studies, including those of the published literature on the productive impact of ICT investments, the specification of the production function that has been used is that of the so-called Cobb-Douglas form (e.g. Linchtenberg, 1995; Brynjolfsson and Hitt, 1996; Gurbaxani, Melville and Kraemer, 1998):

$$Q = A \cdot X_1^{\alpha_1} \cdot X_2^{\alpha_2} \cdot ..... \cdot X_n^{\alpha_n} \qquad (1)$$

This form of the production function has certain advantages; for example it is homogeneous and also it is linear, for constant returns to scale (i.e. if $\alpha_1+\alpha_2+.....+\alpha_n=1$). In its simplest version for n=2, X_1 = capital (C), and X_2 = labour (L). However, as far as microeconomics is concerned, with such a specification, there are certain limitations:

(iv) the marginal products ($\frac{\partial Q}{\partial X_i}$) fall from the beginning;

(v) the elasticities are necessarily constant;

(vi) the elasticities of substitution between X_i, X_j are constant and equal to 1.

For these reasons it is useful to investigate whether a more general form of a production function would be more appropriate for addressing the above research questions in the Greek national context, fitting better to our data than the Cobb-Douglas production function. Among the several generalizations of the Cobb-Douglas form (see for instance Intriligator et al, 1995) we selected to examine the so-called transcendental production function (TPF), which has more practical application in other types of studies than the other generalizations. For the case of the two basic inputs, labour and capital, the transcendental production function is defined as follows:

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{(\alpha_3 L + \alpha_4 K)} \qquad (2)$$

where X_1 = labour (L) and X_2 = capital (K).

Therefore we tested the following null hypotheses:

$H_0^{(1)}$: The function relating the output to the factors of production is of the Cobb-Douglas form, against the specific alternative of the transcendental form.

$H_0^{(2)}$: ICT hard investment makes no contribution to firm output.

In order to avoid problems associated with non-linear estimation, we assume that the stochastic disturbances enter into the Cobb Douglas and the transcendental production function equations in the following way:

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{u_1} \qquad (1')$$

$$Q = A \cdot L^{\alpha_1} \cdot K^{\alpha_2} e^{(\alpha_3 L + \alpha_4 K)} e^{u_2} \qquad (2')$$

with u_1, u_2 obeying the conditions of the Gauss-Markov theorem. Then log-transforming (1') and (2') we have:

$$log(Q) = log(A) + \alpha_1 log(L) + \alpha_2 log(K) + u_1 \qquad (1'')$$

$$log(Q) = log(A) + \alpha_1 log(L) + \alpha_2 log(K) + \alpha_3 L + \alpha_4 K + u_2 \qquad (2'')$$

These equations are both linear and can be estimated by Ordinary Least Squares (OLS).

In this study, the capital input is broken down into two components: one related exclusively to ICT, referred to as computer capital (CK), and one for the rest of the capital input, referred to as non-computer capital or simply capital (K). Such a separation has been successfully used in the past in many relevant studies of the business impact of ICT investments on firm output

(e.g. see Brynjolfsson & Hitt 1996, OECD 2003, OECD 2004, Melville, Kraemer & Gurbaxani 2004).

The above model, and in general all the econometric models to be estimated in this study, will be single equation linear models of the form: $\vec{Y} = X\vec{\beta} + \vec{U}$ where $\vec{Y}$ is a (NX1) vector of the observations of the dependent variable, X is a (NXK) matrix of the observations of the independent variables, $\vec{\beta}$ is a (KX1) vector of model parameters and $\vec{U}$ is a (NX1) vector of stochastic disturbances.

In this framework the null of any test of hypothesis to be performed in this study regarding $\vec{\beta}$ may be stated in the following way:

$$H_0: \; R\vec{\beta} = \vec{r} \qquad (3)$$

where **R** is a (qXK) matrix of known constants (with q<K), which are related to the character of the linear equations hypothesized between the model parameters (usually referred to as 'linear restrictions'), $\vec{r}$ is a (qX1) vector of known constants, and $\vec{\beta}$ is the (KX1) vector of model parameters. For the purposes of this work the test statistic used for H_0: $R\vec{\beta} = \vec{r}$ is the one proposed by the relevant econometric literature (Johnston and Dinardo, 1997; Gujarati, 2003):

$$F = \frac{\dfrac{(\hat{U}_R'\hat{U}_R - \hat{U}_{UR}'\hat{U}_{UR})}{q}}{\dfrac{\hat{U}_{UR}'\hat{U}_{UR}}{(N-K)}} \qquad (4)$$

where $\hat{U}_{UR}$, $\hat{U}_R$ are the observed residuals of the so-called unrestricted regression model (i.e. the initial regression model without any linear restrictions) and restricted regression model (i.e. the regression model with the linear restrictions, the validity of which is to be tested) respectively, q is the number of linear restrictions, K is the number of estimated parameters in the unrestricted model and primes denote transposition. This statistic follows the F distribution with q,(N-K) degrees of freedom. The above statistic can be equivalently expressed in terms of the corresponding coefficients of determination (R^2_{UR} and R^2_R respectively) as:

$$F=[(R^2_{UR}-R^2_R)/q]/[(1-R^2_{UR})/(N-K)] \qquad (5)$$

Within this framework we can test any linear restrictions between the model parameters, including the particular form of the production function (i.e. Cobb-Douglas or transcendental).

Another objective of this thesis is to examine whether the 'soft ICT investment' in ICT human resources, skills and organization makes a positive contribution to the firm output, and to compare this contribution with the ones of the hard ICT investment, the labour and the 'non-ICT' investment. The soft ICT investment constitutes a very important complement of the hard ICT investment. It enables the formulation of the optimal composition of the hard ICT investment, namely the definition of the appropriate IS that should be developed, and also of the exact technical and functional requirements they should fulfil, based on the needs and the strategy of the particular firm, so that the value that will be generated by them for the firm will be maximized. Also it enables a better monitoring and management of the corresponding development projects, so that higher quality IS can be developed through them, and more benefits can be generated for the firm. Finally it enables a more efficient use and management of these IS once they have become operational.

Moreover, the soft ICT investment is vital for designing and implementing the appropriate firm-specific ICT-based process and product innovations, and also the complementary 'co-investments', mentioned above in 2.3, in creating new organizational practices and human skills, re-engineering business processes, etc., which enable a higher degree of exploitation of the capabilities and the potential of ICT, and finally a higher level of business value from the hard ICT investment. Furthermore, since ICT hardware, packaged software and networks are available to competitors as well, they cannot provide a sustainable competitive advantage; it is only their combination with other resources and capabilities of the firm that can result in more sustainable competitive advantages, which necessitates both hard and soft ICT investments.

In this direction, Powell and Dent-Micallef (1997) from an empirical study in the retail industry found that ICT alone cannot provide sustainable performance advantages, but such advantages can be gained only by using ICT for leveraging intangible, complementary human and business resources of the firm.

Also Mata et al (1995), adopting a resource-based view of the firm, examine four basic attributes of ICT in a firm as to whether they can provide a

sustainable competitive advantage: proprietary technologies, capital requirements, technical ICT skills and managerial ICT skills; they conclude that only the managerial ICT skills (defined as the ability of ICT management to understand the business needs of other functional units, customers and suppliers, and in cooperation with them to develop IS that cover these needs) can provide sustainable competitive advantage. For the above reasons the soft ICT investment is necessary for achieving a high level of benefits from the hard ICT investment, so we expect that it is likely to make a positive contribution to the firm output.

The soft ICT investment is by nature multidimensional, so it is highly important to define an appropriate framework for operationalizing and measuring it. After a review of the relevant literature we selected for this purpose the one of the well-established and widely cited Galliers's model of the 'stages of ICT growth' (Galliers & Sutherland, 1991), which has been extensively used, both in research and consulting, for the multidimensional assessment of the level of growth and maturity of an organization with respect to the use and management of ICT. For this purpose it uses 7 basic criteria-dimensions, usually referred to as the '7 s': strategy (=plan of related actions), (organizational) structure, systems (=formal and informal procedures), staff, skills, style (= culture and behaviour) and superordinate goals.

In this preliminary study we have focused on three of these dimensions, which we regard as the most important components of the soft investment of a firm in ICT: ICT structure, ICT staff and ICT skills. For measuring these three dimensions we formulated the corresponding three variables: i) the existence (or not) of a separate ICT department in the firm, which does not belong to any of the other departments of the firm (e.g. to the sales or the financial depertment) (ICT-DEP: binary variable measuring ICT structure), ii) the number of ICT employees (ICT-EMPL: integer variable measuring the ICT staff of the firm) and iii) the extent of ICT training provided to the users (ICT-TR: ordinal variable measuring the extent of ICT training provided to the employees of the firm who use its IS in a scale 1 to 5).

Therefore we tested the following null hypotheses:

$H_0^{(3)}$: The existence of a separate ICT department in the firm makes no contribution to firm output.

$H_0^{(4)}$: The number of ICT employees of the firm makes no contribution to firm output.

$H_0^{(5)}$: The extent of ICT training provided to the users makes no contribution to firm output.

Also we examined whether there is complementarity between the hard ICT investment and each of the above three measures of the soft ICT investment with respect to firm output; in this direction we tested the following hypotheses:

$H_0^{(6)}$: there is no complementarity between the hard ICT capital and the existence of a separate ICT department with respect to firm output.

$H_0^{(7)}$: there is no complementarity between the hard ICT capital and the number of ICT employees with respect to firm output.

$H_0^{(8)}$: there is no complementarity between the hard ICT capital and the extent of ICT training provided to the users with respect to firm output.

For testing hypotheses $H_0^{(3)}$- $H_0^{(8)}$ the econometric model shown in equation (8) of the next section 4 has been estimated, which includes a number of additional independent variables that correspond to the above three measures of soft ICT investment and also product terms of complementarity between them and the computer capital.

Finally another issue that has been examined in this study is the possible effect of the firm size on the structural stability of the constructed econometric models and therefore on the validity of the conclusions drawn from them. To this end initially the data have been sorted according to firm size (based on sales revenue) and then the so-called 'recursive residuals' (i.e. the one step ahead prediction errors) e_i, i = 1..N, where N = the number of items of the sample, as well as their corresponding standard errors have been estimated.

In particular, each recursive residual e_i has been estimated as the difference between the predicted value of the dependent variable of the i-th item of the sample, based on the econometric model that has been estimated from the previous i-1 items, minus the corresponding observed value of the dependent variable of this i-th item. The above resursive residuals are plotted together with the lines indicating their 95% confidence intervals, which correspond to plus and minus twice their recursively estimated standard errors. Residuals that lay outside these two standard error bands are indicative of structural instability.

Such instabilities can be further investigated by estimating resursively the model parameters and their confidence intervals. In this way a sequence of the vectors of the estimated parameters can be created. Then a visual inspection of a plot showing the evolution of each model parameter together with the corresponding confidence interval (i.e. estimated value plus/minus two standard errors lines) can reveal cases of parameter instability separately for each parameter of the model. In the plot, such instabilities will be reflected by vertical 'movements' to a level outside previous confidence bounds. Within the framework stated above, which is described in more detail in by Johnston and Dinardo (1997), we tested the following null hypothesis:

$H_0^{(9)}$: Firm size does not affect the structural stability of the constructed econometric models.

Since the data required for constructing the abovementioned econometric models were not available in Greece (mainly concerning the hard and soft ICT investment of Greek firms), we collected for first time in Greece such a dataset, through a survey among Greek industrial firms in cooperation with the Federation of Greek Industries (FGI). As we mentioned in the 'Introduction', a survey questionnaire (Appendix A) was designed and sent by mail to the 250 biggest firms of FGI. The recipients were asked to fill in the questionnaire and return it by fax or mail within one month. After one month we contacted by phone once again all the recipients who had not responded. Finally were received filled questionnaires from 137 firms.

2.3 Results

2.3.1 Basic Results

Initially we calculated the average yearly ICT spending of the respondent firms and we found it to be at the level of 1.2% of yearly sales revenue; it is lower than in the highly developed countries, where ICT spending has been reported to be at the level of 2-3% (depending on the industry) of sales revenue (e.g. see Robson 1997). A possible explanation of this lower ICT spending by Greek firms is that the competition they face, even though it has increased since the entry of Greece in the European Union, is not as high as the competition faced by the firms in the highly developed countries.

Therefore the market pressure on the Greek firms for more ICT investment and use is lower than in the highly developed countries; however, due to the

growing globalisation of economic activity, the competition faced by the Greek firms is expected to increase in the near future, therefore it is highly likely that there will be more market pressure on them for more ICT investment and usage. Another possible explanation of this lower ICT spending by Greek firms is their smaller size, which results in a lower level of economies of scale in using high fixed cost ICT capital and specialised labour.

In order to test $H_0^{(1)}$ the following models were estimated:

$$log(Q) = \alpha_0 + \alpha_1 log(L) + \alpha_2 log(K) + \alpha_3 log(CK) + u_1 \quad \text{(restricted model)} \quad (6)$$

$$log(Q) = \beta_0 + \beta_1 log(L) + \beta_2 log(K) + \beta_3 log(CK) + \beta_4 L + \beta_5 K + \beta_6 CK + u_2 \quad \text{(unrestricted model)} \quad (7)$$

The estimation results, as well as the coefficients of determination R-squared, are shown in Table 2:

UNRESTRICTED MODEL

Dependent variable : ln Q		
Independent variable	Coefficient	Significance
constant	1.481	0.028
ln (CK)	0.108	0.001
ln (K)	0.176	0.000
ln (L)	0.671	0.000
CK	-5,237E-11	0.920
K	1,305E-13	0.933
L	1,393E-12	0.050
R-squared : 0.942		
RESTRICTED MODEL		
Independent variable	Coefficient	Significance
Constant	0.573	0.186
ln (CK)	0.078	0.001
ln (K)	0.184	0.000
ln (L)	0.732	0.000
R-squared : 0.935		

Table 2. Results of estimation of the restricted and unrestricted models for Hypothesis $H_0^{(1)}$

Using the above results the value of the F-statistic of equation (5) has been calculated:

$$F = [(R^2_{UR} - R^2_R)/q]/[(1 - R^2_{UR})/(N-K)] = 2.74$$

where R^2_{UR} and R^2_R are the coefficients of determination of the unrestricted and the restricted model respectively, q is the number of linear restrictions,

K is the number of estimated parameters in the unrestricted model and N is the sample size, while the corresponding critical F-value at the 0.05 significance level is 2.76. From the above results we can see that two of the additional coefficients included in the unrestricted model, those of the computer capital (CK) and the non-computer capital (K), are clearly insignificant, while the third additional coefficient, that of the labour (L), is only marginally significant at the 5% level.

Also, we remark that the above calculated F-value is slightly less than the critical one, which means that the improvement in the explanatory power of the more complicated unrestricted model is only marginal as compared to that of the restricted model, which has a much simpler form. This means that the production process can be adequately described by the Cobb-Douglas production function, hence, the null hypothesis $H_0^{(1)}$ is not rejected. It is noted that although in the models estimated above the capital input is broken down to computer capital (CK) and non-computer capital (K), the conclusion is the same if total capital is used instead of K and CK.

Concerning hypothesis $H_0^{(2)}$, from the above results it is also evident that the coefficient of computer capital is positive and statistically significant, therefore it makes a positive contribution to firm output, which means that hypothesis $H_0^{(2)}$ is rejected. By comparing the coefficients of the restricted model of Table 2, which are estimates of output elasticities of the corresponding inputs, we remark that the output elasticity of labour (0.732) is approximately ten times higher than the output elasticity of computer capital (0.078) and more than four times higher than the output elasticity of non-computer capital (0.184). That underlines the dominant role of the labour input in the big Greek industrial firms, the lower role of the non-computer capital and the much lower role of the computer capital. Summarizing, it is concluded the hard ICT investment has a positive statistically significant effect on firm output, however its output elasticity is lower than the one of the non-computer capital and much lower than the one of labour.

In order to test hypotheses $H_0^{(3)}$- $H_0^{(8)}$ the following general model form has been used:

$$Q = \prod X_i^{a_i} e^{(\sum b_i z_i + \sum\sum c_{ij} X_i Z_j + U)} \qquad (8)$$

where X_i represent the basic inputs (labour, non-computer capital and computer capital in our case), Z_i represent the variables relating to the soft ICT investment and the product terms X_iZ_i represent complementarities between the soft ICT investment variables and the basic inputs. As described and justified in the previous section 3 the soft ICT investment variables considered in this study are the existence (or not) of a separate ICT department in the firm (ICT-DEP), the number of ICT employees (ICT-EMPL) and the extent of ICT training provided to the users (ICT-TR); since the third variable is ordinal and has five levels, it will be represented in the model by the four binary variables ICT-TR1, ICT-TR2, ICT-TR3, ICT-TR4 (each of them takes value 1 for one of the four higher levels of IC-TR, and value 0 in any other case).

Additionally, the products of these six variables to the computer capital are used to express the possible effects of complementarity between these dimensions of the soft ICT investment and the hard ICT investment. So by log-transforming (8) we formulated a linear model similar to the one of equation (6), but including twelve additional independent variables: the above six soft ICT investment variables and also the product terms of complementarity between them and the computer capital. The results of the estimation of this model are shown in Table 3.

Dependent variable : ln Q		
Independent variable	Coefficient	Significance
constant	1,725	0.067
ln (CK)	0.030	0.040
ln (K)	0.166	0.000
ln (L)	0.736	0.000
ICT-DEP	0.205	0.034
ICT-EMPL	0.003	0.610
ICT-TR1	0.064	0.791
ICT-TR2	0.013	0.954
ICT-TR3	0.102	0.667
ICT-TR4	0.034	0.898
CK* ICT-DEP	-6.70E-010	0.658
CK* ICT-EMPL	1.77E-011	0.652
CK* ICT-TR1	1.05E-009	0.615
CK* ICT-TR2	1.34E-009	0.467
CK* ICT-TR3	3.38E-010	0.881
CK* ICT-TR4	2.21E-009	0.438
R-squared : 0,951		

Table 3. Results of estimation of the model of eq. (8) for testing hypotheses $H_0^{(3)}$- $H_0^{(8)}$

Using the above results the value of the F-statistic is:

$F= [(R^2_{UR}-R^2_R)/q]/[(1- R^2_{UR})/N-K]= 1.96$

where R^2_{UR} and R^2_R are the coefficients of determination of the unrestricted model shown in the above Table 3 and the restricted model shown in the lower part of Table 2 respectively, q is the number of linear restrictions, K is the number of estimated parameters in the unrestricted model and N is the sample size; since the corresponding critical F-value at the 0.05 significance level is 1.99, this means that the overall effect of soft ICT investment variables and complementarities between them and the computer capital is not significant.

However, from the above results it is evident that, though the existence of a separate ICT department in the firm makes a statistically significant positive contribution to firm output, the effect of the number of ICT employees and the extents of ICT training is clearly not statistically significant. Additionally there is no statistically significant effect of the interaction between the computer capital and any of the soft ICT investment variables. We must note, however, that the conclusion concerning the interaction between ICT-DEP and computer capital may be a result of high correlation between the variables ln(CK) and ICT-DEP.

Excluding from the model the above non-significant explanatory variables and in this way allowing for more degrees of freedom a more efficient estimation of model parameters may be obtained; the results are shown in Table 4.

Independent variable: ln (Q)	Coefficient	Standardized Coefficient	Significance
Constant	1.001		0.034
ln (CK)	0.061	0.062	0.013
ln (K)	0.177	0.179	0.000
ln (LT)	0.732	0.787	0.000
ICT-DEP	0.144	0.042	0.032
R-squared : 0.940			

Table 4. Results of estimation of the model of eq. (8) excluding non-significant variables

Using the above results the value of the F-statistic is:

$F= [(R^2_{UR}-R^2_R)/q]/[(1- R^2_{UR})/N-K]=5.75$

while the corresponding critical value at the 0.05 significance level is 4, therefore we can reject the hypothesis $H_0^{(3)}$, which confirms that the effect of having a separate ICT department in the firm is significant, as is

(equivalently) indicated by the t-statistic of the corresponding parameter estimate. Summarizing, the above results do not provide evidence for rejecting hypotheses $H_0^{(4)}$- $H_0^{(8)}$, but provide evidence for rejecting hypothesis $H_0^{(3)}$; so it is concluded that from the three investigated measures of the soft ICT investment, the creation of a structure for managing ICT in the firm, a separate ICT department that does not belong to any of the other departments of the firm, such as the sales or the financial depertment, has a positive statistically significant effect on firm output. It is also interesting to compare the effect of this dimension of the soft ICT investment on output with the effect of the hard ICT investment and also with the effects of the two basic production inputs: the labour and the 'non-ICT' investment.

For this purpose we have used the standardized coefficients of the independent variables of the model of Table 4, which are shown in the third column, next to the unstandardized coefficients. From them we can see that the effect of having a separate ICT department in the firm on output is lower than the effects of the other three production inputs (labour, non-computer capital and computer capital), however it is at a considerable level of 0.042/0.062 = 68% (about two thirds) of the effect of the hard ICT investment. This finding underlines the importance of this dimension of the soft ICT investment, as it can increase by two thirds on average the business value generated by hard ICT investment.

Finally we tested hypothesis $H_0^{(9)}$ which relates to the possibility of a size-of-firm effect on the structure of the estimated econometric models. Initially the recursive residuals have been estimated together with their 95% (i.e. plus/minus two standard errors) confidence band for our 'basic' model:

$$log(Q) = \beta_0 + \beta_1 log(L) + \beta_2 log(K) + \beta_3 log(CK) + u \qquad (9)$$

following the procedure described in the previous section 2.3.

