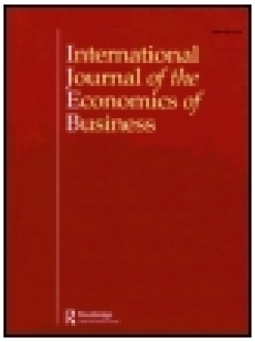

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Are ICT, Workplace Organization, and Human Capital Relevant for Innovation? A Comparative Swiss/Greek Study

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ABSTRACT *This paper investigates and compares the relationships for Swiss and Greek firms between indicators for the intensity of use of modern information and communications technologies (ICT), several forms of workplace organization, and human capital, on the one hand, and several measures of innovation performance at firm level, on the other hand. For the Swiss firms, we find that ICT contribute to innovation activities (a) as enablers of process innovation (but not of product innovation) and (b) as means for increasing the efficiency of the R&D process. The organizational variables for "work design" and "employee voice" show significant positive correlations for most innovation indicators. Human capital matters primarily for R&D activities. The findings for the Greek firms indicate positive correlations of ICT with product and process innovation and of new "work design" with product innovation and R&D. No correlation of human capital with innovation could be found. No complementarities for the three factors with respect to innovation performance could be detected in either country.*

Key words: ICT; Workplace Organization; Human Capital; Product Innovation; Process Innovation.

JEL Classification: O31.

1. Introduction

In the last 15 years, much theoretical and empirical literature in the domains of both economics and business administration has been dedicated to the investigation of the contribution of modern information and communication

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technologies (ICT) to economic performance at country, industry, and firm levels. Considerable work has been done, primarily on the effects of ICT on productivity at different aggregation levels (Cardona, Kretschmer, and Strobel 2013; Wan, Fang, and Wade 2007). In the economics literature, much attention has been paid to the specific character of ICT as "general purpose technology" that is spread and used in many different forms across all sectors of the economy (Bresnahan and Trajtenberg 1995). In the management literature, the focus has been on the specific attributes of ICT with respect to, for example, ICT capital assets, ICT human resources, and ICT technical and managerial skills that enable firms to develop a sustained competitive advantage (Bharadwaj 2000; Mata, Fuerst, and Barney 1995; Mithas, Ramasubbu, and Sambamurthy 2011; Powell and Dent-Micaleff, 1997).

Further, there is a tendency to examine organizational issues in the context of ICT, particularly the direct and indirect (in combination with ICT) impact of workplace organization on firm performance (Arvanitis 2005; Brynjolfsson and Hitt 2000; Brynjolfsson, Hitt, and Yang 2002; Black and Lynch 2001; Moshiri and Simpson 2011). The organizational issues are primarily a concern from a microeconomic point of view, and research on them is found mostly in the more management-oriented literature.

The third factor of interest here, human capital, also plays a prominent role – being regarded as the fuel of the "growth machine" – in both branches of the literature (for a seminal micro-study, see Bresnahan, Brynjolfsson, and Hitt 2002; for a seminal macro-study on this issue, see Vandenbusschee, Aghion, and Meghir, 2006).

Until now, less attention has been paid in the literature to the relationship of these three factors, considered together, to a firm's innovation performance (see Section 2). Thus, our study deals with the rather under-researched question of the effects of ICT, organizational practices, and human capital on innovation in an integrated framework. In this paper, we investigate the relationship between indicators for the intensity of use of ICT (including e-sales and e-procurement information systems), several forms of workplace organization and human capital, and several measures of innovation performance. This is done in an innovation equation framework, in which we also controlled for standard innovation determinants such as demand development, conditions of market competition, and firm size. The empirical analysis uses firm-level data from Swiss and Greek firms, which were collected as part of a survey based on the same questionnaire for both countries.