Figure 1 shows the estimated recursive residuals and the above confidence band:

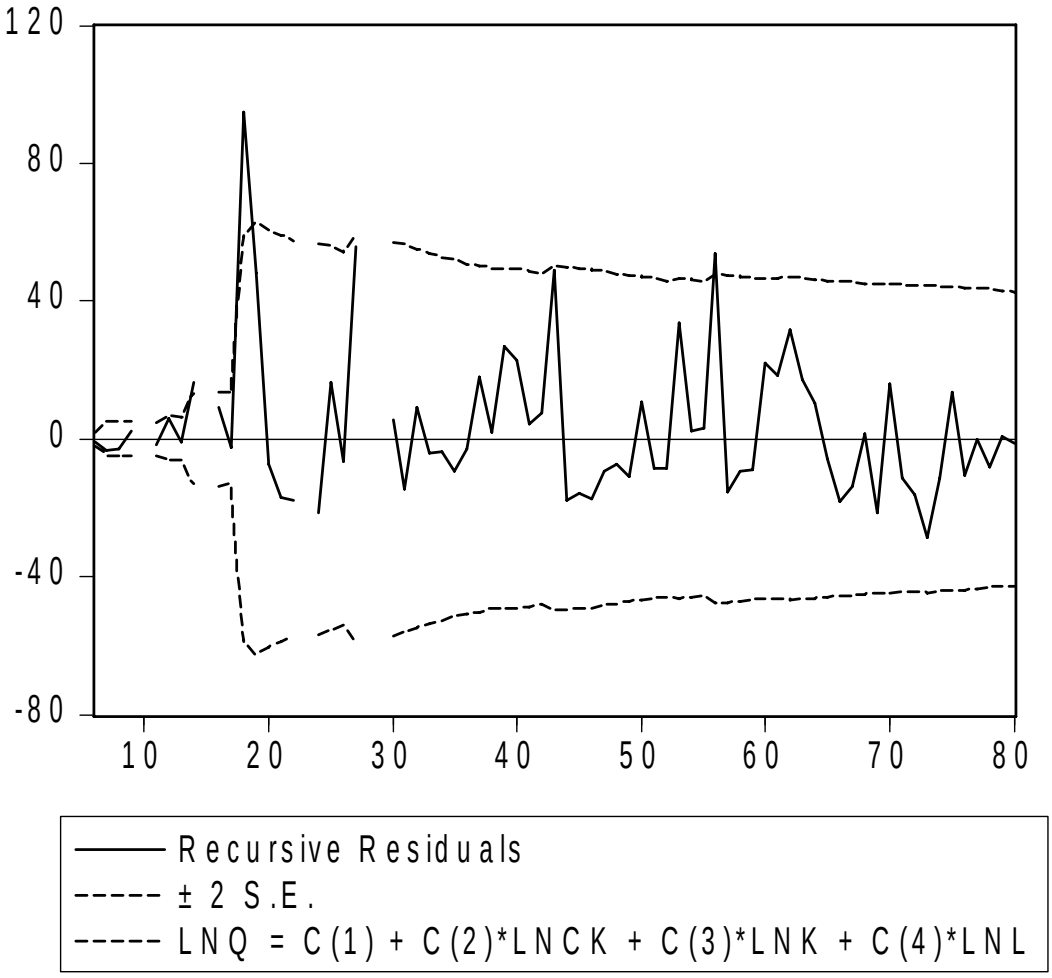


Figure 1. Recursive residuals and their 95% confidence band

From Figure 1 it can be seen that after some instability, up to the sample size of about 20 (which can be attributed to the small sample size the corresponding models and residuals are based on), the recursive residuals remain within the confidence band with two exceptions of rather minor character at sample sizes of 42 (corresponding to sales of about € 43 million) and 56 (corresponding to sales of about € 74 million). In order to investigate whether this may be attributed to a particular coefficient of the model, as mentioned in the previous section 4, the parameters of the model were estimated recursively; these recursive parameter estimates, together with their 95% confidence band are shown in Figure 2.

From the two upper plots of this Figure it is evident that after a sample size of about 30 (corresponding to sales of about € 30 million) the constant as well as the coefficient of log(CK) are fairly stable. The estimates of the coefficient of log(K), as we can see from the left lower plot, shows a small vertical decline at sample size 42, and a small and temporal downward

displacement at sample size 56. Finally the estimates of the coefficient of log(L), as we can see from the right lower plot, shows a very small increase at sample 42 and a temporal displacement at sample size 56. Hence, the instability at sample size 42, spotted in Figure 1, can be attributed mainly to the coefficient of log(K), while the instability at sample size 56 may be attributed to both the coefficients of log(K) and log(L). However, as all these vertical displacements remain inside previous confidence bounds, these instabilities are of minor importance and, by and large, after a sample size of about 30, corresponding to an output of about € 20 million, the models can be considered as being unaffected by the size of firms, for the range of firm sizes that our data cover. Therefore hypothesis $H_0^{(9)}$ cannot be rejected. Similar conclusions have been drawn for the other models that have been estimated in this study.

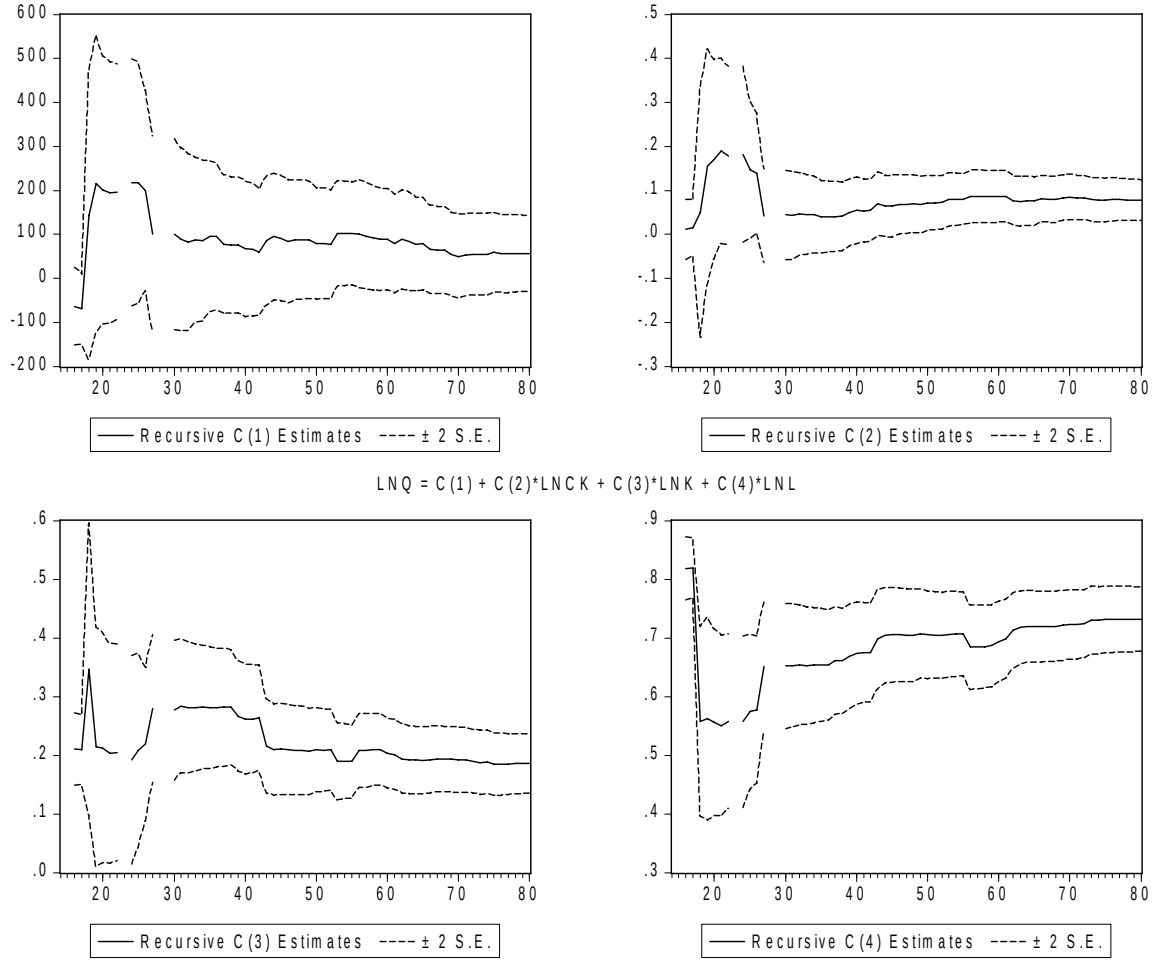


Figure 2. Recursive model parameter estimates and their 95% confidence bands

2.3.2 The effect of IS Management factors

After having the above encouraging results in the previous part of our study, we examine whether there is complementarity between IS investment and a set of IS management factors, which have been reported to be of critical importance in Greece, in a study conducted by Sirigos (2001) on the exploitation of ICT by Greek firms. For this purpose, two business performance measures were selected and used as dependent variables:

- Firm output (total sales revenue), as a basic business performance measure,

- Labour productivity (total sales revenue per employee), as an intermediate business performance measure.

Also, we collected data about four IS management factors, by using four corresponding questions included in the questionnaire of the above mentioned survey among Greek industrial firms in cooperation with the Federation of Greek Industries (FGI), concerning respectively the number of IS employees, the extent of the ICT training provided to the users (in a 5 points scale), the hierarchical level of the ICT organisational unit (whether it is a separate department or a part of another department) and the number of ICT users in the firm (as a measure of the width of ICT coverage of the organisational units/functions). Also, we added one more question concerning the overall satisfaction from IS organisation and management in the firm (in a 5 points scale).

We normalised the first and the fourth of these five variables (number of IS employees, number of ICT users) by dividing them by the number of firm employees. Also we standardised these five variables: from each of them was subtracted its average and then it was divided by its standard deviation, so that finally it has zero average and unit standard deviation. Then we calculated a composite IS management index ISM as the sum of these five standardised variables, and we used this index to examined whether there is complementarity between IS investment and the IS management factors.

In Table 5, we can see the regression results for the impact of computer capital, non-computer capital, labour, IS management and the interaction of computer capital and IS management on output. We remark that the coefficients of both the computer capital and its interaction with the composite IS management index are positive and statistically significant. Therefore, it is concluded that the combination of IS investment with these

IS management factors make an additional positive contribution to firm output beyond the individual positive contribution of the IS investment. This finding indicates that there is complementarity between IS investment and these IS management factors with respect to firm output. Also we remark that the coefficient of the ISM is negative and statistically significant, reflecting the fact that in the imaginary case that these IS management factors were not combined with investment in developing IS, they would create only costs and no benefits, therefore their contribution to the output would be negative.

Dependent variable: ln (Q)		
Independent variable	Coefficient	Significance
constant	0.682	0.113
ln (CK)	0.071	0.003
ln (K)	0.183	0.000
ln (LT)	0.736	0.000
ISM	-0.349	0.035
ln (CK) * ISM	0.016	0.035
R-squared: 0.939		

Table 5. Regression results for the impact of computer capital, non-computer capital, labour, IS management and the interaction of computer capital and IS management on output

In Table 6 we can see the regression results for the impact of normalised computer capital, normalised non-computer capital, normalised labour, IS management and the interaction of normalised computer capital and IS management on labour productivity.

We remark that the coefficients of both the normalised computer capital and its interaction with the composite IS management index are positive and statistically significant. Therefore, it is concluded that the combination of IS investment with these IS management factors make an additional positive contribution to labour productivity, beyond the individual positive contribution of the IS investment. This finding indicates that there is complementarity between IS investment and these IS management factors with respect to labour productivity.

dependent variable : ln (LP=Q/N)		
Independent variable	Coefficient	Significance
constant	0.240	0.561
ln (CK/N)	0.102	0.001
ln (K/N)	0.205	0.000
ln (LT/N)	0.734	0.000
ISM	-0.319	0.050
ln (CK/N) * ISM	0.015	0.053
R-squared : 0.902		

Table 6. Regression results for the impact of normalised computer capital, normalised non-computer capital, normalised labour, IS management and the interaction of normalised computer capital and IS management on labour productivity

This complementarity we found between IS investment and the above IS management factors can be explained based on information systems theory. Sub-optimal use of specialised IS labour results in sub-optimal effort for IS planning and development, and also in inadequate support of IS and their users, leading to reduced benefits from IS investment. Also sub-optimal training of the users results in inefficient use of IS and sub-optimal exploitation of their functionality and capabilities, resulting in reduction of the benefits from IS investment.

If the ICT organisational unit has a low hierarchical level, being part of another department and not a separate department, then it is dealing mainly with the department it belongs to, and can have neither a complete view of the whole firm and all its computerisation needs, nor adequate power and influence; in this case the ICT organisational unit cannot assume a leading role in coordinating IS development and use throughout the firm and ensuring technological homegeneity and interoperability. For these reasons the value from IS investment will be reduced. Finally, a very narrow focus of the ICT investment only on a few organisational units/functions, results in the development of some 'islands of automation': a few tasks will be performed manually and all the other tasks will be performed electronically, resulting in significant integration problems, which increase the data entry and in general the operating costs and reduce considerably the benefits from IS investment.

2.4 Conclusions

This is the first econometric study in Greece, which investigates the effect of both 'hard' ICT investment (i.e. investment in ICT hardware, software and networks) and 'soft' ICT investment (investment in ICT human

resources, skills and organization) on firm output. It has been concluded that ICT spending by firms in Greece is lower than in the highly developed countries; the lower level of competition faced by the Greek firms, and also their smaller size (allowing a lower level of economies of scale), in comparison with the firms of the highly developed countries, are possible explanations.

The hypothesis that the function relating the output to the factors of production (inputs) in the context of the Greek industry is of the Cobb-Douglas form is not rejected against the specific alternative of the more general transcendental form; therefore the production process in the Greek industry can be adequately described by the Cobb-Douglas production function, while the use of the more general transcendental form for this purpose does not improve the explanatory power of the models.

Based on econometric modelling, it has been found that the hard ICT investment has a positive statistically significant effect on firm output; however its output elasticity is lower than the one of the non-computer capital and much lower than the one of the labour. This is mainly due to the abovementioned low level of ICT spending that characterises the Greek industries, which results in a low level of computerization of their functions. The results underline the dominant role of the labour input in the big Greek industrial firms, the lower role of the non-computer capital and the much lower role of the computer capital.

Concerning the soft ICT investment, initially a framework has been developed for operationalizing and measuring it, and for investigating its effect on firm output; this framework is based on the well-established and widely used (both in research and consulting) Galliers's model of the 'stages of ICT growth', which proposes 7 basic assessment dimensions. In this preliminary study we have focused on three of these dimensions, which we consider as the most important ones: ICT structure, ICT staff and ICT skills; we measured them through three corresponding variables: the existence (or not) of a separate ICT department in the firm, the number of ICT employees and the extent of ICT training provided to the users. From these three investigated measures of the soft ICT investment, based on econometric modelling it has been found that the existence of a separate ICT department has a positive statistically significant effect on firm output, which is of considerable magnitude of about two thirds of the effect of the hard ICT investment. This finding underlines the importance of this dimension of the

soft ICT investment, as it can increase by two thirds on average the business value generated by the hard ICT investment.

Furthermore, we examined whether there is complementarity between IS investment and a set of IS management factors, which concern the number of IS employees, the ICT training provided to the users, the hierarchical level of the ICT organisational unit and the number of ICT users in the firm (which is a measure of the width of ICT coverage of the firm organisational units/functions). It was concluded that there is complementarity between IS investment and the above set of IS management factors with respect to firm output and labour productivity. Therefore the combination of IS investment with these IS management factors results in additional increase of firm output and labour productivity beyond the individual effect of IS investment.

Our last conclusion refers to the structural stability of the econometric models we constructed with respect to firm size (measured through sales revenue). Using a method based on the 'recursive residuals' it has been found that after a sample size of about 30, which corresponds to sales of approximately € 20 million, the models structure can be considered as being unaffected by the size of firms, for the range of firm sizes that our data cover. This means that the conclusions drawn from these models are not affected by firm size.

2.5 Contribution

The first contribution of this part of our study is that it examines the effect on business performance not only of the 'hard' ICT investment, but also of the 'soft' ICT investment as well, which has received limited research attention as mentioned above; this 'soft' ICT investment is often neglected by the Greek firms (Sirigos, 2001) and we believe that this might happen also in other similar national contexts (at least to some extent). Also it is interesting that it is the first time that a comparison is made between the effects of these two types of ICT investment (hard and soft) on business performance, and also with the effects of the two 'basic' production inputs: the labour and the 'non-ICT' investment.

A second contribution is the investigation of the complementarity between IS investment and the above set of IS management factors with respect to firm output and labour productivity. It is concluded that the combination of IS investment with these IS management factors results in additional

increase of firm output and labour productivity beyond the individual effect of IS investment.

The third contribution in this part of our study is that it examines which is the most appropriate form of production function to be used as a basis for addressing the above research questions in the Greek national context. While most the previous relevant research has been based on production functions of the so-called Cobb-Douglas form, in this study we investigate whether a more general form of production function would be more appropriate; this issue has never been examined in the previous relevant research.

Finally, a fourth contribution in this part of our research is that it examines for first time in such studies the effect of the firm size on the structural stability of the constructed econometric models, and therefore on the validity of the conclusions drawn from them, using a method based on the 'recursive residuals'.

Based on the results and contributions of this dissertation the following publications have been produced:

- Loukis, E., Sapounas, I., Milionis, A. (2009), "The effect of hard and soft information and communication technologies investment on manufacturing business performance in Greece - A preliminary econometric study", Telematics and Informatics Journal, 26(2), pp. 193-210.

- Loukis, E., Sapounas, I. (2005), "The Impact of Information Systems Investment and Management on Business Performance in Greece", in the Proceedings of 13th European Conference on Information Systems (ECIS 2005), Regensburg, Germany, May 26-28.

- Sapounas, I., Loukis, E., Milionis, A. (2007), "The Effect of Information Systems Investment and Management on Manufacturing Business Performance in Greece. A preliminary econometric study", in the Proceedings of the 4th International Conference in Applied Financial Economics (QASS 2007), Samos, Greece, July 12-14.

CHAPTER 3:

THE EFFECT OF GENERALIZED COMPETITION AND STRATEGY ON THE BUSINESS VALUE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

3.1 Introduction

As mentioned in the first chapter, extensive research has been conducted on the business value that ICT investment generates, aiming mainly at the assessment and understanding of the impact of ICT investment on business performance, and also at the identification of factors affecting the magnitude of this impact. In particular in the section 1.2 'Literature Review' has been mentioned that previous research has shown that the magnitude of the business value ICT generate for an organization is affected to a large extent by a number of 'internal factors', which are related to the internal functions of the organization, such as the simultaneous development of new work practices, new business processes, new human skills, innovation, new IS management structures, etc. (e.g. Brynjolfsson, Hitt and Yang 2000, Ramirez 2003, Arvanitis 2003 and 2005, Loukis and Sapounas 2004, Hempell 2005).

However, limited research has been conducted on the effect of 'external factors', which are related to the external environment of the organization, on the business value generated by its ICT investment. Melville, Kraemer and Gurbaxani (2004) in their literature review conclude that 'We know very little about how industry characteristics moderate the degree of IT business value' and suggest that empirical research is required in this direction and especially for investigating the effects of competition on the efficiency gains achieved via ICT. Therefore it is necessary to investigate the effect of external factors as well on the business value generated by ICT, in order to find out whether there are external conditions resulting to systematically higher or lower ICT business value, and also to understand the underlying reasons, so that organizations can take them into account in planning their ICT investment.

In this direction this part of our study describes an empirical study of the effect of two external environment related factors, the 'generalized'

competition an organization faces, as it is conceptualised by the well established 'Five Forces Framework' of M. Porter (Porter 1980), and the strategies an organization follows in response to its external environment, on the business value generated by its ICT investment. In particular, the research objective of this part of our study to investigate whether:

i) the intensity of each of the M. Porter's 'five forces framework' (bargaining power of suppliers, bargaining power of buyers, competitive rivalry from competitors, threat of new entrants and threat of substitute products or services), which constitute the basic dimensions of the generalised competition an organization faces,

ii) and the degree of following each of the six fundamental strategies an organization can, according to the relevant literature, follow in response to its external environment (cost leadership, quality differentiation, specialised products/services, frequent introduction of new products/services, expansion to markets of other countries and expansion to new activities)

affect systematically (positively or negatively) the business value generated by the ICT investment of the organization, which is quantified as the contribution of its ICT investment to output. Such an investigation has never been conducted before, since all previous relevant research dealt with the effect of 'internal factors' on the business value that ICT investments generate; the above research questions i) and ii) have not been addressed by the literature despite their significance for ICT planning in organizations.

3.2 Literature review

As mentioned in the 'Introduction', limited research has been conducted about the effect of factors related to the external environment of the organization on the business value generated by its ICT investment. One of the most important factors of the external environment of an organization is the competition it faces. The economic literature has been emphasizing for long time (e.g. Primeaux 1977) that higher competition results in more efficient utilization of resources; so we can expect that higher competition might result in more efficient utilization of ICT resources and therefore higher levels of ICT business value.

On the contrary, Brynjolfsson and Hitt (1996) argue that higher competition may 'compete away' part of the business value generated by ICT, by putting pressure on the organization to transfer part of this business value to the

consumers of its products/services (e.g. as increased quality of products and/or services at the same price, or even at a lower price, etc.) and increase consumer surplus, but at the same time decreasing the business value the organization gets from its ICT investment; so, based on this argument, we can expect that higher competition might reduce the magnitude of the business value an organization finally gets from its ICT investment.

These mixed expectations are also stressed by Melville, Kraemer and Gurbaxani (2004) in their literature review of the ICT business value research, who mention that 'Although in highly competitive markets firms may apply IT more efficiently, profitability may suffer as gains to IT application are competed away' and suggest that empirical research is required in this direction. It is also worth noting that even this limited literature on this topic focuses on only one of the dimensions of the competition an organization faces: the competitive rivalry from its competitors. However, strategic management literature (e.g. Porter 1980, Porter 1985, Wheelen and Hunger 2004, Johnson and Scholes 2005) has emphasized long time ago the need to adopt a wider and multidimensional view of competition.

According to the M. Porter's 'Five Forces Framework' for the analysis of competition and profitability potential of an industry or sector (Porter 1980), there are five different competitive forces an organization faces, which all in combination determine its competitive position and profitability potential: bargaining power of suppliers, bargaining power of buyers, competitive rivalry from competitors, threat of new entrants and threat of substitute products or services. Therefore empirical research is required, based on 'real-life' data, in order to investigate the effects of all the above five dimensions of the 'generalized competition' organizations face on the business value they get from their ICT investment.

Also, limited is the research that has been conducted on the effect of the strategies an organization follows, in order to respond to pressures from its external environment, on the business value generated by its ICT investment. According to strategic management literature (e.g. Porter 1980, Porter 1985, Wheelen and Hunger 2004, Johnson and Scholes 2005) there are some fundamental strategies that an organization can to follow in order to respond to pressures of its external environment: cost leadership, quality differentiation, specialised products/services, frequent introduction of new products/ services, expansion to markets of other countries and expansion to

new activities.

Each of these strategies necessitates a different way of using ICT, with different objectives and focus; for example a cost leadership strategy necessitates a quite different way of using ICT, with quite different objectives and focus (e.g. cost monitoring, cost minimization, etc.), than a quality differentiation strategy (in which the focus of ICT use may be on improved customer service, designing better and highly specialised products and services, etc.).

It should be noted that the mutual relation between strategy and ICT has been extensively emphasized by the relevant literature (e.g. Porter and Millar 1985, Kearns and Lederer 2000, Galliers 2004, Byrd et al 2006), which concludes that ICT can be of critical importance both for supporting the strategy of an organization, and also for redefining and enriching it with new ICT-based ways of generating revenue and achieving competitive advantages. Therefore it is quite interesting to investigate empirically, based on 'real-life' data, the effect of following each of the above fundamental strategies on the business value organizations get from their ICT investment.

3.3 Hypotheses, Method and Data

Taking into account the conclusions of the above literature review we defined the research objective of this study to be the investigation of the effect of:

a) each of the five dimensions of the 'generalized competition' an organization faces according to M. Porter's 'Five Forces Framework' (Porter 1980), namely of the bargaining power of suppliers, the bargaining power of buyers, the competitive rivalry from competitors, the threat of new entrants and the threat of substitute products or services,

b) and of following each of the abovementioned six fundamental strategies, namely cost leadership, quality differentiation, specialised products/services, frequent introduction of new products/services, expansion to markets of other countries and expansion to new activities,

on the business value organizations get from their ICT investment, and in particular on the contribution of ICT to output.

In order to accomplish this research objective we formulated and tested quantitatively with 'real-life' data the eleven research hypotheses H1 to H11. The first five of them (H1 to H5) concern the effect of the above five dimensions of the 'generalized competition' on the contribution of ICT to output; the theoretical foundations of these five hypotheses are outlined in the penultimate paragraph of the previous 'Literature Review' section. The other six research hypotheses H6 to H11 concern the effect of following the abovementioned six fundamental strategies on the contribution of ICT to output; their theoretical foundations are outlined in the last paragraph of the previous 'Literature Review' section. In particular, our research hypotheses were:

H1: the level of bargaining power of suppliers affects the contribution of ICT to firm output

H2: the level of bargaining power of buyers affects the contribution of ICT to firm output

H3: the level of competitive rivalry from competitors affects the contribution of ICT to firm output

H4: the level of threat of new entrants affects the contribution of ICT to firm output

H5: the level of threat of substitute products or services affects the contribution of ICT to firm output

H6: the degree of following a cost leadership strategy affects the contribution of ICT to firm output

H7: the degree of following a quality differentiation strategy affects the contribution of ICT to firm output

H8: the degree of following a specialised product/services strategy affects the contribution of ICT to firm output

H9: the degree of following a strategy of frequent introduction of new products/services affects the contribution of ICT to firm output

H10: the degree of following a strategy of expansion to markets of other countries affects the contribution of ICT to firm output

H11: the degree of following a strategy of expansion to new activities affects the contribution of ICT to firm output

For testing the above eleven hypotheses H1 to H11 econometric models for firm output were constructed, based on the microeconomic production theory, and in particular on the Cobb Douglas production function, which has been extensively used in the past in economic studies as a basis for the estimation of the contribution to firm output of various firm inputs, including ICT investment (e.g. Brynjolfsson & Hitt 1996, Stolarick 1999, OECD 2003, Ramirez 2003, OECD 2004).

In particular, we used as our basis the following 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 (which is equal to yearly sales revenue minus yearly expenses for buying materials and services), L is the yearly labour expenses, K is the non-computer capital and CK is the computer capital, while the $\beta_1 - \beta_3$ are the corresponding output elasticities with respect to these three inputs (L, K and CK). By log-transforming this model, we obtain the following linear model:

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

In order to investigate the effect of each of the above eleven factors of the hypotheses H1 to H11 (level of bargaining power of suppliers, level of bargaining power of buyers, etc.) on the contribution of ICT to output, we added to the above model one more 'interaction term', which is equal to the product of the corresponding factor F to the ln(CK):

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

In all the models we constructed according to the above equations 3.2 and 3.3 using 'real-life' data we performed a number of tests concerning the basic assumptions of the 'classical' linear regression model according to the recommendations of the relevant econometrics literature (Gujarati 2003, Greene 2003). In particular, the assumptions of error normality (normal distribution of error values) and homoscediasticity (constant error variance across observations), were tested by plotting and inspecting the residuals' histograms. The existence of error autocorrelation was tested through the Durbin-Watson test. Finally, the existence of multicollinearity (high levels of correlation among independent variables), was tested by calculating and examining the independent variables correlation matrix, the condition index

(CI), and also the tolerance (TOL) and the variance inflation factor (VIF) of each independent variable.

The data we used in this study for constructing the econometric models were collected through a survey among Greek companies, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', in cooperation with ICAP, one of the largest business information and consulting companies of Greece. As we mentioned in the 'Introduction', three samples of 300 Greek firms each were randomly selected from the database of ICAP (all these three samples included firms from the same industries and sizes), which includes financial and other business information for approximately 135,000 Greek firms, and consisted of 304 Greek companies from the 27 most important sectors of Greek economy (Appendix B).

Initially the questionnaire was sent by post to the firms of the first sample; after three weeks the firms who had not responded were contacted by phone. Firms that definitely refused to participate in this survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample, while in a few cases that exhausted the firms of the second sample we had to proceed to the third sample. Following the above procedure, which aimed to maintain the proportions of the industry and size classes, we received answered questionnaires from 281 companies (88 small, 105 medium and 78 large ones), so the response rate was 92.4%.

3.4 Results

Initially we estimated the model of equation (3.2) of the previous section, and the results are shown in Table 7. We remark 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 output. These results confirm the relevant conclusion we had drawn in our previous study (Loukis and Sapounas 2004), which was based on a different dataset collected in a survey among Greek companies, that ICT investments of Greek companies make a positive and statistically significant contribution to their output.

Dependent variable : ln (VA)		
Independent variable	Coefficient	Significance
constant	2.677	0.003
ln (L)	0.558	0.000
ln (K)	0.155	0.030
ln (CK)	0.219	0.009
R-squared: 0.70		

Table 7. Regression results for the impact of labour, non-computer capital and computer capital on output

Then, proceeding to the basic research questions of this study, in order to examine the effect of each of the abovementioned five dimensions of the generalized competition on the contribution of ICT to output, we estimated the model of equation (3.3) for each of the five factors of the research hypotheses H1 to H5: level of bargaining power of suppliers (SP), level of bargaining power of buyers (BP), level of competitive rivalry from competitors (CR), level of threat of new entrants (NE) and level of threat of substitute products or services (SPS).

From these five models, only the model for the bargaining power of suppliers (factor SP), which is shown in Table 8, had an interaction term with a statistically significant coefficient; in the other four models the coefficient of the interaction term was not statistically significant. These findings support hypothesis H1, but provide no support for hypotheses H2 to H5. From the positive and statistically significant value of the interaction term in the model of Table 8 it is concluded that higher levels of bargaining power of suppliers result in higher contribution of ICT to output. These results can be explained taking into account the basic characteristics of the Greek economy, which is characterised by small markets and small numbers of competitors in most sectors (since the total population of Greece is 10.9 million people). For this reason the competitive rivalry, the threat of new entrants, the threat of substitute products or services and the bargaining power of buyers are not so intensive as to create big pressures on the Greek companies for a more efficient utilization of their ICT resources and finally result in higher levels of contribution of ICT to output.

However, in such small markets very often the number of potential suppliers of basic inputs in some sectors is limited (in many cases we have practically monopolies or oligopolies), resulting in high levels of bargaining power of these suppliers and therefore in high levels of prices for basic inputs, putting quite big pressures on the Greek companies for a more efficient utilization of their ICT resources for supporting an efficient management of

these expensive inputs; for this purpose they have to develop mainly 'efficiency-oriented' applications, which support the efficient planning and monitoring of their operations and of the consumption and transformation of their inputs (e.g. inventory and warehouse management systems, master production planning/monitoring systems, material requirements planning/monitoring systems, etc.). These critical applications increase the contribution of ICT investment to output ((0.167+5*0.019)/(0.167+0.019))= 1,41: increase 41%), and in general the business value it creates.

Dependent variable : ln (LP = VA)		
Independent variable	Coefficient	Significance
constant	2.348	0.010
ln (L)	0.569	0.000
ln (K)	0.158	0.025
ln (CK)	0.167	0.049
ln (CK)*SP	0.019	0.014
R-squared : 0.73	Increasing of contribution of ICT: 41%	

Table 8. Regression results for the impact of labour, non-computer capital, computer capital and interaction between computer capital and bargaining power of suppliers on output

In order to examine the effect of following each of the six fundamental strategies mentioned in the previous section on the contribution of ICT to output, we estimated the model of equation (3.3) for each of the six factors of the research hypotheses H6 to H11: degree of following a cost leadership strategy (CL), degree of following a quality differentiation strategy (QD), degree of following a specialised products/services strategy (SPE), degree of following a strategy of frequent introduction of new products/services (NPS), degree of following a strategy of expansion to markets of other countries (ENC) and degree of following a strategy of expansion to new activities (ENA).

From these six models, only the one corresponding to the strategy of frequent introduction of new products/services (factor NPS), which is shown in Table 9, had an interaction term with a statistically significant coefficient (at the 10% significance level); in the other five models the coefficient of the interaction term was not statistically significant. These findings support hypothesis H9, but provide no support for hypotheses H6, H7, H8, H10 and H11. From the positive and statistically significant value of the interaction term in this model it is concluded that following to a high degree a strategy of frequent introduction of new products/services results in higher levels of contribution of ICT to output. This conclusion can be

explained taking into account that such a strategy necessitates both 'innovation-oriented' applications (for supporting the analysis of market research data, the design of new products/services and of their production and delivery processes, marketing plans, etc.) and 'efficiency-oriented' applications (for supporting the efficient planning and monitoring of the production and delivery processes of many new products/services, which usually have to share production and delivery resources with many older products/services, creating high levels of complexity, which can be efficiently managed only using ICT).

Such innovation-oriented and efficiency-oriented applications increase the contribution of ICT investment to output, and in general the business value it creates. Moreover, following a strategy of frequent introduction of new products/services often necessitates devising innovative ways of using ICT, which further increase their contribution to output ((0.153+5*0.013)/(0.153+0.013))= 1,31: increase 31%) and in general the business value they create.

Dependent variable : ln (LP = VA)		
Independent variable	Coefficient	Significance
Constant	2.603	0.004
ln (L)	0.554	0.000
ln (K)	0.182	0.013
ln (CK)	0.153	0.092
ln (CK)*NPS	0.013	0.082
R-squared : 0.73	Increasing of contribution of ICT: 31%	

Table 9. Regression results for the impact of labour, non-computer capital, computer capital and interaction between computer capital and strategy of frequent introduction of new products/services on output

3.5 Conclusions

The central conclusion drawn from this part of our study is that the business value generated by ICT depends not only on 'internal factors' but also on 'external factors' as well; in particular, there are external environment conditions that result in higher business value from ICT investment by necessitating a more efficient and effective use of ICT. Especially, it has been concluded that from the 'Five Forces' of M. Porter's framework, only the bargaining power of suppliers affects ICT business value; in particular, so higher levels of bargaining power of suppliers create big pressures for the development of mainly 'efficiency-oriented' applications, and in general

for a more efficient utilization of ICT resources, increasing the contribution of ICT investment to output (41%).

Another important conclusion drawn from this part of our study is that there are specific strategies for responding to the external environment, which are characterised by frequent products/services innovations, increasing the contribution of ICT investment to output (31%); in such innovation strategies the relation between strategy and ICT seems to be much stronger than in the other types of strategies: ICT are much more important both for enabling and enriching innovations strategies, and also for supporting their implementation.

Furthermore, it has been concluded that, following a strategy of frequent introduction of new products/services, creates big pressures for the development of both 'innovation-oriented' and 'efficiency-oriented' applications, and in general for more innovative and more efficient utilization of ICT resources, resulting in an increase of the contribution of ICT investment to output.

3.6 Contribution

In this part of the study we examine the effect of

- the 'generalized' competition a firm faces, which is measured in accordance with M. Porter's 'Five Forces Framework' (including the bargaining power of its suppliers, the bargaining power of its buyers, the competitive rivalry from its competitors, the threat of new entrants and the threat of substitute products or services),

- and also of six fundamental strategies firms follow in response to their external environment (cost leadership, differentiation, specilized products/services, frequent introduction of new products/services, expansion to other country markets, expansion to new activities),

on the business value generated by ICT investment, and in particular on the contribution of the ICT investment to output.

It has established that particular external environments (characterized by high supplier bargain power) and particular strategies (frequent introduction of products/services) result in higher levels of business value from ICT investments. Such an investigation has never been conducted before, since

all previous relevant research dealt with the effect of 'internal factors' on the business value generated by ICT investment.

Based on the results and contributions of this dissertation the following publications have been produced:

- Loukis, E., Sapounas, I. and Aivalis, K. (2008), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", Journal of Enterprise Information Management, 21(1), pp. 24-38.

- Loukis, E., Sapounas, I., Aivalis, K. (2006), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", in the Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS 2006), Alikante, Spain, July 6-7.

CHAPTER 4:

THE EFFECT OF STRATEGIC ALIGNMENT AT DIFFERENT HIERARCHICAL LEVELS ON THE BUSINESS VALUE OF INFORMATION AND COMMUNICATION TECHNOLOGIES

4.1 Introduction

As mentioned in the previous chapter, the business value ICT generate depends not only on the above 'internal' factors and conditions, which are related to the internal functions of the organization, but also on 'external' factors as well, which are related to the external environment of the organization, such as the 'generalized competition' it faces and the strategies it adopts for responding to external pressures (e.g. Loukis, Sapounas and Aivalis 2006).

Another factor that is regarded by the relevant literature as highly important for increasing the business value that ICT generate for organizations is the ICT strategic alignment. Byrd et al (2006) define it as 'the alignment of information systems strategy with business strategy', while Broadbent and Weil (1993) define it as 'the extent to which business strategies were enabled, supported and stimulated by information strategies'. Luftman (2000) provides a more detailed definition stating that 'Business-IT alignment refers to applying Information Technology (IT) in an appropriate and timely way, in harmony with business strategies, goals and needs ... This definition of alignment addresses: 1. How IT is aligned with the business, and 2. How the business should or could be aligned with IT'. Strategic alignment has been consistently among the key issues that IS practitioners and researchers face for many years (e.g. Dickson et al 1984, Brancheau et al 1986, Brancheau et al 1996, Palvia et al 2003, Luftman and McLean 2004, Luftman 2005); it should be noted that in the two most recent formal surveys of the key IS management concerns conducted by the Society for Information Management (SIM) (www.simnet.org) the ICT strategic alignment was ranked as the most important issue that IS managers face (Luftman and McLean 2004, Luftman 2005).

For this reason extensive research has been conducted about ICT strategic alignment in the last thirty years, investigating various aspects of it, as

described in more detail in the next 'Literature Review' section. However, only a small part of this research has dealt with the most important aspect of strategic alignment: its impact on business performance. Also, most of the relatively few empirical studies that have been conducted about the contribution of strategic alignment to some measures/dimensions of business performance, which are reviewed in the next section, are based on managers' subjective perceptions of business performance or contribution of IS to business performance, as dependent variables, and not on objective measures of them; only one of these studies (Byrd et al 2006) is based on objective measures of business performance and ICT contribution to it, though using partial models.

Another characteristic of these previous studies is that they focus on ICT strategic alignment only in the formulation of strategy at the executive level, though the relevant literature has repeatedly and consistently underlined the need of extending ICT strategic alignment throughout the hierarchy, so that it covers the middle and the lower hierarchical levels, and also the whole strategy lifecycle, including both formulation and implementation phases (e.g. Chan and Huff 1992, Luftman et all 1999, Luftman 2000, Allen and Wilson 2003, Rantham et al 2004, Campbell et al 2005, Bleistein et al 2006a, Bleistein et al 2006b, Gutierrez et all 2006). Moreover, all previous empirical studies of the impact of ICT strategic alignment to business performance have been conducted in the context of only a few countries, mainly in USA and UK, which are characterized by high levels of economic development and ICT diffusion and bigger markets; also USA and UK have particular socio-cultural characteristics, differing considerably in all the five dimensions of national culture proposed by Prof. Hofstede (Hofstede G. and Hofstede G. J. 2005) from the corresponding world average levels (both countries differing in the same direction) (see www.geert-hofstede.com/). Therefore the results of these studies are conditional on the characteristics of these particular national contexts, since the relevant literature emphasizes that the national context is significantly affecting all issues and dimensions of ICT business value (e.g. OECD 2003, OECD 2004, Melville et al 2004).

4.2 Literature review

Considerable research has been conducted in the last twenty years concerning various dimensions of ICT strategic alignment. This research can

be grouped into three basic streams: i) conceptualization and basic understanding of ICT strategic alignment ii) development of models and frameworks for assessing and directing ICT strategic alignment, and iii) Impact of ICT strategic alignment on business performance. These three research streams are reviewed next.

4.2.1 Conceptualization and basic understanding of enterprise systems strategic alignment

The main objective of this research stream is to conceptualize and understand the ICT strategic alignment, focusing on the identification of its basic processes, barriers, critical success factors and benefits (King, 1978; Lederer & Mendelow, 1988; Earl, 1989; Jarvenpaa & Ives, 1990; Zviran, 1990; Chan, 1992; Earl, 1993; Luftman, 1996; Reich & Benbasat, 1996; Armstrong & Sambamurthy, 1999; Luftman, Papp & Brier 1999; Luftman & Brier, 1999; Kearns & Lederer, 2000; Reich & Benbasat, 2000; Allen & Wilson, 2003; Campbell et al, 2005; Rantham et al, 2005).

Due to space limitations we are going to outline briefly only the most representative publications of this research stream. Lederer and Mendelow (1988) argue that one of the most important barriers of ICT strategic alignment is the difficulty of convincing top management of the potential strategic potential of ICT, because the top management usually lacks sufficient awareness on ICT strategic potential, regards the use of computers as a strictly operational support tool, perceives a credibility gap, does not view information as a resource, demands financial justification and also is action-oriented; for overcoming these difficulties the authors propose a number of techniques: educate top management, market IS department accomplishments to the top management, have users to do this ‘selling’, promote the business image of the IS department, respond to ‘outside forces’ influencing top managers, capitalize on changes in management and perform highly sophisticated IS planning that necessitate top management involvement.

Jarvenpaa & Ives (1991) conclude that the ‘involvement’ of executives in IS activities (i.e. the ‘psychological state’) is more strongly associated with the progressive use of ICT in the enterprise than the ‘participation’ of executives in IS activities (i.e. their ‘actual behaviors’); also executive involvement is influenced by a CEO's participation, prevailing organizational conditions, and the executive's functional background.

Earl (1993) identified five basic approaches that are adopted by businesses for achieving enterprise systems strategic alignment: the business-led approach, the method-led approach, the administrative approach, the technological approach and the organizational approach; each of these approaches has different characteristics and therefore different likelihood of success, the organizational approach appearing to be more effective.

Luftman, Papp and Brier (1999) identified a number of enablers of alignment between business and ICT strategies: senior-executive support for IT, IT involvement in strategy development, IT understanding the business, partnership between IT and non-IT units, well-prioritized IT projects and IT demonstrating leadership).