Both Greece and Switzerland are small, open economies, but they are characterized by quite different levels of economic and technological development. Table 1 shows a series of indicators referring to the economic and innovation performance of the two countries in 2007 (our data refer to the period 2003–2005). The overall picture is quite clear: Switzerland performs significantly better than Greece on every indicator. This is the case not only for the economic indicators that serve as measures of international competitiveness (imports and exports – particularly high-tech exports – and FDI outflows, all of them as a percentage of GDP), but also for the innovation indicators (business R&D intensity and "innovation status" according to the European Innovation Scoreboard). In previous research, macroeconomic and policy-related factors are usually taken into consideration when explaining *country-level* differences with respect to innovation performance. However, specific microeconomic

Table 1. Key figures for Greece and Switzerland

	Greece	Switzerland
Innovation status[1]	'Moderate'	'Leader'
Business R&D intensity[2]	0.3	3.1
Tertiary-level graduates[3]	33.2	41.4
IT equipment[4]	10.9	20.3
Exports and imports[5]	28.0	51.0
High-tech exports[6]	30.5	75.9
Foreign direct investment[7]	0.9	12.3

Notes: [1]As classified in European Innovation Scoreboard (2008).
[2]As percentage of value added in industry 2007.
[3]Tertiary-level graduates as percentage of total employment 2007.
[4]IT equipment as percentage of fixed non-resident investment 2007.
[5]Total exports and imports as percentage of GDP 2007.
[6]High-tech and medium high-tech exports as percentage of exports of goods 2007.
[7]FDI outflows as percentage of GDP 2007.
Sources: EIS (European Innovation Scoreboard) (2008); OECD (2009).

factors might exist that influence *firm-level* innovation performance that lie hidden behind macroeconomic performance and might also contribute to the explanation of existing performance differences. Such factors can be specifically investigated at the microlevel in a comparative setting. This is the intention of the present paper.

This paper contributes to the literature in three ways. First, it analyses the three factors – information technology, organization, and human capital – which are considered to have been important drivers of innovation performance in the last 15–20 years, in an integrated framework. Second, it uses several innovation indicators that cover both the input and the output side of the innovation process. Third, it does the analysis in a comparative setting for two countries, Greece and Switzerland, with quite different levels of technological and economic development.[1]

The paper is structured as follows. Section 2 presents the conceptual framework and related empirical literature. Section 3 describes the data used in the study. Section 4 refers to the model specification and the econometric procedure. The results are presented in Section 5. The final section contains a summary and conclusions.

2. Conceptual Framework and Related Empirical Literature

2.1. The "New Firm" Paradigm

Over the last two decades, several changes in the production process at firm level have taken place in many OECD countries, relating to the development of ICT, the use of new organizational modes in enterprises, and the increase in labour skill requirements. Based on these interrelated changes, many authors postulated a shift towards a new "firm paradigm", which they labelled differently depending on their focus on technological changes, new organizational practices, or the increase in demand for high employee qualifications. Burns and Stalker (1994) characterized this paradigm shift as one from a "mechanistic" to an "organic" firm structure, Milgrom and Roberts

(1990) from the "mass production model" to the "flexible multiproduct firm", and Lindbeck and Snower (2000) from a "Tayloristic" to a "holistic" organization of work. Related empirical literature based on firm-level data focused mainly on the direct effects of such changes on firms' economic performance, mostly measured by average labour productivity (for US firms see, e.g. Black and Lynch 2001; Bresnahan, Brynjolfsson, and Hitt 2002; for French firms: Caroli and Van Reenen 2001; for German firms: Hempell 2003; for UK firms: Crespi, Criscuolo, and Haskel 2006; for Swiss firms: Arvanitis 2005; for Greek firms: Loukis, Sapounas, and Milionis 2009; comparative study of Greek and Swiss firms: Arvanitis and Loukis 2009; for Spanish firms: Badescu and Garcés-Ayerbe 2009; for Canadian firms: Moshiri and Simpson 2011).

However, until now, less attention has been given in the literature to the possible effects of ICT, workplace organization, and human capital on *innovation* performance. *Direct* effects of these factors on innovation could be considered as *indirect* effects on economic performance via innovation, given that innovation affects economic performance positively (Hall, Mairesse, and Mohnen 2010).

A further point refers to possible interactions between human capital, ICT, and workplace organization that could mutually enhance their impact on innovation performance. Such complementarities are postulated and also partly empirically confirmed with respect to productivity (for the respective discussion and a summary of related literature, see Arvanitis and Loukis 2009). There is some empirical evidence for complementarities with respect to innovation performance between single organizational practices in the wider sense. For example, based on Dutch data, Beugelsdijk (2008) found positive interaction effects only between task rotation and performance-based pay schemes, flexible working time and performance-based pay, and training and standby contracts. In a further study based on Canadian data, Zoghi, Mohr, and Meyer (2010) could not find any interaction effect between decentralization and performance-based pay schemes with respect to innovation. We know of no study systematically investigating the interdependencies between ICT, workplace organization, and human capital in the context of innovation performance.