Reich & Benbasat (2000) investigated the influence of four factors on the 'social dimension' of ICT strategic alignment (defined as the extent to which business and IT executives mutually understand and are committed to both the business and the IT mission, objectives, and plans): shared domain knowledge between business and IT executives, IT implementation success, communication between business and IT executives, and connections between business and IT planning processes; they found that all these four factors influence 'short-term alignment', while only the shared domain knowledge influences 'long-term alignment'.

Campbell et al (2005), based on a review of the previous research on ICT strategic alignment, identify two basic approaches in it: the 'social' (focusing primarily on the people involved in achieving alignment) and the 'intellectual' (investigating mainly the relevant plans and planning methodologies); also, they remark that most of the research on ICT strategic alignment adopts the intellectual approach, and recommend a combination of these two approaches as the optimal approach.

Also adopting such a combined approach and based on the analysis of the content from a number of interviews with senior ICT managers they concluded that all of them believed that strategic alignment generally depends upon communication, collaboration, development of trust and shared domain knowledge, as suggested in the relevant literature; however, it was practically problematic to achieve these prerequisites, due to the prevalent culture in their organizations that promoted competition between departments.

This research stream has provided a basic conceptualization and understanding of the ICT strategic alignment, concerning mainly its basic

processes, barriers, critical success factors and benefits. However, more in-depth research is required on these topics, in various types and sizes of enterprises, in various industries and national and cultural contexts, and for various types of ICT, in order to get a deeper and more complete understanding of them.

4.2.2 Development of models/frameworks for directing/assessing enterprise systems strategic alignment

This research stream aims to support the practical application in 'real-life' of the ICT strategic alignment concept by developing models/frameworks for assisting the technical and the business management in directing and assessing enterprise systems strategic alignment. The most widely used of the models/frameworks that have been developed for directing strategic alignment is the 'Strategic Alignment Model' (SAM) developed by Henderson and Venkatraman (1999).

As we can see in Figure 1 it is based on two basic dimensions of required linkage: i) the 'strategic fit' (=linkage between 'external components' (concerning the external environment of the enterprise) and 'internal components' (concerning the internal environment of the enterprise)) and ii) the 'functional integration' (=linkage between the 'business domain' and the 'IS domain'). In the strategic fit dimension the model views strategy as consisting of two components, the 'external' and the 'internal' one, which should be well integrated.

In particular, it views ICT strategy as consisting of one component concerning the 'external domain' (=decisions on how the enterprise is positioned in the ICT marketplace, e.g. which of the existing ICT in the marketplace it is going to use, which are their required performance and cost attributes, what kind of relations it has with their vendors, such as outsourcing, strategic alliances, etc.) and one component concerning the 'internal domain' (=decisions on how the internal ICT infrastructure of the enterprise will be configured and managed: ICT architecture, processes and skills), which should be well integrated. Similarly it views business strategy as consisting of two components which should be also well integrated: one component concerning the 'external domain' (= decisions about business scope, distinctive competencies and business relations with other organizations) and one component concerning the 'internal domain' (= decisions about its administrative infrastructure/architecture, business

processes and human resources skills). In the functional integration dimension the model views two domains, the business domain and the IS/ICT domain, and proposes integration between them at two levels: 'strategic integration' (=integration between their external domain components) and 'operational integration' (=integration between their internal domain components).

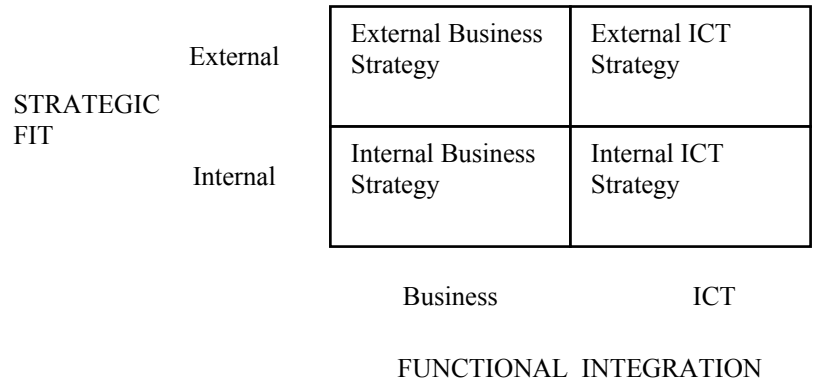


Figure 3. The 'Strategic Alignment Model' (SAM), Henderson, J. C., Venkatraman, H. (1999)

Based on the above dimensions the SAM proposes that the complete enterprise systems strategic alignment consists in the integration between these four domains of strategic choice: business external strategy, ICT external strategy, business internal strategy and ICT internal strategy. Also using this model the authors propose and describe four alignment perspectives: business strategy execution (external business strategy → internal business strategy → internal ICT strategy), technology-based transformation (external business strategy → external ICT strategy → internal ICT strategy), exploitation of ICT competitive potential (external ICT strategy → external business strategy → internal business strategy) and service level improvement (external ICT strategy → internal ICT strategy → internal business strategy).

Smaczny (2001) argues that a major disadvantage of the SAM is that its basic alignment approach is the sequential development of strategies; he states that this approach was the appropriate one for the period in which SAM was developed (characterized by a more stable business environment), but latter, due to major market changes and also due to the increased reliance of organizations on ICT, it has become slow and insufficient (at least for some industries and business contexts). For this reason he proposes

a ‘fusion’ approach instead, which allows business and ICT strategies to be developed and implemented simultaneously.

On the contrary Avison et al (2004) used successfully and validated this SAM in a financial services firm, and finally concluded that it has a good conceptual and practical value; also they developed a framework for its practical application, which enables the technology and business management to determine the current level of alignment and to monitor and change it in the future as required.

Furthermore, it is worth mentioning another approach that developed by Van Der Zee & De Jong (1999) for planning and setting goals for ICT and evaluating its results based on the business context, which is founded on the concepts of the Balanced Business Scorecard.

Also, a number of models/frameworks have been developed for assisting technical and business management in assessing the level of ICT strategic alignment in their organization. The most widely used of them is the ‘Strategic Alignment Maturity Model’ (SAMM) developed by Luftman (2000); it is based on six criteria of ICT strategic alignment maturity (Communications Maturity, Competency/Value Measurement Maturity, Governance Maturity, Partnership Maturity, Scope & Architecture Maturity, Skills Maturity), each of them consisting of a number of attributes (sub-criteria), which are evaluated in a five-levels scale (Initial/Ad-hoc Process, Committed Process, Established Focused Process, Improved/Managed Process, Optimised Process).

The SAMM enables the evaluation of ICT alignment practices in an organization and also the design of improvements of them. Another IT alignment maturity model has been developed by the IT Governance Institute (ITGI) (www.itgi.org) as part of the CobiT (Control objectives for IT and related Technologies) framework (ITGI, 2005). In particular, CobiT includes a process named ‘Define a Strategic Information Technology Plan’, which aims to satisfy ‘the business requirement to strike an optimum balance of Information Technology opportunities and IT business requirements’; this process includes a strategic alignment maturity model consisting of six levels (0:Non-existent, 1:Initial/AdHoc, 2:Repeatable and Intuitive, 3:Defined Process, 4:Managed and Measurable, 5:Optimized) and also guidance for using it in order to assess the maturity level of an organization.

Bleistein et al (2006a, 2006b) argue that ICT strategic alignment is necessary not only at the executive level, but also at the level of the

individual IT projects as well; in this direction they propose a requirements engineering framework that addresses the business strategy and the alignment of IT projects' requirements with business strategy.

4.2.3 Impact of ICT strategic alignment on business performance

However, only a small part of the extensive research that has been conducted on ICT strategic alignment is dealing with its impact on business performance, despite the critical importance of this question. In the following we review the main empirical studies that have been conducted in this direction.

King and Teo examined empirically the impact of four types of integration between the business plan (BP) and the information plan (ISP) (administrative, sequential, reciprocal, full integration) on the perceived extent of various kinds of ISP problems (concerning organization, implementation, database, hardware and cost) and also on the perceived IS contribution to various measures of organizational performance (Teo and King 1996, King and Teo 2000); using data from 157 large USA firms from the Corporate 1000 Book they found that the extent of BP-ISP integration has a statistically significant positive relation with the perceived IS contribution to organizational performance, and also a statistically significant negative relation with the perceived extent of ISP problems.

Chan et al (1997) investigated empirically the impact of IS strategic alignment on perceived IS effectiveness and perceived business performance; using data from 164 North-American financial services and manufacturing firms from the Dun and Bradstreet directories (from USA and Canada) with more than 100 employees they constructed a structural equations model (SEM), from which it was concluded that IS strategic alignment has statistically significant positive contributions to both perceived IS effectiveness and perceived business performance.

Using the same data Sabherwal and Chan (2001) addressed the same research question, but in regard to business strategy, considering three different business strategies: for 'defenders', 'prospectors' and 'analyzers'; their results indicate that ICT strategic alignment affects perceived business performance, but only in some organizations that adopt a 'prospector' or 'analyzer' business strategy, and not in the ones adopting a 'defender' business strategy.

Cragg et al (2002) examined the link between IT strategic alignment and four measures of perceived firm performance in the context of small firms; using data from 250 small UK manufacturing firms they concluded that the subgroup of them with higher levels of alignment had higher levels of all these four measures of perceived firm performance than the subgroup with lower levels of alignment.

Bergeron et al (2003), based on data collected through a mail survey from 110 Canadian small and medium firms (having between 10 and 300 employees), and using cluster analysis found that low-performance firms exhibited a conflictual coalignment pattern of business strategy, business structure, IT strategy and IT structure.

The only previous empirical investigation of the impact of ICT alignment on business performance that has been based on objective measures of business performance and IS contribution to it was the one conducted by Byrd et al (2005); based on data from 275 companies in South-eastern USA that manufacture fabricated metal products, they constructed econometric models with sales revenue per employee and profit per employee as dependent variables, while as independent variables they used: a) the IT expenditure per employee, b) a measure of IS strategic alignment (examining four different IS strategic alignment measures) and c) an interaction term equal to the product of the above two variables (the IT expenditure per employee and the IS strategic alignment measure). In all these econometric models the coefficient of this interaction term was found to be positive and statistically significant, so it was concluded that there is a synergistic coupling (positive interaction) between IT strategic alignment and IT investment with respect to firm performance. However, the econometric models constructed in this study were partial, since they did not include some necessary independent variables, such as non-IT capital and labour; according to fundamental production economics the output of a firm is a function of the labour and the capital it uses, so most of the published quantitative studies of the contribution of IS investment to business performance (e.g. Brynjolfsson and Hitt 1996, Stolarick 1999, Ramirez 2003, Arvanitis 2005, Hempell 2005, Loukis, Sapounas and Aivalis 2006) are based on the well-established and validated Cobb-Douglas production function, which expresses firm output as an exponential function of labour and capital (which is usually divided into IT capital and non-IT capital, in order to examine whether these two types of capital have different elasticities and marginal productivities).

According to the econometrics literature (e.g. Greene 2003, Gujarati 2003) the omission of a necessary independent variable (model underfitting) introduces biases in the estimation of the model coefficients. In particular each of the coefficients will be overestimated, if the corresponding independent variable is positively correlated with the omitted independent variable, or will be underestimated, if the corresponding variable is negatively correlated with the omitted independent variable; taking into account that in the above study the omitted independent variables (non-IT capital and labour) are probably positively correlated with the included variables (IT expenditure per employee, IS strategic alignment measure and interaction term), it is likely that their calculated coefficients might be overestimated.

From the above review of the relatively few empirical studies that have been conducted about the contribution of ICT strategic alignment to business performance it is concluded that nearly all of them (with the exception of the one conducted by Byrd et al (2005)) are based on managers' subjective perceptions of business performance or contribution of IS to business performance, as dependent variables, and do not use objective measures of them; also, as explained above, the only of these studies that uses objective measures (by Byrd et al 2005) is based on partial models.

Another characteristic of these previous studies is their focus on ICT strategic alignment only in the formulation of strategy at the executive level; however, they are not dealing with ICT strategic alignment in the middle and the lower hierarchical levels, and also in the strategy implementation phase. Therefore further empirical research is required concerning the contribution of ICT strategic alignment to business performance, in many different national contexts, based on quantitative business performance measures and bigger firm samples, and examining ICT strategic alignment in both strategy formulation and implementation, and also at various hierarchical levels.

4.3 Hypotheses, Method and Data

The basic mechanism for ICT alignment is to establish a bilateral relationship between the ICT Plan and the Business/Strategy Plan formulation processes, which allows:

- the mission, goals, competitive strategy, future directions, action plan, etc. of the company, and also the analysis of its external environment (e.g. competition, opportunities, threats, etc.) and the analysis of its internal environment (e.g. capabilities, strengths, weaknesses, etc.), which are basic elements of Business/Strategy Plan, to be taken into account for the formulation of the ICT Plan,

- and also the capabilities, strengths and weaknesses of existing and planned IS, the forms and the extent of ICT usage in the industry, the emerging ICT that may interest and influence the company, etc., which are basic elements of the ICT Plan, to be taken into account for the formulation of the Business/Strategy Plan.

This bilateral co-ordination results in the selection of the most appropriate IS investments, which support to the highest possible extent the selected business strategy and action plan of the company. The analysis of its internal environment constitutes a very good foundation for determining the most appropriate internal IS that should be built, in order to support its internal business functions, reinforce its strengths and reduce its weaknesses; also it allows to use ICT in combination with unique resources of the company, in order to reinforce their potential for providing sustainable competitive advantage. The analysis of the external environment of the company constitutes a very good foundation for determining the most appropriate inter-organizational and 'outward-looking' (e.g. Internet-based) IS that should be developed, for connecting the company with customers, suppliers and business partners.

Furthermore, the whole process followed for achieving a bilateral relationship between the ICT Plan and the Business/Strategy Plan increases IS managers' business awareness and knowledge and executives' awareness and knowledge about the capabilities and opportunities offered by ICT; also it builds mutual understanding and communication between executives and IT managers and facilitates a fruitful knowledge sharing among them, which can produce ICT-based competitive advantages (Kearns and Lederer 2003).

Armstrong and Sambamurthy (1999) have concluded that the inclusion of IT managers in the top management team and their formal and informal interactions with it increase their knowledge on business strategy and processes and their capability to optimise IS investment and utilize better the existing IS. For the above reasons, we calculated a composite ICT

strategic alignment index (STRAL-ICT) as the sum of the following ICT strategic alignment variables:

- The degree of bilateral relationship between the ICT Plan and the Business/Strategy Plan (BP-ICTP)
- The degree of involvement of the organizational units (e.g. directorates, departments) of the business in the formulation of the ICT Plan (OU-ICTP)
- The degree of involvement of the organisational units (e.g. directorates, departments) of the business in IS and applications development projects (OU-PROJ)
- The degree of involvement of the organisational units (e.g. directorates, departments) of the business in decision making concerning ICT issues (OU-ICTD)

Before we used the above-mentioned ICT strategic alignment composite Index, we tested it for convergent validity and reliability, according to the relevant multi-variable literature (Byrne (2001), Straub et al (2004), Kline (2005)). Then, we tested our first hypothesis H1:

H1: the degree of ICT strategic alignment affects positively the contribution of ICT to business performance

Also, the exploitation of the great strategic potential of ICT, which has been analysed briefly in the first paragraph of the previous 'Literature Review' section, necessitates a close and bilateral interaction between ICT strategy and business strategy; only such an interaction can enable and facilitate the conception of new ideas concerning ICT-based product and process innovations and other ICT-based ways of achieving competitive advantage. For the above reasons we expect that higher level of bilateral relationship between the ICT Plan and the Business/Strategy Plan might increase the contribution of ICT to business performance. Therefore our second hypothesis H2 is:

H2: the degree of bilateral relationship between the ICT Plan and the Business/Strategy Plan affects positively the contribution of ICT to business performance

The relevant literature has repeatedly and consistently underlined the need of ICT strategic alignment not only at the executive level, but also throughout the hierarchy, covering the middle and the lower hierarchical

levels as well, and also the whole strategy lifecycle, including both formulation and implementation phases (e.g. Chan and Huff 1992, Luftman et all 1999, Luftman 2000, Allen and Wilson 2003, Rantham et al 2004, Campbell et al 2005, Bleistein et al 2006a, Bleistein et al 2006b, Gutierrez et all 2006).

Chan and Huff (1992) emphasize that strategies (both business and ICT ones) are developed at the higher hierarchical levels, but essentially implemented at the middle and the lower hierarchical levels of an organization, so more attention needs to be paid to the dynamics of ICT alignment at these levels.

Campbell and Kay (2005) concluded that both researchers and practitioners need to consider ICT alignment issues at all levels of the organization; it is not sufficient to develop aligned strategies at the executive level, but it is necessary to ensure that alignment occurs during implementation. They also state that alignment at one level does not guarantee alignment at the other levels.

Furthermore, the strategic management literature (e.g. Davies 1993, Wheelen and Hunger 2004, Johnson and Scholes 2005) emphasize that very good strategies sometimes are not implemented properly, so the outcomes are finally much lower than the expectations; for this reason they recommend that appropriate mechanisms should be set-up for the communication of the strategy to the middle and lower hierarchical levels, and also to the organization of its complete and proper implementation at these levels.

Therefore, it is necessary to examine to what extent other mechanisms of ICT alignment, which concern the middle and lower hierarchical levels, and also both strategy formulation and implementation, increase the contribution of ICT to business performance. In this direction the second ICT alignment mechanism we examined concerned ICT strategy formulation at the middle and lower hierarchical levels: it was the involvement of the organizational units (e.g. directorates, departments) of the business in the formulation of the ICT Plan. We expect that their contribution will improve substantially the ICT Plan (e.g. concerning the IS that should be developed for offering them support in implementing the business strategy, or additional IS that will enable innovations, offer competitive advantages, etc.), so it might increase the contribution of ICT to business performance. Thus, our third hypothesis H3 is:

H3: the degree of involvement of the organizational units (e.g. directorates, departments) of the business in the formulation of the ICT Plan affects the contribution of ICT to business performance

The above-mentioned ICT alignment mechanisms, we examined in the above direction, concern ICT strategy implementation. The ICT strategy is implemented mainly through IS and applications development projects, in which the involvement of the organisational units (e.g. directorates, departments) that will use them is necessary for aligning them with their work methods and processes that reflect the business strategies (e.g. Avison & Fitzgerald 2002, Bleistein et al 2006a, Bleistein et al 2006b).

For this reason the next ICT alignment mechanism we examined was the involvement of the organizational units of the business in IS and applications development projects. We expect that their contribution will improve substantially these new IS and applications (e.g. by defining appropriate requirements so that the implementation of the business strategy is supported to the highest possible extent, by testing them and identifying problems that may prevent or decrease the support they offer to business strategies, etc.), so it might increase the contribution of ICT to business performance. Thus, our fourth hypothesis H4 is:

H4: the degree of involvement of the organisational units (e.g. directorates, departments) of the business in IS and applications development projects affects the contribution of ICT to business performance

However, the implementation of ICT strategy is not limited to IS and applications development projects, but also includes other decisions and actions concerning ICT issues (e.g. concerning IS operations, maintenance, support, upgrades, level of services, solutions of various kinds of IS-related problems, etc.). For this reason the last ICT alignment mechanism we examined was the involvement of the organizational units of the business (e.g. directorates, departments) in decisions concerning ICT issues. We expect that their involvement in these decisions will increase the support offered by the IS to the implementation of business strategy, so it might increase the contribution of ICT to business performance. Thus, our fifth hypothesis H5 is:

H5: the degree of involvement of the organisational units (e.g. directorates, departments) of the business in decision-making concerning ICT issues affects the contribution of ICT to business performance

For testing the above fifth hypotheses H1 – H5, we constructed econometric models for firm output, which are based on the microeconomic production theory, and in particular on the Cobb-Douglas production function; the Cobb-Douglas production function has been extensively used in the past for estimating the contribution to firm output of various firm inputs, including ICT investment (e.g. Brynjolfsson & Hitt 1996, Stolarick 1999, OECD 2003, Ramirez 2003, OECD 2004).

In particular, we used an extended form of the Cobb-Douglas production function, in which the capital is divided into computer capital and non-computer capital:

$$VA = e^{\beta_0} L^{\beta_1} K^{\beta_2} CK^{\beta_3} \qquad (4.1)$$

where VA is the yearly firm value added (which is equal to yearly sales revenue minus yearly expenses for buying materials and services), and L, K and CK are the yearly labour expenses, the non-computer capital and the computer capital respectively, while the $\beta_1 - \beta_3$ are the corresponding output elasticities with respect to these three inputs. By log-transforming this model, we obtain the following linear model:

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK) + u_t \qquad (4.2)$$

In order to investigate the effect of each of the above fifth ICT alignment mechanisms of hypotheses H1 to H5 on the contribution of ICT to value added, we added to this model one more 'interaction term', which is equal to the product of the corresponding factor variable to the ln(CK):

$$\ln VA = \beta_0 + \beta_1 \ln(L) + \beta_2 \ln(K) + \beta_3 \ln(CK) + \beta_4 \ln(CK) \cdot F + u_t \qquad (4.3)$$

This approach offers the advantages of using an objective measure of business performance (the VA) and also of estimating objectively the contribution of the computer capital to this measure of business performance (coefficient β_3 of equation 4.3) and its increase due to ICT strategic alignment (coefficient β_4 of equation 4.3); furthermore, it includes all the necessary independent variables that according to production economics affect the dependent variable (i.e. not only the computer capital, but also the non-computer capital and the labour expenses), so that we do not have problems of omission of important independent variables (model underfitting).

The data we used in this study for constructing the econometric models were collected through a survey among Greek companies, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies', in cooperation with ICAP, one of the

largest business information and consulting companies of Greece. As we mentioned in the 'Introduction', three samples of 300 Greek firms each were randomly selected from the database of ICAP (all these three samples included firms from the same industries and sizes), which includes financial and other business information for approximately 135,000 Greek firms, and consisted of 304 Greek companies from the 27 most important sectors of Greek economy (Appendix B). Initially the questionnaire was sent by post to the firms of the first sample; after three weeks the firms who had not responded were contacted by phone. Firms that definitely refused to participate in this survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample, while in a few cases that exhausted the firms of the second sample we had to proceed to the third sample. Following the above procedure, which aimed to maintain the proportions of the industry and size classes, we received answered questionnaires from 281 companies (88 small, 105 medium and 78 large ones), so the response rate was 92.4%.

4.4 Results

As mentioned previously, before we used the above-mentioned ICT strategic alignment composite Index, we tested it for convergent validity and reliability, according to the relevant multi-variable literature (Byrne (2001), Straub et al (2004), Kline (2005)). In particular, we conducted a Principal Component Analysis for the above four mentioned ICT strategic alignment variables, which gave as only one main component, so we concluded that the four above mentioned variables converge to one factor, the ICT strategic alignment composite Index. In order to confirm the previous result, we conducted a Confirmatory Factor Analysis, supposing that the four ICT strategic alignment variables reflect one factor. The previous hypothesis was confirmed given that all the Incremental Fit Indices (NFI, RFI, IFI, TLI, CFI) exceeded the level of 0.9, according to the relevant multi-variable literature. Furthermore, RMSEA is lower from the maximum permissible level of 0.08, according to the relevant literature and also the standardized loadings of the four ICT alignment variables were all statistically significant and exceeded the lower level of 0.06, according to the relevant literature. So, we confirmed that the four above-mentioned ICT alignment variables converge to one factor. On the other hand, for reliability test, we measure Cronbach Alpha coefficient (0.839). It exceeded the lower level of

0.7, according to the relevant literature. Therefore, we confirmed for the ICT strategic alignment composite Index for convergent validity and reliability.

Then, having confirmed the convergent validity and the reliability of this ICT strategic alignment composite Index, we estimated the model of equation (4.2) of the previous section, and the results are shown in Table 10. We remark 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. These results confirm the conclusion of a previous study (Loukis and Sapounas 2004) that ICT investments of Greek companies make a positive and statistically significant contribution to their output. Also from the standardized coefficients we can see that the computer capital has a higher impact on firm value added (0.233) than the non-computer capital (0.140).

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	2.313		0.000
ln (L)	0.608	0.581	0.000
ln (K)	0.122	0.140	0.002
ln (CK)	0.235	0.233	0.000
R-squared : 0.723			

Table 10. Regression model for the impact of labour, non-computer capital and computer capital on firm value added

In order to examine the effect of each of the abovementioned fifth ICT alignment mechanisms on the contribution of ICT to value added, we estimated the model of equation (4.3) for each of the fifth variables of the research hypotheses H1 to H5 (STRAL-ICT: composite ICT strategic alignment Index, BP_ICTP: degree of bilateral relation between the ICT Plan and the Business/Strategy Plan, OU_ICTP: degree of involvement of the organisational units in the formulation of the ICT plan, OU_PROJ: involvement of the organisational units in IS and applications development projects and OU_ICTD: involvement of the organisational units in the decision-making concerning ICT issues).

We can see these five models in Tables 11-15 respectively. In order to compare the increases of the impact of ICT capital to the firm value added caused by the fifth above-mentioned ICT alignment mechanisms, we calculated for each of these corresponding models the 'ICT Impact Increase Factor' (IIF), calculated using the following formula:

$$IIF = \frac{SC[\ln(CK)\cdot F]}{SC(CK)} \quad (4.4)$$

where SC(CK) is the standardized coefficient of computer capital and $SC[\ln(CK)\cdot F]$ is the standardized coefficient of the interaction term.

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	2.855		0.000
ln (L)	0.544	0.520	0.000
ln (K)	0.106	0.134	0.001
ln (CK)	0.244	0.271	0.000
STRAL_ICT	0.047	0.127	0.000
R-squared : 0.761		IIF=0.47	

Table 11. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and composite ICT strategic alignment Index on firm value added

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	3.186		0.000
ln (L)	0.541	0.518	0.000
ln (K)	0.102	0.130	0.002
ln (CK)	0.245	0.271	0.000
BP_ICTP	0.108	0.120	0.001
R-squared : 0.758		IIF=0.44	

Table 12. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and degree of bilateral relation between the ICT Plan and the Business/Strategy Plan on firm value added

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	2.915		0.000
ln (L)	0.543	0.520	0.000
ln (K)	0.105	0.133	0.002
ln (CK)	0.256	0.283	0.000
OU_ICTP	0.130	0.097	0.006
R-squared : 0.755		IIF=0.34	

Table 13. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and degree of involvement of the organisational units in the formulation of the ICT Plan on firm value added

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	2.547		0.000
ln (L)	0.550	0.526	0.000
ln (K)	0.113	0.143	0.001
ln (CK)	0.252	0.279	0.001
OU_PROJ	0.165	0.117	0.000
R-squared : 0.739		IIF=0.42	

Table 14. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and degree of involvement of the organizational units in IS and applications development projects on firm value added

Dependent variable : ln (VA)			
Independent variable	Coefficient	Standardized Coefficient	Significance
constant	2.500		0.000
ln (L)	0.552	0.528	0.000
ln (K)	0.113	0.144	0.001
ln (CK)	0.268	0.297	0.000
OU_ICTD	0.108	0.074	0.027
R-squared : 0.729		IIF=0.25	

Table 15. Regression model for the impact of labour, non-computer capital, computer capital and interaction between computer capital and degree of involvement of the organisational units in the decision-making concerning ICT issues on firm value added

Initially we examine the impact of one composite ICT strategic alignment Index and four ICT alignment mechanisms that concern the ICT strategy formulation. In the model of Table 11 we remark that the coefficient of the interaction term is positive and statistically significant (since its significance lower than 5%). Therefore a higher degree of composite ICT strategic alignment Index will increase the contribution of ICT investment to firm value added. This finding supports hypothesis H1. From the same Table we can see that the IIF (i.e. the ratio of the standardized coefficient of the interaction term to the standardized coefficient computer capital) equals to 0.127/0.271=0.47, which means that this composite ICT alignment variable causes a mean increase of the impact of ICT capital to the firm value added by 47%. So it can be concluded that the composite ICT alignment Index increases significantly ICT business value.

Similarly in the model of Table 12 we remark that the coefficient of the interaction term is positive and statistically significant (since its significance lower than 5%). Therefore a higher degree of bilateral relation between the ICT Plan and the Business/Strategy Plan will increase the contribution of ICT investment to firm value added. This finding supports hypothesis H2. From the same Table we can see that the IIF (i.e. the ratio of

the standardized coefficient of the interaction term to the standardized coefficient computer capital) equals to 0.120/0.271=0.44, which means that bilateral relation between the ICT Plan and the Business/Strategy Plan causes a mean increase of the impact of ICT capital to the firm value added by 44%. So it can be concluded that bilateral relation between the ICT Plan and the Business/Strategy Plan increases significantly ICT business value.

Similarly in the model of Table 13 we remark that the coefficient of the interaction term is positive and statistically significant (its significance being lower than 5%). Therefore a higher degree of involvement of the organisational units (e.g. directorates, departments) in the formulation of the ICT Plan will increase the contribution of ICT investment to firm value added. This finding supports hypothesis H3. From the same Table we can see that in this model the IIF equals to 0.097/0.283=0.34, which means that this ICT alignment mechanism causes a mean increase of the impact of ICT capital to the firm value added by 34%. Therefore the involvement of the organisational units in the formulation of the ICT plan increases significantly ICT business value as well, but to a slightly lower extent than the bilateral relation between the ICT Plan and the Business/Strategy Plan.

Next we examine the impact of the other two ICT alignment mechanisms that concern the ICT strategy implementation. In the model of Table 14 we can see that the coefficient of the interaction term is positive and statistically significant (its significance being lower than 5%), which means that a higher degree of involvement of the organizational units in IS and applications development projects will increase the contribution of ICT investment to firm value added. This finding supports hypothesis H4. From the same Table we can see that in this model the IIF equals to 0.117/0.279=0.42, which means that this implementation-level ICT alignment mechanism causes a mean increase of the impact of ICT capital to the firm value added by 42%. Therefore the involvement of the organizational units in IS and applications development projects increases quite significantly ICT business value, to a much higher extent than all the examined ICT alignment mechanisms.

Finally by examining the model of Table 15 we can see that the coefficient of the interaction term is positive and statistically significant (its significance being lower than 5%), which means that a higher degree of involvement of the organisational units decision-making concerning ICT issues will increase the contribution of ICT investment to firm value added. This finding supports hypothesis H5. From the same Table we can see that in

this model the IIF equals to 0.074/0.297=0.25, which means that this ICT alignment mechanism causes a mean increase of the impact of ICT capital to the firm value added by 25%. Therefore the involvement of the organisational units in decision-making concerning ICT issues increases significantly ICT business value as well, but to a lower extent than all the other mechanisms we examined.

4.5 Conclusions

In this part of our study, it has been presented an empirical investigation of the impact of 'multi level' ICT alignment, incorporating four different mechanisms of ICT strategic alignment, which concern different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by ICT, based on firm-level data from Greek companies. It uses objective measures of business performance (value added calculated as yearly sales revenue minus yearly expenses for buying materials and services) and ICT investment, and also objective estimation (through complete econometric models based on the Cobb-Douglas production function) of the contribution of ICT to this measure of business performance.

Our main conclusion is that ICT strategic alignment results in a significant increase (by about 47% on average) of the business value generated by ICT. Furthermore, all the four ICT strategic alignment mechanisms we examined cause a significant increase of the business value generated by ICT. The bilateral relationship between the ICT Plan and the Business/Strategy Plan and the involvement of the organisational units (e.g. directorates, departments) of the business in IS and applications development projects have the most increasing impact to the ICT business value (by about 42% and 44% on average respectively). The implication of this conclusion for business managers is that it is worth committing resources to ICT strategic alignment, since the benefits it offers are quite significant.

Our third conclusion is that significant increase of ICT business value can be achieved not only through the 'classic' ICT strategic alignment mechanisms that concerns strategy formulation at the executive level, which have attracted most of the research attention, but also through ICT alignment mechanisms at the middle and the lower hierarchical levels that concern both strategy formulation and implementation.

4.6 Contribution

The first contribution of this part of our study is the formulation and statistical assessment (as to convergent validity and reliability) of a composite ICT strategic alignment Index, which takes into account four different mechanisms of ICT strategic alignment at different hierarchical levels. Initialy we examine its validity and reliability. Then we used it for investigating the impact of ICT strategic alignment on ICT business value, and we concluded that it causes a significant increase (47%) of the business value generated by ICT. It should also be noted that in this investigation we used objective measures of business performance and ICT investment, and also objective estimation of the contribution of ICT to business performance.

A second contribution is that we investigated the effect of each of these different mechanisms of strategic alignment, which concern different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by ICT investment. We found that the highest increase of ICT business value is caused by the bilateral relationship between the ICT Plan and the Business/Strategy Plan and the involvement of the organisational units (e.g. directorates, departments) of the business in IS and applications development projects.

Based on the results and contributions of this dissertation the following publication has been produced:

Loukis, E., Sapounas, I., Aivalis, K. (2009), "Enterprise Systems Strategic Alignment and Business Value", reviewed chapter in the Handbook of Research on Enterprise Systems, pp. 152-168, Idea Group Inc

CHAPTER 5:

NEW FORMS OF WORKPLACE ORGANIZATION AND LABOUR PRODUCTIVITY IN GREECE AND SWITZERLAND

5.1 Introduction

The modern economy is characterized by an increasing importance of some 'new' production factors, such as human skills (often referred to as 'human capital'), new workplace organization (often referred to as 'organizational capital'), information and communication technologies (ICT) ('technological capital') and knowledge capital, in addition to the traditional production factors (i.e. the 'traditional' physical capital and the labour). In most developed and developing countries firms make big investments for acquiring and using these new production factors, so it is of critical importance to investigate their contribution to the impact on firm performance.

In this direction, considerable research has been performed, concerning the impact of ICT investments on firm performance. As we mentioned in the 'Introduction', this research initially found very little empirical evidence of a positive contribution of ICT investment to firm performance, giving rise to the 'ICT Productivity Paradox' (Brynjolfsson 1993); however more recent research in this area produced some empirical evidence of positive contribution of ICT investment to several measures of firm performance (OECD 2004), probably reflecting the improvements in ICT use and exploitation by firms that had taken place in-between.

Also, the contribution of human capital to economic growth at aggregate, sector and firm level has been researched and recognized (e.g. Barro 1999, Middendorf 2006). Recently there has been research interest in new organizational practices, such as 'employee voice' and new forms of 'work design', and their impact on firm performance (e.g. Murphy 2002, Black and Lynch 2004).

In the same direction, the research that has been conducted on the impact of ICT capital on firm performance, has produced some first evidence that the contribution of ICT investments can increase significantly, if they are combined with the development of new work practices, business processes,

organisational structures, skills, etc. (e.g. Devaraj and Kohli 2000, Brynjolfsson and Hitt 2000). A number of empirical studies have been conducted in order to investigate the impact of the above three factors - ICT capital, human capital and new organizational practices on firm performance, which have produced some first conclusions on these critical questions, and also some first evidence supporting the existence of such complementarities.

However, we remark that between the conclusions of these studies there are some similarities, but also several differences as well, which might be (at least to some extent) due to differences in sample composition (the samples of these studies are from different sectors and industries), in national context (different countries), in variables and models specification and also in the nature of the investigations (cross-sectional versus longitudinal).

Therefore, further empirical research is required concerning the impact of ICT capital, human capital, new organizational practices on firm performance. More empirical studies need to be conducted, covering different sectors and industries (in order to understand better the effect of sector and industry characteristics on the above impacts), and also several different national contexts, including not only highly developed countries but also less developed countries as well (in order to understand better the effect of national context on the above impacts).

In these directions, in this part of our study we describe a comparative empirical study of the effect of ICT capital, human capital, new organizational practices, also controlling for the knowledge capital, on labour productivity in Greece and Switzerland, based on firm-level data from both countries. Its analytical framework is that of a firm-level production function. Both the Greek and the Swiss parts of this study are based on firm-level data collected through the same questionnaire and from samples of similar composition (concerning firm sizes and sectors), and also use the same variables and models specification, so they are comparable.

5.2 Review of Previous Relevant Research

As mentioned in the 'Introduction', the business value generated by the significant financial resources invested by organizations in information and communication technologies (ICT) has been a major research topic in the area of information systems (IS) for long time (for more than 20 years), due to its vital importance for the ICT industry, the IS practitioners and the

public policy makers. Extensive research has been conducted on this topic, in order to assess and understand the business value of ICT investment and also to produce some evidence that the contribution of ICT investments can increase significantly, if they are combined with the adaptation and modification of existing work practices, business processes, organisational structures, skills, etc., which have been designed mostly in the pre-ICT era, so they do not take into account the capabilities offered by ICT (e.g. Devaraj and Kohli 2000, Brynjolfsson and Hitt 2000, Ramirez 2003, OECD 2003); according to Brynjolfsson and Hitt (2000) "...both case studies and econometric work point to organizational complements such as new business processes, new skills and new organizational and industry structures as a major driver of the contribution of information technology".

Another research stream empirically investigates simultaneously the impact of ICT, organizational capital and human capital (or at least two of them) on business performance; In Table 16 we can see the main empirical studies that have been conducted in this research stream and their conclusions.

Table 16. Summary of the Empirical Literature

Study	ICT	ORG	HC	Complementarity
USA:				
Black/Lynch (2000)				
- cross-section	positive	positive	n.s.	n.s.
- longitudinal	positive	positive	n.s.	n.s.
Capelli/Neumark (2001)				
- cross-section	positive	positive	n.s.	n.s.
- longitudinal	positive	positive	n.c.	n.s.
Bresnahan et al. (2002)				
- cross-section	positive	positive	positive	ORG/ICT; HC/ICT
Brynjolfsson et al. (2002)				
- longitudinal	positive	n.s.	n.c.	ORG/ICT
Australia:				
Gretton et al. (2002)				
- longitudinal	positive	positive	positive	ORG/ICT; HC/ICT
Germany:				
Bertschek/Kaiser (2001)				
- cross-section	positive	positive	n.c.	n.s.
Wolf/Zwick (2002)				
- longitudinal	positive	positive	positive	n.c.
Hempell (2003)				
- longitudinal	positive	n.c.	n.s.	ICT/HC
Bauer (2003)				
- cross-section	n.a.	n.s.	n.a.	n.c.
- longitudinal	n.a.	positive	n.a.	n.c.

France:				
Caroli/Van Reenen (2001)				
- longitudinal	n.s.	positive	n.s.	ORG/HC
Switzerland:				
Arvanitis (2005)				
- cross-section	positive	positive	positive	ICT/HC
UK:				
Crespi et al. (2006)				
- longitudinal	positive	n.s.	n.c.	ICT/ORG

Notes: the dependent variable is average labour productivity; ICT: information and communication technologies; ORG: workplace organization; HC: human capital; „positive“: statistically significant (at the test level of 10%) positive coefficient of the variables(s) for ICT, ORG and HC respectively; n.s.: statistically not significant (at the test level of 10%); n.c.: not considered; n.a.: not avaiable (for such cases in which the corresponding variables are included in the models, but the results are not explicitly presented).

According to Table 16, Black and Lynch (2000) examined the impact of workplace innovation on labour productivity using cross sectional data from a representative sample of US manufacturing employers in 1993. This survey contained a wealth of information on workplace organization, information technology and human capital investments of individual employers during 1993. They used these data along with additional longitudinal information on past output, employment and capital investment to estimate the relationship between workplace practices and labour productivity. In both of these studies, they found that workplace practices do matter for labour productivity. However, the authors found that what was associated with higher productivity was not so much whether an employer adopted a particular work practice but rather how that work practice was actually implemented within the establishment. For example, simply adopting a Total Quality Management system has an insignificant or negative impact on productivity unless the proportion of workers involved in regular decision-making within the plant is also high. In other words, it is not so much what you say you do, but how you do it that matters.

Cappelli and Neumark (2001), using the same surveys as in Black and Lynch (2000) previous research, examined the relationship between productivity, wages, and workplace practices. However, they only studied manufacturing establishments, which were in existence from 1977–96. They estimated the impact of workplace practices on the change in labour productivity of these establishments over the period 1977–93 and 1977–96. However, any manufacturing establishment that was ‘born’ after 1977 is excluded from

their analysis. They do this to address the problem of omitted variable bias associated with unobserved establishment characteristics but the assumption that no US establishments in 1977 used any high performance practices (e.g., profit sharing, employee participation in decision making, or investments in human capital) is an incorrect characterization of US employers. In addition, during the 1980's and 1990's many firms opened brand new plants to implement new forms of workplace organisation. To exclude these types of establishments as well from the analysis significantly reduces the generalisability of the results and may bias them against finding any effect of workplace practices on productivity.

Bertschek & Kaiser (2001) analyzed the relationship between ICT investment, non-ICT investment, labour productivity and workplace re-organization. Firms were assumed to re-organize workplaces if the productivity gains arising from workplace re-organization, exceeding the associated re-organization costs. Two different types of organizational change were considered: introduction of group-work and flattening of hierarchies. Empirical evidence was provided for a sample of 411 firms from the German business-related services sector. The authors developed and estimated a model for labour productivity and firms' decision to re-organize workplaces that allows workplace re-organization to affect any parameter of the labour productivity equation. The methodology they used allowed them to take account of strategic complementarities between the input factors and workplace re-organization. The estimation results showed that changes in human resources practices did not significantly affect firms' output elasticities, with respect to ICT capital, non-ICT capital and labour, although most of the point estimates of the individual output elasticities and of the control variables for observable firm heterogeneity were larger, if workplace re-organization was realized. The authors applied "Kernel density estimation technique" and demonstrated that for firms with organizational change. The entire labour productivity distribution shifted significantly out to the right, if workplace reorganization took place, indicating that workplace re-organization induced an increase in labour productivity that was attributable to complementarities between the various input factors and workplace reorganization. By contrast, firms without organizational change would not have realized significant productivity gains, if they had re-organized workplaces.

Caroli & Van Reenen (2001) investigated the determination and consequences of organizational changes (OC) in a panel of British and French establishments. Organizational changes included the decentralization of authority, delayering of managerial functions, and increased multi-tasking. The authors argued that OC and skills were complements. They offered support for the hypothesis of "skill-biased" organizational change with three empirical findings. First, organizational changes reduced the demand for unskilled workers in both countries. Second, OC was negatively associated with increases in regional skill price differentials (a measure of the relative supply of skill). Third, OC leaded to greater productivity increases in establishments with human capital, but the effects of OC was not simply due to its correlation with technological change but had an independent role.