2.2. *ICT and Innovation*

2.2.1. Conceptual Background. Following Kleis et al. (2012), we posit that the use of ICT contributes to firms' innovation activities through three main channels. The first channel involves improving the management of the knowledge used in the innovation process. This knowledge might be internally created or externally acquired. ICT enable the efficient storage and high accessibility of this knowledge throughout an enterprise. Internal networks, e-mail systems, and electronic databases all facilitate the transfer of knowledge and the communication between innovation participants. This is particularly the case for external information, which is critical for successful innovation (Klevorick et al. 1995; Laursen and Salter 2006).

Second, ICT enable a more efficient cooperation in innovation with external partners. The creation of new knowledge through collaboration with other firms has become more and more important in the last 20 years (Enkel, Gassmann, and Chesbrough 2009). ICT facilitate the exchange of information with external partners that are located far away from the focal firm.

Third, ICT contribute directly to the generation of innovations in several ways (ICT-enabled innovations; see, e.g. Brynjolfsson and Saunders 2010; Tapscott, Ticoll, and Lowi 2000). These technologies can enable new products and services, and also the variety and personalization of existing products and services, which were not operationally and economically feasible before without ICT. Kleis et al. (2012) identified three main stages of the innovation process, for which the application of ICT has proved to be useful. First, the stage of the generation of ideas for new products can benefit from information systems (e.g. customer relationship management [CRM]) that enable a firm to analyse customers' communication and transaction data and to identify needs that can be covered by new products or significant modifications of existing products. Further, ICT enable the development of efficient design capabilities for new products. For example, technologies such as computer-aided design (CAD) and computer-aided manufacturing (CAM) help to digitize a new product's design and make it available throughout the innovation process. Finally, ICT help integrate design and production systems, so that errors of information transfer and translation are reduced and, as a consequence, the efficiency of this last stage of the innovation process is increased.

In sum, we expect a positive impact of ICT through these three channels on innovation performance.

2.2.2. Related Empirical Literature. The existing empirical literature on the impact of ICT on innovation is quite heterogeneous with respect to the sectors of the economy and the time periods covered, the measures of ICT and innovation, as well as the methods of analysis used. Most of them are based on firm-level data from only one country; three studies use data from more than one country.

In particular, Han and Ravichandran (2006) examined the relationship between IT investment and firm innovation outcome based on data for 450 US manufacturing firms. They found that IT investment did not have a direct effect on innovation outcomes measured by patent counts, but the interaction between ICT investment and R&D expenditure positively affected innovation. Kleis et al. (2012) analysed data from 201 large US manufacturing firms over the period 1987–1997, and found that ICT capital has a positive effect on patents output (which is used as a product innovation measure).

Gago and Rubalcaba (2007) focused on the service sector, and investigated the impact of ICT on service innovation based on data from 557 Spanish service firms. They found that ICT correlated positively with the importance of firms' innovations for productivity and costs, product or market expansion, employment and required skills, and services quality and fulfilment of ecological standards.

There are also three German studies focusing on the effects of different types of enterprise software on innovation. Engelstätter and Sarbu (2013) investigated the relationship between the use of sector-specific standardized/packaged enterprise software and customized enterprise software on service innovation (335 German firms; 2007–2009). The results showed that primarily customized enterprise software contributes to innovation. Engelstätter (2012) examined the relationship between three types of enterprise software offering different types of functionality – enterprise resource planning (ERP), supply-chain management (SCM), and CRM – and firms' innovation performance. The results showed that process innovation is positively correlated with the use of SCM and EPR systems, while product innovation is positively correlated with CRM. Finally, Meyer (2010) found that social software applications, for example blogs and teamwork platforms, impact service innovation positively.

In a study based on 2500 UK SMEs in 2004, Higon (2011) found that ICT mainly enhance process innovation, while only specific market-oriented ICT applications (such as websites, or ICT supporting R&D) favour product innovation.