Bresnahan et al. (2002) investigated the hypothesis that the combination of three related innovations: information technology, complementary workplace reorganization, and new products and services constitute a significant skill-biased technical change, affecting labour demand in the United States. Using detailed firm-level data the authors found evidence of complementarities among all three of these innovations in factor demand and productivity regressions. In addition, firms that adopt these innovations tended to use more skilled labour. The effects of IT on labour demand were greater when IT was combined with the particular organizational investments they identified, highlighting the importance of IT-enabled organizational change.

By covering several hundred firms over a period of eleven years, Brynjolfsson et al. (2002) explained the extent to which computerization was associated with both direct and indirect measures of intangible assets. This approach helped reveal the pattern of interactions among IT, organizational practices, and market valuations. If these assets are in fact becoming more important in modern economies, in part because of the information revolution engendered by computers and telecommunications, it is incumbent upon us to understand not only particular cases, but also any broader relationships and patterns that exist in the data. Their main results were consistent with each of the testable implications about complementarities between computers and organizational design:

- The financial markets put a higher value on firms with more installed computer capital. The increase in market value associated with each

dollar of IT substantially exceeds the valuation placed on other types of capital.

- Computer-intensive firms tend to have measurably different organizational characteristics, involving teams, more broadly defined jobs, and greater decentralization of certain types of decision-making.
- Firms with these organizational characteristics have higher market valuations than their competitors, even when all their other measured assets are the same.
- Companies with higher levels of *both* computer investment and these organizational characteristics have disproportionately higher market valuations than firms that invest heavily on only one or the other dimension.
- Firms with higher levels of IT, these organizational characteristics, or both have higher measured productivity in subsequent years.

Gretton et al. (2002) brought together aggregate and sectoral growth accounting and econometric analysis of a firm-level longitudinal dataset. The main objectives were to explore the factors affecting the uptake of ICT in Australia and to assess the effects of ICT on output and productivity performance at the aggregate, sectoral and firm levels. The focus had been on ICT products - chiefly, computer hardware and software. ICT services have not been included. This research presented a picture of strong ICT uptake in Australia in the 1990's, which, in concert with restructuring of firms and production, had brought performance gains. The firm-level econometric analysis in this research had found positive links between ICT usage and productivity growth in all industry sectors examined. Significant interactions between ICT use and complementary organisational variables were also found in nearly all sectors. In this study, the complementary factors for which there were data and which were found to have significant influence, were: human capital, innovation, usage of advanced business practices and intensity of organisational restructuring.

Wolf & Zwick (2002) assessed the productivity effects of a broad variety of measures, they simultaneously account for both unobserved heterogeneity and endogeneity, by using establishment panel data for Germany. They showed that increasing employee participation enhance firm productivity in Germany, whereas incentive systems did not foster productivity. Their results further indicated that firms with structural productivity problems

tended to introduce organisational changes that increase employee participation whereas well performing firms are more likely to offer incentives.

Hempell (2003) explored whether ICT investments and firm sponsored training programmes were complementary. Three approaches were applied to panel data from German service companies for the time period 1994–98. Results for a system of interrelated factor demands indicated that training complements ICT, but not other capital goods. SYS–GMM estimates of production functions revealed that ICT capital was most productive, if complemented by training measures in skill–intensive firms. Comparing the impacts on productivity and wage costs showed that ICT raised the profitability of training high–skilled employees.

Using a German employer-employee matched panel dataset, Bauer (2003) examined the effects of High Performance Workplace Systems (HPWS) on labour productivity (defined as sales per worker) and labour efficiency (defined as the inverse of unit labour costs). The estimation results indicated that simple cross-sectional estimates of the effects of implementing HPWS on labour productivity were biased downward due to unobserved time-invariant establishment effects and the endogeneity of the used measure for innovative workplace practices. The latter bias appeared to be quantitatively more important. Results from estimating a correlated random coefficient model further suggested that a potential bias in the 2SLS-estimates due to self-selection seemed to be negligible. The estimated effects of HPWS on labour productivity were economically important and rising over time. However, corresponding positive effects of HPWS on labour efficiency occurred, only in the long run. Finally, due to rising wages associated with the adoption of HPWS, the effects of these systems on labour efficiency were smaller than the corresponding effects on labour productivity.

Arvanitis (2005) explored empirically the hypothesis that ICT, new organizational practices and human capital are important determinants of firm efficiency and performance, further that the combined use of these three factors leads to a mutual strengthening of their impact on firm performance. The analytical framework was that of a production function at firm level. The new contribution of this study to the empirical literature is that it is the first empirical study of this type for the Swiss business sector, using a rich data set at firm level for the year 1999 which were collected by

means of a postal survey, and giving particular attention to the complementarity issue (several approaches) and to the endogenization of the technology and organization variables.

Crespi et al. (2006) examined the relationships between productivity growth IT investment and organisational change, using UK firm panel data. Consistent with the small number of other micro studies, the authors found:

- IT appeared to have high returns in a growth accounting sense, when organisational change was omitted; when it was included the IT returns were greatly reduced
- IT and organisational change interacted in their effect on productivity growth
- Non-IT investment and organisational change did not interact in their effect on productivity growth
- Organisational change was affected by competition
- There were strong effects on the probability of introducing organisational change from ownership. US-owned firms were much more likely to introduce organisational change relative to foreign owned firms which were more likely still relative to UK firms

As we conclude from the previous relevant research, most of these studies find a statistically significant positive effect for ICT and organizational capital, and only few of them for human capital; We remark that most USA studies did not find a statistically significant positive effect for human capital. With respect to these direct effects Swiss firms tend to give more attention to human capital than to organization relative to firms in other countries. Concerning complementarities only two of the USA studies find statistically significant complementarities between ICT and organizational capital, and also between ICT and human capital; also the Australian study shows the existence of complementarities primarily between ICT and human capital and – somewhat weaker – between ICT and organizational capital. In the European studies there is a tendency for complementarities between ICT and human capital and between organizational and human capital. The results are indicative but not completely comparable because some of the observed differences can be traced back to differences with respect to the sectors and industries covered in the studies, the specification of the independent variables and the nature of the investigations (cross-sectional versus longitudinal).

5.3 Conceptional Framework, Hypotheses and Data

5.3.1 The new firm model

The last fifteen to twenty years have witnessed a constellation of important changes of the production process, such as the extensive use of computer-aided production technologies, the advances in information and communication technologies, the emerging of new ideas how to organize firms, changes in the skill requirements of labour and changes in employee preferences toward more flexible working conditions. On this ground, recently many authors even postulated a shift to a new 'firm paradigm'. Some of them focus their attention mainly to technological changes, some find the introduction of new organizational practices a central characteristic of this 'paradigm change', while a third group concentrates primarily on the shift of firm demand to high-skilled labour in the last twenty years and analyzes the determinants of this shift. In this section we briefly review some of this literature. Milgrom and Roberts (1990), focusing mainly to manufacturing, proclaim the replacement of the "mass production model by the vision of a flexible multi-product firm that emphasizes quality and speedy response to market conditions while utilizing technologically advanced equipment and new forms of organization". Changes in the production techniques and their implications for firm efficiency and performance build the main subject of their theoretical analysis. Lindbeck and Snower (2000) analyze the shift from 'tayloristic' organization (characterized by specialization by tasks) to 'holistic' organization (featuring job rotation, integration of tasks and learning across tasks)". In a following paper the same authors elaborate on the idea of the "firm as a pool of factor complementarities", thus identifying factor complementarity as constitutive to the determination of a firm's boundaries (Lindbeck and Snower 2003). Bresnahan et al. (2002) take the relative demand of skilled-labour as starting point of their analysis and consider the increased use of "complementary systems" of information technologies, workplace organization and product innovation as drivers of skill-biased technical change. A point, which is central in all types of analysis and also builds a common characteristic of them is the existence of complementarities among several factors which mutually enhance their impact on firm performance.

5.3.2 Role of ICT

The benefits of ICT for a firm include savings of inputs, general cost reductions, higher flexibility and improvement in product quality. The new technology may save labour or some specific labour skills; it may reduce capital needs through, for example, increased utilization of equipment, reduction of inventories or space requirements and so on. It may also lead to higher product quality or better conditions for product development. Moreover, it may increase the flexibility of the production process allowing the exploitation of economies of scale (see e.g. Milgrom and Roberts 1990, 1995). A specific feature of ICT is related to networking and communication. As new technologies reduce the cost of lateral communication, firms use these technologies to facilitate communication among employees and reduce co-ordination costs. Monitoring technologies can also be used to reduce the number of supervisors required in the production process. Thus, the use of ICT has direct implications for firm organization. While inventions that lead to improvements in ICT are quickly available throughout the economy, complementary organizational changes involve a process of co-invention by individual firms (Bresnahan and Greenstein 1997). Identifying and implementing such organizational changes is difficult and costly. These adjustment difficulties lead to variation across firms in the use of ICT, its organizational complements and the resulting outcomes.

5.3.3 Role of new organizational practices

Some theories have been developed to explain why new high-skill and high-involvement workplaces may be more effective (see e.g. Ichniowski et al. 2000). These can be divided, first, into theories that focus on the effort and motivation of workers and work groups and suggest that due to the positive worker incentives created by new organizational forms the worker performance increases. A second group of theories focuses on changes of the structure of organizations that improve efficiency (see also Aghion et al. 1999, for a discussion of the characteristics of recent developments in the structure of European and US companies). We concentrate here more on this second group. These theories imply that new arrangements can make organizational structures more efficient. For example, decentralizing decision-making to self-directed teams can reduce the number of supervisors and middle-level managers required while improving communication;

employee involvement can eliminate or reduce grievances and other sources of conflict within the firm, thus improving performance (see Mookherjee 2006 for a survey of the theoretical literature on decentralization, hierarchies and incentives). Also for the organizational practices there exist interdependencies with other factors and inputs. Some of the changes of work design are associated with the introduction and diffusion of information technologies within the firm. For example, Greenan and Guellec (1994) show in a theoretical paper that the relative efficiency of a centralized mode of firm organization in which knowledge is confined to specialized workers and a decentralized one in which every worker participates in learning depends on the technological level of the firm: "whereas the centralized style is more efficient when the technological level is low, the decentralized one becomes more efficient when the technological level is higher".

5.3.4 Role of human capital

The shift toward skilled workers appears to have accelerated in the last twenty years. While many factors have contributed to this increase most authors think that this effect is attributable primarily to skill-biased technical change. The size, breadth and timing of the recent labour demand shift have led many to seek skill-biased technical change in the largest and most widespread new technology of the last years: the ICT (see Bresnahan et al. 2002). On the one hand, high-skilled labour is a precondition for the use of ICT; for example, training in problem-solving, statistical process controls and computer skills can increase the benefits of ICT. On the other hand, highly computerized systems not only systematically substitute computer decision-making for human decision-making in routine work, but also produce a large quantity of data, which needs high-skilled workers, managers and professionals to get adequately utilized.

5.3.5 Hypotheses

The above discussion of the literature shows that there are some common testable hypotheses with respect to the contribution of ICT, new organizational practices and human capital to firm efficiency and performance, which can be at best put together in the framework of a production function containing besides the classical production factors,

labour and traditional physical capital, also the new ones, ICT capital, organization capital and human capital (see Brynjolfsson and Hitt 2000 for a recent survey of empirical literature on this line):

Hypothesis 1: There are considerable direct positive effects of ICT, organization, human capital and knowledge capital on firm performance

Hypothesis 2: The national context has an impact on the above direct effects.

5.3.6 Data

Greek data

The data we used in the Greek part of this study were collected through a survey among Greek enterprises based on the same questionnaire that has been used in the Swiss part of the study. This questionnaire was translated into Greek and pre-tested by three experts highly experienced in such surveys and questionnaires, from ICAP, one of the largest business information and consulting companies of Greece, and also by two postgraduate students from the University of Aegean with experience in information systems research. Based on their remarks the final version of the questionnaire was developed. Three samples of 300 Greek firms each were randomly selected from the database of ICAP (which consists of approximately 135,000 Greek firms from all industries), being all 'similar' to the sample of the Swiss part of the study: all these three samples included firms from the same industries and sizes, and the proportions of all the industry and size classes were the same as in the Swiss sample.

Initially the questionnaire was sent by post to the firms of the first sample; after three weeks the firms who had not responded were contacted by phone. Firms that definitely refused to participate in this survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample, while in a few cases that exhausted the firms of the second sample we had to proceed to the third sample. Following the above procedure, which aimed to maintain the proportions of the industry and size classes, we finally received responses from 281 firms; after an examination of the returned completed questionnaires we excluded 10 cases with contradictory or non-plausible answers, and the remaining 271 valid responses were used for the analyses.

In Table 17 we can see the structure of the final data set we used for the Greek part of the by industry and firm size class.

Table 17. Composition of the Greek data set by industries and firm size classes

	Greece	
	N	%
Industry:		
Food, beverage	25	9.2
Textiles	6	2.2
Clothing, leather	7	2.6
Wood processing	3	1.1
Paper	3	1.1
Printing	12	4.4
Chemicals	12	4.4
Plastics, rubber	6	2.2
Glass, stone, clay	9	3.3
Metal	4	1.5
Metal working	7	2.6
Machinery	1	0.4
Electrical machinery	2	0.7
Electronics, instruments	3	1.1
Vehicles	2	0.7
Other manufacturing	5	1.8
Energy	3	1.1
Construction	14	5.2
Wholesale trade	51	19.2
Retail trade	21	7.7
Hotels, catering	27	10.0
Transport, Telecommunication	15	5.2
Banks, insurances	5	1.8
Real estate, leasing	2	0.7
Business services	16	5.9
Personal services	10	3.7
Firm size:		
20-49 employees	88	32.5
50-249 employees	105	38.7
250 employees and more	78	28.8
Total	271	100.0

A non-response analysis was performed (survey of a sample of the non-respondents), which did not indicate any serious selectivity bias with respect to the use of ICT, new organizational practices, vocational education and job-related training. For these 271 firms we also retrieved from the database of ICAP some economic data for 2004 that were not collected through the questionnaire. So we finally obtained for all these Greek firms

all the economic data that were collected for the firms of the above Swiss data set through the Swiss questionnaire, with only one difference: the Swiss questionnaire collected the 'gross investment expenditure in 2004', as a measure of 'traditional capital', while from the ICAP database we could retrieve only the 'assets value at the end of 2004' for this purpose. However, we believe that this is not a problem, since both these variables are good measures of the 'traditional capital' a firm uses. In Table C1 (Appendix C) we can see some descriptive statistics of the basic variables for the Greek data set. In the Table 18 are shown the definitions of the model variables.

Table 18. Definition of model variables

Variables	Definition and measurement
logCL	Logarithm of gross investment expenditure per employee 2004
logASSETN	Logarithm of assets value per employee at the and of 2004
logQUAL	Logarithm of the share of employees with tertiary level education 2004
LogTRAIN	Logarithm of employees participating to internal and/or external training courses initialized or supported by the firm 2004
logRDL	Logarithm of R&D expenditure per employee (average of the period 2003-2005);
INTERNET	Six-level ordinate variable for the intensity of *internet use*: share of employees using internet in daily work: 0: 0%; 1: 1-20%; 2: 21-40%; 3: 41-60%; 4: 61-80%; 5: 81-100%
INTRANET	Six-level ordinate variable for the intensity of i*ntranet use*: share of employees using internet in daily work: 0: 0%; 1: 1-20%; 2: 21-40%; 3: 41-60%; 4: 61-80%; 5: 81-100%
TWORK	Ordinate variable measuring how widespread is *team-work* inside a firm on a five-point Likert scale (1: 'very weakly widespread'; 5: 'very strongly widespread'); team work: project groups, quality circles, semi-autonomous teams, etc.
JROT	Ordinate variable measuring how widespread is *job rotation* inside a firm on a five-point Likert scale (1: 'very weakly widespread'; 5: 'very strongly widespread'); team work: project groups, quality circles, semi-autonomous teams, etc.
LEVEL	Three-level ordinate variable for the change of the number of *managerial levels* in the period 2000-2005: 1: increase; 2: no change; 3: decrease
COMP_OVERALL	Three-level ordinate variable measuring the *change* of the distribution of decision competences between managers and employees inside a firm in the period 2000-2005: 1: shift towards managers; 2. no shift; 3: shift towards employees
COMP_WORKPACE	Ordinate variable measuring the distribution of

	decision competences to determine work *pace* (1: 'primarily managers'; 5: 'primarily employees')
COMP_WORKSEQ	Ordinate variable measuring the distribution of decision competences to determine the *sequence* of the tasks to be performed (1: 'primarily managers'; 5: 'primarily employees')
COMP_WORKASSIGN	Ordinate variable measuring the distribution of decision *competences to assign tasks* to the employees (1: 'primarily managers'; 5: 'primarily employees')
COMP_WORKWAY	Ordinate variable measuring the distribution of decision competences to determine the *way* of performing tasks (1: 'primarily managers'; 5: 'primarily employees')
COMP_PRODUCTION	Ordinate variable measuring the distribution of decision competences to solve emerging *production problems* (1: 'primarily managers'; 5: 'primarily employees')
COMP_CUSTOMER-CONTACT	Ordinate variable measuring the distribution of decision competences to *contact customers* (1: 'primarily managers'; 5: 'primarily employees')
COMP_CUSTOMER	Ordinate variable measuring the distribution of decision competences to solve emerging *problems with customers* (1: 'primarily managers'; 5: 'primarily employees')

Swiss data

The data used in the Swiss part of this study were collected in the course of a survey among Swiss enterprises using a questionnaire which included questions on the incidence and within-firm diffusion of several ICT technologies (e-mail, Internet, intranet, extranet) and new organizational practices (team-work, job rotation, employees‘ involvement), employees‘ vocational education and job-related training, and also on basic economic data for 2004 (sales, value of intermediate inputs, investment expenditure, number of employees, etc.). The survey was based on a disproportionately stratified (with respect to firm size) random sample of firms with at least 20 employees covering all relevant industries of the business sector as well as firm size classes (on the whole 29 industries, and within each industry three industry-specific firm size classes with full coverage of the upper class of large firms). Answers were received from 1895 firms, i.e. 38.7% of the firms in the underlying sample. The response rates do not vary much across industries and size classes with a few exceptions (over-representation of paper and energy industry, under-representation of hotels, catering and retail trade).

In Table 19 we can see the structure of the data set we used for the Swiss part of this study by industry and firm size class.

Table 19. Composition of the Swiss data set by industries and firm size classes

	Switzerland	
	N	%
Industry:		
Food, beverage	77	4.5
Textiles	24	1.4
Clothing, leather	6	0.3
Wood processing	27	1.6
Paper	24	1.4
Printing	53	3.0
Chemicals	66	3.8
Plastics, rubber	38	2.2
Glass, stone, clay	29	1.7
Metal	24	1.4
Metal working	106	6.2
Machinery	165	9.7
Electrical machinery	50	2.9
Electronics, instruments	122	7.1
Vehicles	20	1.1
Other manufacturing	30	1.8
Energy	33	1.9
Construction	179	10.5
Wholesale trade	142	8.3
Retail trade	102	6.0
Hotels, catering	56	3.3
Transport, Telecommunication	91	5.3
Banks, insurances	73	4.3
Real estate, leasing	11	0.6
Business services	151	8.8
Personal services	11	0.6
Firm size:		
20-49 employees	474	27.7
50-249 employees	875	51.2
250 employees and more	361	21.1
Total	1710	100.0

The non-response analysis (based on a follow-up survey of a sample of the non-respondents) did not indicate any serious selectivity bias with respect to the use of ICT and new organizational practices (team-work, job rotation). A careful examination of the data of these 1895 firms led to the exclusion of 185 cases with contradictory or non-plausible answers, so the remaining 1710 valid answers were finally used for the analyses presented in the following sections. In Table C1 (Appendix C) are shown some descriptive statistics of the basic variables for the Swiss data set.

5.4 Patterns of use of ICT, New Organizational Practices and Human Capital in Greece and Switzerland

For both the Greek and the Swiss data, as mentioned in the previous section, initially we calculated their descriptive statistics; the most important of them are shown in Table 20, and also in the abovementioned Table C1 (Appendix C), and enable us to draw some conclusions on the patterns of use of ICT, new organizational practices and human capital in Greece and Switzerland and also make comparisons between them.

Table 20. Patterns of use of ICT and new Organizational Forms in Greece and Switzerland

Variable	Greece	Switzerland
Average value-added per employee in Euro	74,506	106,821
Percentage of firms in which ... % of employees are using *internet:*		
0	3.0	3.6
1-20	52.1	37.8
21-40	15.6	18.5
41-60	13.0	13.7
61-80	8.9	9.3
81-100	7.4	17.1
Percentage of firms in which ... % of employees are using *intranet*:		
0	24.4	43.5
1-20	27.4	15.1
21-40	12.5	10.3
41-60	11.4	8.7
61-80	7.0	7.3
81-100	17.3	15.1
Percentage of employees with tertiary-level education	26.2	20.8
Percentage of employees with job-related training	23.3	26.8
Teamwork (1)	25.9	24.3
Job rotation (1)	7.7	3.6
Change of the number of management levels since 2000:		
- increase	15.6	3.7
- no change	80.7	87.3
- decrease	3.7	9.0
Overall distribution of decision competencies since 2000:		
- shift towards managers	7.4	3.4
- no shift	68.6	63.0
- shift towards employees	24.0	33.6
Distribution of decision competencies with respect to (2):		
work pace	9.9	12.3
sequence of tasks	2.2	13.8
assignment of tasks	0.4	4.8
way of performing tasks	4.8	15.2
solving of production problems	5.9	4.4

contact to customers	18.1	25.1
solving problems with customers	4.8	8.6

(1): percentage of firms reporting the values 4 or 5 of an ordinate variable measuring how widespread is *team-work* and job rotation resp. inside a firm on a five-point Likert scale; (2): percentage of firms reporting the values 4 or 5 of an ordinate variable measuring the distribution of decision competences to determine work *pace, the sequence of tasks etc. inside a firm* an on a five-point Likert scale

Concerning the ICT capital there are remarkable differences between the patters of Internet usage (which is 'outwards-looking' aiming at linking the firm to the outside world) and intranet usage (which is 'inwards-looking' aiming at linking employees and organizational units within the firm). As we can see from the above mentioned Table 20, the percentage of firms not using Internet (3.0% in Greece and 3.6% in Switzerland) is very small.

In both countries the class with the highest relative frequency is that of the firms with 1-20% of their employees using the Internet (52.1% in Greece and 37.8% in Switzerland), while much smaller is the percentage of the firms characterised by extensive diffusion of the Internet with more than 60% of their employees using the Internet (16.3% in Greece and 26.4% in Switzerland). A comparison between the two countries leads to the conclusion that while the share of firms using the Internet is almost the same in both countries (97.0% in Greece and 96.4% in Switzerland), the intensity of use of Internet in those Swiss firms that have introduced this technology is higher than in the Greek firms (also from Table C1 (Appendix C) we can see that the mean of this variable is 3.380 for Switzerland and 2.948 for Greece).

On the contrary, there is considerable percentage of firms that do not have an intranet in both countries (24.4% in Greece and 43.5% in Switzerland). The class with the highest relative frequency in both countries is again that of the firms with 1-20% of their employees using intranet, but it has lower relative frequency than the corresponding class (1-20%) of Internet usage in both countries (27.4% in Greece and 15.1% in Switzerland); the percentage of the firms with extensive intra-firm diffusion of intranet technology having more than 60% of their employees using the firm intranet is slightly lower in Greece 24.3% but higher 22.4% in Switzerland. The comparison between the two countries leads to the conclusion that the share of firms not having an intranet is higher in Switzerland than in Greece (43.5% and 24.4% respectively) and the intensity of use of intranet in the Greek firms is higher than in the Swiss firms (also from Table C1 (Appendix C) we can see the

mean of this variable is 2.668 for Switzerland and 3.015 for Greece). We also remark that in the Greek firms the use of Internet and intranet on average are at similar level (from Table C1 (Appendix C) we can see that the averages of the corresponding variables are 2.948 and 3.015 respectively), while in the Swiss firms a more 'outward-looking' use of ICT can be observed: the use of Internet is higher than the use of intranet (the averages of the corresponding variables being 3.380 and 2.668 respectively).

Concerning the human capital, in Table 20, we can see that the mean percentage of employees with vocational education at the tertiary level is 26.2% in the Greek firms and 20.8% in the Swiss firms; the share of employees receiving job-related training is 26.8% in the Swiss firms and 23.3% in the Greek firms. So the comparison between the two countries results again in a 'mixed' conclusion: from the two forms of human capital we examined, Swiss firms give to their employees more job-related training than the Greek firms, while the later employ more tertiary level personnel than the former.

From the new organizational practices associated with new forms of 'work design' in Tables 20 and C1 (Appendix C) we can see that the most frequently adopted of them is team-work (with 25.9% of the Greek firms and 24.3% of the Swiss firms having extensive diffusion of 'team-work' at the levels of 4 (strongly widespread) or 5 (very strongly widespread)). Much lower is the adoption of 'decrease of management levels' (by 9.0% of the Swiss firms and 3.7% of the Greek firms) and of the 'job rotation' (by 7.7% of the Greek firms and 3.6% of the Swiss firms). A comparison between the two countries again gives a 'mixed' conclusion: the percentage of the firms that decreased management levels is much larger in the Swiss firms than in the Greek firms, while the adoption of job rotation is higher in the later than in the former; concerning the level of adoption of team-work by taking into account the results of both Table 20 and Table C1 (Appendix C) we conclude it is higher in the Swiss firms than in the Greek firms (from Table C1 (Appendix C) we can see that the mean of this variable is 2.218 for Switzerland and 1.925 for Greece).

However, for the 'employee voice'-related new organizational practices the comparison between the two countries gives a clear conclusion that Swiss firms adopt them to a much higher extent than the Greek ones. In a considerable percentage of the firms there has been a shift of the overall distribution of competences towards employees since 2000 (in 33.6% of the

Swiss firms and 24.0% of the Greek firms). The highest decentralization has been made in the competences of contacting customers (with 25.1% of the Swiss firms and 18.1% of the Greek firms reporting one of the two higher values (4 or 5) of the ordinate variable measuring how widespread this type of decentralization is inside a firm on a five-point Likert scale), followed by decentralization in deciding the way of performing various tasks (15.2% and 4.8% respectively), the sequence of tasks (13.8% and 2.2% respectively) and the work pace (12.3% and 9.9% respectively).

Finally it is worth commenting that concerning the knowledge capital, as we can see in Table C1 (Appendix C), the investment per employee in research and development in the Swiss firms is much higher than in the Greek firms.

5.5 Model Specification and Variables

Throughout this part of our study we use the logarithm of annual value added (sales revenue minus value of intermediate inputs) per employee as dependent variable. As independent variables in our models, we used measures of "ICT capital", "organizational capital", "human capital" "physical capital" and "knowledge capital". In particular, as measures for technology input, particularly ICT input ("ICT capital") we used the intensity of use of two important ICT, Internet (linking to the outside world) and intranet (linking within the firm), quantified by the share of employees using Internet and intranet respectively in their daily work. The firms were asked to report this share not by a precise figure but within a range of twenty percentage points in a six-level scale: 0%, 1% to 20%, 21% to 40%, 41% to 60%, 61% to 80% and 81% to 100%. Based on these data we constructed two ordinal variables, i.e. one for Internet and one for intranet, taking the values 0 to 5, thus covering the whole range from 0% to 100% (see above mentioned Table 18). The idea behind this variable is that a measure of the diffusion of a certain technology within a firm would be a more precise proxy for 'ICT capital' than the mere incidence of this technology or some kind of simple hardware measure (e.g. number of installed personal computers). We expect in general a positive correlation of these technology variables with labour productivity.

The measurement of organizational inputs, here restricted to inputs related to workplace organization, is an issue still open to discussion, since there is not yet a definite agreement among applied economists to the exact

definition of “organizational capital” (see Black and Lynch 2002 and Lev 2003, Appelbaum et al 2000). In order to choose the variables related to changes and/or introduction and use of new organizational practices at the workplace level we draw on the definition offered by Black and Lynch (2002), who distinguish three components of organizational capital: “work design”, “employee voice” and “workforce training”. The first component “work design” includes practices that involve changing the occupational structure of the workplace, the number of levels of management within the firm, the existence and diffusion of job rotation, the job share arrangements and the level of cross-functional co-operation. The second component “employee voice” is associated with practices that give employees, especially non-managerial ones, greater autonomy and discretion in the structure of their work, such as individual job enrichment schemes, decentralization of decision competencies that give to employees more decision competences, etc. Based on the above definitions in this study we regard ‘organizational capital’ as consisting of the first two of these components, “work design” and “employee voice”, while we view the third component “workforce training” as part of the human capital of the firm, as explained in the following paragraph. In this direction we constructed the following three- or five-level ordinate variables covering most of the above-discussed aspects of organisational capital (see Table 18):

i) for measuring “work design” practices: intensity of use of team-work (project groups, quality circles, semi-autonomous teams), intensity of use of job rotation, increase/stability/decrease of the number of management levels;

ii) for measuring “employee voice”: overall shift of decision competencies from managers to employees inside a firm and distribution of decision competencies between manages and employees inside a firm with respect to: (a) work pace, (b) sequence of the tasks to be performed, (c) the assignment of tasks, (d) the way of performing tasks, (e) solving emerging production problem, (f) contacts to customers and (g) solving emerging problems with customers. We expect an overall positive correlation of organizational variables with average labour productivity, but we do not have sign expectations for every single variable.

For measuring human capital we use two variables: the share of employees with vocational education at the tertiary level (universities, business and technical colleges, etc.) and the share of employees receiving job-related

training (internal and/or external training courses initialized or supported by the firm) (see Table 18). According to standard analysis (see e.g. Barro and Lee 1994), we expect a positive correlation of these variables to labour productivity.

Further, we control for physical capital (measured through the logarithm of annual gross investment expenditure per employee in the Swiss part of the study, and the logarithm of assets value per employee in the Greek part of it), knowledge capital (measured through the logarithm of annual R&D expenditure per employee), firm size and sector affiliation. Firm size controls could also serve as an approximation for firm age controls (young firms are mostly small), thus taking into consideration the possibility that firm age could play a role in the relationship between decentralization and technology as postulated in Acemoglu et al. (2006). Finally, controls for sector affiliation could be seen also as controls for the heterogeneity of a firm's environment, a further factor influencing technology-decentralization relationship according to Acemoglu et al. (2006).

5.6 Results

5.6.1 Greek results

In Table 21a we can see OLS estimates of the basic model based on the Greek data (see Table C2a (Appendix C) for the correlation matrix of the model variables). One problem we had was that, because of high correlation between the two technological variables measuring the intensity of use of Internet and intranet, when both of them were included in the same model as independent variables, only one had statistically significant coefficient, while the other did not have statistically significant coefficient; however, if each of them was removed from the model, the coefficient of the other became statistically significant, since they both are characterised by high correlations with the dependent variable (labour productivity). The same happened with the two human capital variables measuring the share of employees with tertiary education and the share of employees receiving job-related training. So we finally selected to use from the two technological variables the one measuring the intensity of intranet use as independent variable, as it had higher correlation with the dependent variable; similarly from the two human capital variables we selected to use the share of employees with vocational education at the tertiary level as independent variable. Also, since between the organizational variables there are also

high levels of correlation, we also estimated eleven variants of this model, each of them having only one of these organizational variables. In only three of these eleven models the organizational variable had statistically significant coefficient: in the ones with the extent of decentralization of decision competencies concerning the sequence of tasks to be performed, the way of performing tasks and the work pace, which are shown in Table 21a.

Table 21a: Basic model: average labour productivity (log (value-added per employee) 2004 [(1)] (OLS estimates); Greece

Explanatory variables	(1)		(2)		(3)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
logASSETN	0.118***	0.179	0.112***	0.172	0.111***	0.170
	(0.040)		(0.040)		(0.040)	
logQUAL	0.143*	0.136	0.137*	0.131	0.148*	0.141
	(0.074)		(0.073)		(0.074)	
logTRAIN	//		//		//	
logRDL	0.008	0.023	0.009	0.024	0.018	0.032
	(0.024)		(0.024)		(0.024)	
INTERNET	//		//		//	
INTRANET	0.116***	0.186	0.108**	0.174	0.116***	0.187
	(0.043)		(0.043)		(0.043)	
TWORK	0.020	0.033	0.011	0.018	0.026	0.042
	(0.038)		(0.038)		(0.039)	
JROT	-0.007	-0.010	0.014	0.019	0.003	0.004
	(0.045)		(0.046)		(0.046)	
LEVEL	-0.002	0.001	-0.010	-0.004	-0.020	-0.008
	(0.153)		(0.153)		(0.154)	
COMP_OVERALL	//		//		//	
COMP_WORKPACE	//		//		0.110*	0.105
					(0.067)	
COMP_WORKSEQ	0.153*	0.120	//		//	
	(0.079)					
COMP_WORKASSIGN	//		//		//	
COMP_WORKWAY	//		0.182**	0.152	//	
			(0.078)			
COMP_PRODUCTION	//		//		//	
COMP_CUSTOMER-CONTACT	//		//		//	
COMP_CUSTOMER	//		//		//	
Middle-sized firms	0.056	0.025	0.040	0.018	0.059	0.027
	(0.157)		(0.156)		(0.158)	
Large firms	-0.015	-0.006	-0.062	-0.026	-0.011	-0.005
	(0.173)		(0.173)		(0.174)	
Services firms	0.096	0.044	0.136	0.062	0.122	0.056

	(0.138)		(0.138)		(0.138)	
Constant	8.499***		8.495***		8.570***	
	(0.551)		(0.544)		(0.547)	
N	252		252		252	
DF	11		11		11	
SER	1.023		1.020		1.025	
F	4.062***		4.247***		3.956***	
R^2adj	0.118		0.124		0.114	

(1): calculated in full-time equivalents; reference group for sector dummies: construction; reference group for firm size dummies: firms with less than 20 employees; standard errors in brackets; ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively; heteroscedasticity-robust standard errors (White procedure).

From the models shown in Table 21a we can see that the coefficients of the technological variable measuring the intensity of intranet use are positive and statistically significant, which means that higher intensity of use of these technologies in a firm results in higher labour productivity. Also the human capital variable measuring the share of employees with tertiary education has statistically significant positive coefficient. Furthermore, the physical capital variable has statistically significant positive coefficient as well, but the coefficient of the knowledge capital variable is not statistically significant. Concerning the three organizational variables representing "work design" from the models of Table 21a, we can see that they do not show a statistically significantly effect on labour productivity.

In conclusion, for Greece we found statistically significant positive effects for the variables of ICT, physical capital, human capital, and for three variables measuring aspects of organizational capital.

5.6.2 Swiss results

In Table 21b are shown the results of the OLS estimates of the basic model using the Swiss data (see Table C2b (Appendix C) for the correlation matrix of the model variables).

Table 21b: Basic model: average labour productivity (log (value added per employee)) 2004 (1) (OLS estimates); Switzerland

Explanatory variables	(1)		(2)		(3)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
logCL	0.033***	0.123	0.033***	0.122	0.034***	0.127
	(0.009)		(0.009)		(0.009)	
logQUAL	0.043**	0.094	0.041***	0.091	0.040***	0.088
	(0.013)		(0.013)		(0.013)	
logTRAIN	0.032**	0.077	0.031***	0.075	0.034***	0.083
	(0.010)		(0.010)		(0.010)	

logRDL	0.013**	0.097	0.014***	0.106	0.014***	0.104
	(0.004)		(0.004)		(0.004)	
INTERNET	0.027**	0.082	0.023**	0.068	0.026**	0.076
	(0.011)		(0.011)		(0.011)	
INTRANET	0.031***	0.112	0.031***	0.115	0.030***	0.109
	(0.009)		(0.009)		(0.009)	
TWORK	0.002	0.008	0.003	0.008	0.002	0.007
	(0.007)		(0.007)		(0.007)	
JROT	-0.014	-0.032	-0.016*	-0.037	-0.016	-0.036
	(0.010)		(0.009)		(0.010)	
LEVEL	0.033	0.023	0.032	0.023	0.026	0.018
	(0.035)		(0.036)		(0.036)	
COMP_OVERALL	0.007	0.007	0.001	0.002	0.008	0.008
	(0.022)		(0.022)		(0.022)	
COMP_WORKPACE	-0.002	-0.004	//		//	
	(0.016)					
COMP_WORKSEQ	-0.002	-0.004	//		//	
	(0.014)					
COMP_WORKASSIGN	-0.005	-0.008	//		//	
	(0.016)					
COMP_WORKWAY	-0.014	-0.027	//		//	
	(0.013)					
COMP_PRODUCTION	0.002	0.003	//		//	
	(0.015)					
COMP_CUSTOMER-	0.027**	0.065	0.038***	0.090	//	
CONTACT	(0.013)		(0.010)			
COMP_CUSTOMER	0.020	0.039	//		0.038***	0.076
	(0.016)				(0.011)	
Middle-sized firms	0.010	0.019	0.005	0.009	0.006	0.012
	(0.014)		(0.014)		(0.014)	
Large firms	0.022*	0.054	0.021	0.051	0.020	0.049
	(0.013)		(0.013)		(0.013)	
High-tech manufacturing	0.038	0.033	0.041	0.035	0.045	0.039
	(0.042)		(0.042)		(0.042)	
Low-tech manufacturing	0.087**	0.078	0.087**	0.077	0.092**	0.082
	(0.039)		(0.039)		(0.038)	
Modern services	0.187***	0.129	0.188***	0.128	0.202***	0.137
	(0.057)		(0.057)		(0.057)	
Traditional services	0.021	0.018	0.025	0.021	0.041	0.035
	(0.041)		(0.041)		(0.040)	
Constant	10.926***		10.919***		10.914***	
	(0.118)		(0.111)		(0.111)	
N	1710		1710		1710	
DF	23		17		17	
SER	0.449		0.451		0.451	
F	17.9***		24.1***		23.8***	
R^2adj	0.189		0.187		0.185	

(1): calculated in full-time equivalents; reference group for sector dummies: construction; reference group for firm size dummies: firms with less than 20 employees; standard errors in brackets; ***, **, * denote statistical significance at the 1%, 5% and 10% level respectively; heteroscedasticity-robust standard errors (White procedure).

We can see that the coefficients of the two technological variables measuring the intensity of use of internet and intranet are, as expected, positive and statistically significant. This means that the higher the intensity of use of these technologies among the employees of a firm, the higher is also labour productivity, all other things being equal. Also, both proxy variables for human capital have, as expected, statistically significant positive coefficients. The strongest effect comes from formal education, but job-related training is also important. Further, we have positive effects for physical and knowledge capital.

On the contrary we could not find any statistically significant effects for the three organizational variables representing "work design" (with the exception of a weak negative effect of the variable for job rotation in model 2 in Table 21b). Also there was no indication of significant effect for the overall delegation of competences from managers to employees. Finally, in order to exclude the possibility of multi-collinearity the eight "employee voice" variables measuring the extent of decentralization of particular competencies from managers to employees were inserted separately in the estimation equation, and only two of them have been found to have positive and statistically significant coefficients: the one measuring decentralization of competences for contacting customers and the one measuring decentralization of competences for solving customers' problems; the corresponding models are shown in Table 21b. Therefore we conclude that an overall shift of competences towards employees may prove to be too unspecific to lead to a positive performance impact; it is the clear-targeted delegation of specific competencies from managers to employees, with respect to contacting customer problems and solving customers' problems that could enhance productivity. On the whole, the organizational variables correlate considerably weaker with the dependent variable (and explain less of its variance) than the technological variables.

In sum, for Switzerland we found statistically significant positive effects for all single variables belonging to the variable blocks of technology and human capital, for the physical and knowledge capital variables, but for only two of the eleven variables measuring aspects of the organizational capital, which are associated with "employee voice" practices (however different from the ones found as having significant effect on labour productivity for Greece).

5.7 Conclusions

In this part of our study, we presented a comparative empirical study of the effect of ICT capital, human capital, organizational capital (new organizational practices), also controlling for the physical and the knowledge capital, on labour productivity in Greece and Switzerland, based on firm-level data from both countries. Both the Greek and the Swiss parts of this study have been based on the same questionnaire and samples of similar composition (concerning firm sizes and sectors), and also use the same variables and models specification, so they are comparable. In this section we summarize the empirical results and discuss similarities and differences between the two countries.

- For both countries we found statistically significant positive effects for ICT capital, human capital and "employee voice" oriented organizational practices on labour productivity; also we found no statistically significant effect for "work design" oriented organizational changes.

- However, we found considerable differences between the two countries. Swiss firms are more efficient and mature in forming and using knowledge capital, than the Greek ones. Also, the "employee voice" effect on labour productivity, which is, as already mentioned, significantly positive for both countries, is based on different types of practices in the two countries. In Greece, positive and statistically significant effect on business performance has the decentralization of competences referring to the working conditions (work pace, work way, work sequence), while in Switzerland the decentralization of competences having to do with the work content (contact to customers, solving of problems related to customers). These differences can be interpreted as reflecting different management philosophies and different levels of employee autonomy.

Therefore, hypothesis 1 is supported in both countries with respect to ICT capital, human capital and 'employee voice' – oriented new organizational practices, while with respect to knowledge capital it is supported only for Switzerland.

Also, this study provides evidence that the national context influences the effect of these 'new' production factors on labor productivity, therefore hypothesis 2 is supported. Further research is required in this direction in more countries, in order to understand better these effects of the national context and the main mechanisms that generate them.

5.8 Contribution

The contribution of this part of our study to the empirical literature is two-fold. First, it is the first fully comparative empirical study on the above critical research questions in two different countries from an economic viewpoint, so it enables us to examine whether the national context has an impact on the effect of ICT capital, human capital, new organizational practices and knowledge capital on firm labour productivity.

Second, it is the first study of this type for Greece, whose economy is quite different from the economies of the highly developed countries, in which most of the empirical studies on these research questions have been conducted (such as USA, Germany, Australia, Switzerland, etc.). Greece does not belong to the highly developed countries, though it has made considerable economic progress in the last decade and has become a full member of the European Economic and Monetary Union. Also, it is characterized by lower level of economic development, smaller size of internal market, smaller average firm size and lower level of R&D intensity and innovation.

CHAPTER 6:

CONCLUSIONS AND FUTURE RESEARCH

Since the previous relevant research has focused on the effect of internal environment factors on ICT business value, in this dissertation we investigated the effect on ICT business value of other types of factors, which have not been examined before: i) factors associated with the ICT department (soft ICT investment in ICT structures, personnel and skills), ii) factors associated with strategy (ICT strategic alignment and business strategy), iii) factors associated with the sectoral external environment (generalised competition), and iv) factors associated with the national external environment, as shown below in Figure 4.

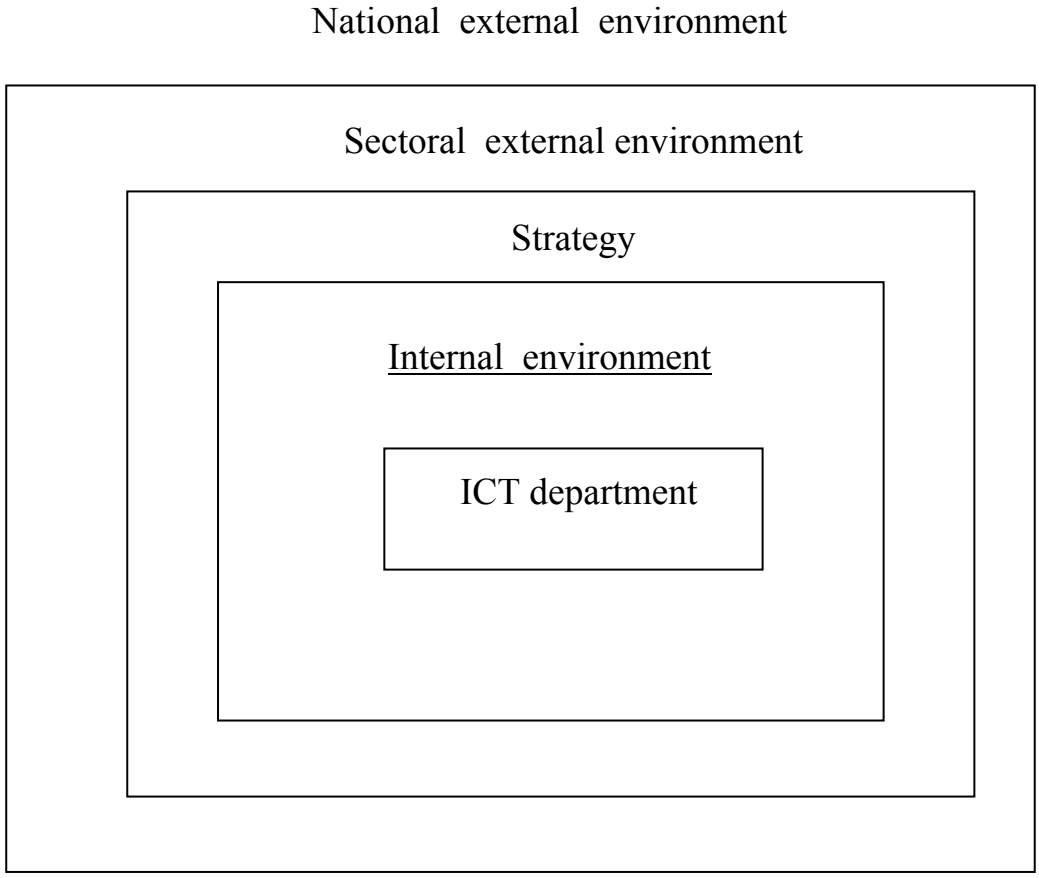


Figure 4. The main areas of focus and contribution of the dissertation (not underlined) and the area of focus of previous research (underlined)

In the first part of this study we investigated empirically the effect of both 'hard' ICT investment (i.e. investment in ICT hardware, software and networks) and 'soft' ICT investment (investment in ICT human resources,

skills and organization) on firm output. Initially the hypothesis that the function relating the output to the factors of production (inputs) in the context of the Greek industry is of the Cobb-Douglas form is not rejected against the specific alternative of the more general transcendental form; therefore the production process in the Greek industry can be adequately described by the Cobb-Douglas production function, while the use of the more general transcendental form for this purpose does not improve the explanatory power of the models. Then based on econometric modelling, it has been found that the hard ICT investment has a positive statistically significant effect on firm output; however its output elasticity is lower than the one of the non-computer capital and much lower than the one of the labour.

Concerning the soft ICT investment, we developed a framework for operationalizing and measuring it, and for investigating its effect on firm output; this framework is based on the well-established and widely used (both in research and consulting) Galliers's model of the 'stages of ICT growth'. In this study we have focused on three of these dimensions, which we consider as the most important ones: ICT structure, ICT staff and ICT skills; we measured them through three corresponding variables: the existence (or not) of a separate ICT department in the firm, the number of ICT employees and the extent of ICT training provided to the users. From these three investigated measures of the soft ICT investment, based on econometric modelling it has been found that the existence of a separate ICT department has a positive statistically significant effect on firm output, which is of considerable magnitude of about two thirds of the effect of the hard ICT investment. This finding underlines the importance of this dimension of the soft ICT investment, as it can increase by two thirds on average the business value generated by the hard ICT investment.

Furthermore, we examined whether there is complementarity between IS investment and a set of IS management factors, which concern the number of IS employees, the ICT training provided to the users, the hierarchical level of the ICT organisational unit and the number of ICT users in the firm (which is a measure of the width of ICT coverage of the firm organisational units/functions). It was concluded that there is complementarity between IS investment and the above set of IS management factors with respect to firm output and labour productivity. Therefore the combination of IS investment with these IS management factors results in additional increase of firm

output and labour productivity beyond the individual effect of IS investment.

The final conclusion of this first part of our study refers to the structural stability of the econometric models we constructed with respect to firm size (measured through sales revenue). Using a method based on the 'recursive residuals' it has been found that after a sample size of about 30, which corresponds to sales of approximately € 20 million, the models structure can be considered as being unaffected by the size of firms, for the range of firm sizes that our data cover. This means that the conclusions drawn from these models are not affected by firm size.

In the second part we empirically investigated the effect of two external environment related factors, the 'generalized' competition a firm faces, as it is conceptualised by the well established 'Five Forces Framework' of M. Porter (Porter 1980), and the strategies it follows in response to its external environment, on the business value generated by its ICT investment. It has been concluded that from the 'Five Forces' of M. Porter's framework, only the bargaining power of suppliers affects positively ICT business value; higher levels of bargaining power of suppliers create big pressures for the development of mainly 'efficiency-oriented' applications, and in general for a more efficient utilization of ICT resources, increasing the contribution of ICT investment to output (by 41%). Another important conclusion drawn is that there are specific strategies for responding to the external environment, which are characterised by frequent products/services innovations, increasing the contribution of ICT investment to output (36%); in such innovation strategies ICT are quite important both for enabling and enriching innovations strategies, and also for supporting their implementation. Following a strategy of frequent introduction of new products/services, creates big pressures for the development of both 'innovation-oriented' and 'efficiency-oriented' applications, and in general for more innovative and more efficient utilization of ICT resources, resulting in an increase of the contribution of ICT investment to output. Therefore the business value generated by ICT depends not only on 'internal factors' but also on 'external factors' as well.

In the third part of this study we investigated the impact of 'multi level' ICT alignment, incorporating four different mechanisms of ICT strategic alignment, which concern different hierarchical levels, and also both strategy formulation and implementation, on the business value generated by

ICT. It has been concluded that ICT strategic alignment results in a significant increase (by about 47% on average) of the business value generated by ICT. Furthermore, all the four ICT strategic alignment mechanisms we examined cause a significant increase of the business value generated by ICT. The bilateral relationship between the ICT Plan and the Business/Strategy Plan and the involvement of the organisational units (e.g. directorates, departments) of the business in IS and applications development projects have the most increasing impact to the ICT business value (by about 42% and 44% on average respectively). The implication of this conclusion for business managers is that it is worth committing resources to ICT strategic alignment, since the benefits it offers are quite significant. A significant increase of ICT business value can be achieved not only through the 'classic' ICT strategic alignment mechanisms that concerns strategy formulation at the executive level, which have attracted most of the research attention, but also through ICT alignment mechanisms at the middle and the lower hierarchical levels that concern both strategy formulation and implementation.

Finally in the fourth part we conducted a comparative empirical study of the effect of ICT capital, human capital, organizational capital (new organizational practices), also controlling for the physical and the knowledge capital, on labour productivity in Greece and Switzerland, based on firm-level data from both countries. For both countries we found statistically significant positive effects for ICT capital, human capital and "employee voice" oriented organizational practices on labour productivity; also we found no statistically significant effect for "work design" oriented organizational changes. However, we found considerable differences between the two countries as well. Swiss firms are more efficient and mature in forming and using knowledge capital, than the Greek ones. Also, the "employee voice" effect on labour productivity, which is significantly positive for both countries, is based on different types of practices in the two countries. In Greece, positive and statistically significant effect on business performance has the decentralization of competences referring to the working conditions (work pace, work way, work sequence), while in Switzerland the decentralization of competences having to do with the work content (contact to customers, solving of problems related to customers). The results of this study provide evidence that the national context influences the effect of these 'new' production factors on labor productivity.

The conclusions of this dissertation open up new directions of future research for:

- investigating the effect of more types of 'soft' ICT investment on ICT business value, and also the internal and external antecedents of the former, e.g. the effect of external environment and strategy on soft ICT investment,
- investigating the effect of other external environment related factors, e.g. environmental complexity, uncertainty, etc., and also various sectoral characteristics, such as degree of technological change, regulation, workforce composition, etc., on the business value that ICT generate for organizations,
- examining not only 'whether', but also 'how', various external factors, and also various strategies, affect ICT business value (e.g. by affecting various internal factors or variables), possibly by estimating more complex models with several 'layers' of variables using structural equation models (SEM),
- investigating in general the interrelation between external and internal factors affecting ICT business value and the direct and indirect effects of them on ICT business value, using SEM as well,
- addressing the research questions dealt with in the present dissertation, and also the above future research directions, in various national contexts of more or less developed countries, in order to understand the effect of various national context characteristics; it should be taken into account that most of the knowledge we currently have on the contribution of ICT capital, human capital, organizational capital (new organizational practices) and knowledge capital has been based on studies conducted in a few highly developed countries, so it might reflect, at least to some extent, characteristics of these national contexts.

PUBLICATIONS

Based on the results and contributions of this dissertation the following publications have been produced:

Journal papers

- Loukis, E., Sapounas, I. and Milionis, A. (2009), "The effect of hard and soft information and communication technologies investment on manufacturing business performance in Greece - A preliminary econometric study", Telematics and Informatics, 26(2), pp.193-210.

- Loukis, E., Sapounas, I., Aivalis, K. (2008), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", Journal of Enterprise Information Management, 21 (1), pp. 24-38.

Research book chapters

- Loukis, E. Sapounas, I. and Aivalis, K. (2009), "Enterprise Systems Strategic Alignment and Business Value", chapter in: Handbook of Research on Enterprise Systems, Idea Group Inc, pp. 152-168.

Conference papers

- Loukis, E., Sapounas, I. (2005), "The Impact of Information Systems Investment and Management on Business Performance in Greece", in the Proceedings of 13th European Conference on Information Systems (ECIS 2005), Regensburg, Germany, May 26-28.

- Loukis, E., Sapounas, I., Aivalis, K. (2006), "The Effect of Generalized Competition and Strategy on the Business Value of Information and Communication Technologies", in the Proceedings of the European and Mediterranean Conference on Information Systems (EMCIS 2006), Alikante, Spain, July 6-7.

- Sapounas, I., Loukis, E., Milionis, A. (2007), "The Effect of Information Systems Investment and Management on Manufacturing Business Performance in Greece. A preliminary econometric study", in the Proceedings of the 4th International Conference in Applied Financial Economics (QASS 2007), Samos, Greece, July 12-14.

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APPENDICES

APPENDIX A

Survey questions (used in this dissertation) in cooperation with the Federation of Greek Industries (FGI):

- Total number of employees in your firm: _____

- Total sales revenues (1999): _____

- Total number of ICT employees in your firm: _____

- The existence of a separate ICT department in the firm: YES □
  NO □

- Your corporation provides ICT training to the employees:

not at all	to a small degree	to a moderate degree	to a high degree	to a very high degree
□	□	□	□	□

- Which are the annual ICT investments (average of the period 1997-1999): _____Euro

APPENDIX B

Survey questions (used in this dissertation) from the survey, titled 'Usage of information and communication technologies, modern organization forms and innovation in the Greek companies' (conducted in cooperation with ICAP):

- Total number of employees in your firm (full time equivalent): _____

- Of the total number of employees in your corporation, about what percent fall into each of the following categories:

  - employees with vocational education at the tertiary level ___ %
  - employees with no vocational education at the tertiary level ___ %

  total number of employees 100 %

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

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

- Yearly total labour (personnel) expenses (without VAT): _____ Euro

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

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

Answer the following questions in a scale of 1 to 5, where 5= to a very high degree, 4 = to a high degree, 3 = to a moderate degree, 2 = to a small degree, 1 = to a very small degree or not at all

- To what degree the business environment of your company has the following characteristics?

High bargaining power of suppliers	1	2	3	4	5
High bargaining power of buyers	1	2	3	4	5
High competitive rivalry from competitors	1	2	3	4	5
High threat of new entrants	1	2	3	4	5
High threat of substitute products or services	1	2	3	4	5

- To what degree your company follows each of the following strategies?

Cost leadership	1	2	3	4	5
Quality differentiation	1	2	3	4	5
Specialised products/services	1	2	3	4	5
Frequent introduction of new products/services	1	2	3	4	5

Expansion to markets of other countries	1	2	3	4	5
Expansion to new activities	1	2	3	4	5

- Investment per employee in research and development (average of the period 2003-2005) _____ Euro

- The number of management levels (of the period 2000-2005) has:

been increased	no change	been decresed
□	□	□

- How widespread is *team-work* in your firm:

very weakly	weakly	moderately	strongly	very strongly
□	□	□	□	□

- How widespread is job-rotation in your firm:

very weakly	weakly	moderately	strongly	very strongly
□	□	□	□	□

- Decentralization decisions / competences in your firm: in each of the following 7 sub-questions answer, which is the *change* of the distribution of decision competences between managers and employees in a scale of 1 to 5, where 1: primarily managers; 5: primarily employees:

	primarily employees 1	2	3	4	primarily managers 5
• Who determines the *sequence* of tasks to be performed?	□	□	□	□	□
• *Who assigns tasks* to the employees?	□	□	□	□	□
• Who determines the *way* of performing tasks?	□	□	□	□	□
• Who determines the work *pace?*	□	□	□	□	□
• Who is responsible to solve emerging *production problems?*	□	□	□	□	□
• Who is responsible to *contact customers?*	□	□	□	□	□
• Who is responsible to solve emerging *Problems with customers?*	□	□	□	□	□

- The distribution of decision competences between managers and employees inside your corporation in the period 2000-2005 has:

□ 1: been changed towards managers (centralization)
□ 2. no change (no shift)
□ 3: been changed towards employees (decentralization)

- Which is the percent of employees participating to internal and/or external training courses initialized or supported by the firm 2004? _____ %

- Which is the percent of employees in your firm, who use *internet* in daily work: _____ %

- Which is the percent of employees in your firm, who use *intranet* in daily work: _____ %

- Is there in your organization a written plan concerning the exploitation and use of ICTs (e.g. in the next one to three years) (ICT Plan) that describes the new IS and applications that will be developed, the new technological components (hardware, software, networks) that will be acquired, etc.?

YES _____ NO____

- If the answer in the previous question was YES: to what degree there is bilateral relationship between the ICT Plan and the Overall Business/Strategy Plan?

not at all	to a small degree	to a moderate degree	to a high degree	to a very high degree
□	□	□	□	□

Answer the following questions in a scale of 1 to 5, where 1 = not at all, 2 = to a small degree, 3 = to a moderate degree, 4 = to a high degree, 5= to a very high degree:

- To what degree the organizational units of various levels (e.g. directorates, departments) are involved

in the formulation of the ICT Plan	1	2	3	4	5
in IS and applications development proj	1	2	3	4	5
in decision making concerning ICT issu	1	2	3	4	5

APPENDIX C

Table C1. Descriptive statistics of variables

	Greece		Switzerland	
Variable	Mean	Standard deviation	Mean	Standard deviation
Log (value added per employee)	10.833	1.088	11.834	0.515
LogASSETN (logCL)	10.084	1.660	8.699	1.856
logQUAL	2.869	1.040	2.534	1.099
LogTRAIN	2.386	1.454	2.725	1.212
logRDL	1.798	2.961	3.936	3.702
INTERNET	2.948	1.340	3.380	1.491
INTRANET	3.015	1.793	2.668	1.877
TWORK	1.915	1.775	2.218	1.677
JROT	0.945	1.493	0.505	1.145
LEVEL	1.881	0.423	2.053	0.350
COMP_OVERALL	2.166	0.536	2.304	0.529
COMP_WORKPACE	2.196	1.045	2.743	0.703
COMP_WORKSEQ	1.834	0.864	2.540	0.870
COMP_WORKASSIGN	1.483	0.654	2.038	0.686
COMP_WORKWAY	2.081	0.921	2.509	0.910
COMP_PRODUCTION	1.985	0.950	2.103	0.698
COMP_CUSTOMER-CONTACT	2.426	1.201	2.650	1.414
COMP_CUSTOMER	1.970	0.977	2.155	0.975

Table C2a: Correlation matrix: basic model Greece

	Log ASSETN	Log QUAL	Log TRAIN	Log RDL	INTERNET	INTRANET	TWORK	JROT	LEVEL	COMP_OVERALL	COMP_WORKPACE	COMP_WORKSEQ	COMP_WORKASSIGN	COMP_WORKWAY	COMP_PRODUCTION	COMP_CUSTOMER-CONTACT
logQUAL	0.122	1														
LogTRAIN	0.060	0.402	1													
logRDL	0.114	0.132	0.057	1												
INTERNET	-0.035	0.437	0.248	0.091	1											
INTRANET	-0.019	0.483	0.358	0.103	0.641	1										
TWORK	0.081	0.109	0.112	0.157	0.073	0.069	1									
JROT	0.021	-0.019	0.176	0.129	-0.026	0.054	0.241	1								
LEVEL	-0.015	0.013	-0.025	-0.043	0.063	-0.017	-0.020	-0.057	1							
COMP_OVERALL	0.016	0.074	0.067	0.053	0.105	0.117	0.003	-0.012	-0.046	1						
COMP_WORKPACE	0.046	0.209	0.127	0.074	0.164	0.206	-0.119	-0.143	0.062	0.167	1					
COMP_WORKSEQ	-0.016	0.242	0.222	0.102	0.237	0.226	0.020	-0.004	-0.015	0.164	0.364	1				
COMP_WORKASSIGN	0.022	0.123	0.141	0.020	0.118	0.038	0.102	-0.041	-0.100	0.129	0.186	0.352	1			
COMP_WORKWAY	0.059	0.266	0.123	0.145	0.235	0.264	0.091	-0.132	0.034	0.124	0.509	0.457	0.390	1		
COMP_PRODUCTION	0.022	0.301	0.218	0.154	0.291	0.289	0.131	0.020	-0.049	0.107	0.320	0.344	0.291	0.366	1	
COMP_CUSTOMER-CONTACT	-0.002	0.232	0.331	0.058	0.205	0.237	-0.019	-0.002	-0.067	0.091	0.213	0.275	0.143	0.156	0.252	1
COMP_CUSTOMER	0.000	0.199	0.222	0.096	0.189	0.286	0.048	0.029	-0.073	0.116	0.183	0.200	0.260	0.210	0.370	0.589

Table C2b: Correlation matrix: basic model Switzerland

	logCL	Log QUAL	Log TRAIN	logRDL	INTERNET	INTRANET	TWORK	JROT	LEVEL	COMP_OVERALL	COMP_WORKPACE	COMP_WORKSEQ	COMP_WORKASSIGN	COMP_WORKWAY	COMP_PRODUCTION	COMP_CUSTOMER-CONTACT
logQUAL	0.126	1														
LogTRAIN	0.142	0.211	1													
logRDL	0.175	0.259	0.117	1												
INTERNET	0.046	0.386	0.270	0.197	1											
INTRANET	0.111	0.323	0.273	0.262	0.598	1										
TWORK	0.100	0.222	0.244	0.265	0.205	0.288	1									
JROT	0.060	-0.002	0.084	0.103	-0.032	0.020	0.175	1								
LEVEL	-0.042	-0.003	0.032	-0.003	-0.050	0.028	0.024	0.040	1							
COMP_OVERALL	0.068	0.083	0.120	0.112	0.023	0.065	0.146	0.092	0.093	1						
COMP_WORKPACE	-0.004	0.067	0.090	0.047	0.157	0.152	0.066	-0.025	0.009	0.101	1					
COMP_WORKSEQ	0.053	0.163	0.130	0.123	0.159	0.188	0.126	-0.057	0.029	0.170	0.410	1				
COMP_WORKASSIGN	0.001	0.072	0.087	0.069	0.123	0.109	0.087	0.001	0.053	0.125	0.266	0.369	1			
COMP_WORKWAY	0.057	0.178	0.103	0.119	0.175	0.186	0.127	-0.039	0.002	0.107	0.301	0.370	0.292	1		
COMP_PRODUCTION	0.091	0.15	0.126	0.082	0.103	0.131	0.118	-0.007	0.036	0.101	0.203	0.266	0.233	0.320	1	
COMP_CUSTOMER-CONTACT	0.092	0.083	0.163	0.095	0.235	0.222	0.125	-0.059	0.036	0.131	0.250	0.326	0.256	0.227	0.271	1
COMP_CUSTOMER	0.051	0.118	0.064	0.132	0.201	0.199	0.108	-0.075	0.058	0.074	0.211	0.264	0.262	0.222	0.304	0.642