Finally, there exist three multi-country studies. Tether (2005) investigated to what extent there are differences in innovation between manufacturing and services firms using data collected from the European Innobarometer survey of 2002. He concluded that technology is more important for innovation in manufacturing firms than it is in service firms in Europe. Spiezia (2011) reported the findings of separate investigations of the effects of ICT on firms' capabilities to innovate, which were performed under the coordination of the OECD. The investigation teams used large data sets for firms from nine European countries and Canada. The findings seem to support the hypothesis that ICT are enablers of innovation, particularly for product and marketing innovations, in both manufacturing and services. Ollo-Lopez and Aramendia-Muneta (2012) examined the impact of ICT on innovation in the glass, ceramics, and cement industries based on data for 676 firms in 2009 from Germany, Spain, France, Italy, Poland, and the UK. The results for the pooled data for all six countries showed that some ICT elements favoured product (CAD) and/or process innovations (CAD, ERP, online services).

2.3. Workplace Organization and Innovation

2.3.1. Conceptual Background. The study of the relationship between workplace organization and firm performance is an important topic in both the economic and the management literature (see, e.g. Black and Lynch 2001; Ichniowski et al. 2000). There are two main conceptual approaches. The first one concentrates on the effort and motivation of workers, and analyses how new organizational practices create positive worker incentives and, as a consequence, lead to an improvement in employee performance (see Mookherjee 2006; for a survey of the theoretical literature on decentralization, hierarchies, and incentives). The second approach focuses on changes in the structure of organizations that improve efficiency (see also Aghion, Caroli, and García-Peñalosa 1999, for a discussion of the characteristics of changes in structure of European and US companies). Of course, motivational and structural factors might interact with each other. For example, decentralizing decision making to teams can reduce the number of managerial levels required; decentralization of decision making can lead to increased employee involvement that can eliminate or reduce sources of conflict within the firm, thus improving performance.

Similarly, it can be argued that decentralized decision making, information sharing, and collaborative workplace arrangements might enhance the knowledge creation process (Lee and Choi 2003; Zoghi, Mohr, and Meyer 2010). Increased delegation of decision making to employees and increased use of teams may better allow for the discovery and utilization of knowledge in the organization, particularly when there are incentives that foster such behaviour (Laursen and Foss 2003). From a more general point of view, Acemoglu et al. (2007) theoretically derived the empirical prediction that firms closer to the technological frontier (i.e. potentially innovative firms) are more likely to choose decentralization.

2.3.2. Related Empirical Studies. A series of empirical studies covering a number of European countries, the USA, Canada, Australia, and Korea investigated the relationship between innovation performance and organizational characteristics and management practices.

Based on data for 487 firms in 1990, the study by Michie and Sheehan (1999) found a positive correlation between investment in R&D and new technology, on the one hand, and "high-commitment" organizational practices (teamwork, information sharing between workers and managers, increased assignment flexibility, innovative incentive pay plans, etc.) on the other.

Based on large data sets of British and French manufacturing firms in the 1990s, Acemoglu et al. (2007) empirically investigated, besides the abovementioned theoretical analysis, the relationship between several indicators of organizational decentralization and measures of the distance from the technological frontier. They showed, among other things, that firms closer to the technological frontier are more likely to choose decentralization.

In a further study, based on data from 1995 UK SMEs in the 1990s, Cosh, Fu, and Hughes (2012) found that decentralized decision making in combination with a formal structure and written plans is positively correlated with innovation performance, and is superior to other structures.

Using data for 1900 Danish firms, Laursen and Foss (2003) investigated the relationship between systems of human resource management containing several organizational practices and innovation measures. They found that innovation performance correlated positively with an organizational measure of the intensity of use of several organizational practices for four (out of nine) manufacturing sectors. In a subsequent study, based on data for 1000 Danish firms, the same authors examined the relation between delegation of responsibility and innovation, and found a significantly positive correlation between them (Foss and Laursen 2005). This finding was also confirmed by a further study with data for 1544 Danish firms coming from both the manufacturing and service sectors (Lund Vinding 2006).

Hempell and Zwick (2008) investigated the effects of two organizational practices, employee participation and outsourcing, on the likelihood of the introduction of products and/or process innovations. Based on data for 900 German firms in 2002 and 2004, the results showed that employee participation is positively associated with product and process innovations, while outsourcing favours innovations in the short run, but reduces innovation performance in the long run.

In a study based on panel data for 3200 Canadian firms in 1999, 2001, and 2003, Zoghi, Mohr, and Meyer (2010) explored the relationship between workplace organization – in particular decentralization, information sharing, and incentive pay schemes – and innovation. They showed that the positive correlation between workplace organization and innovation holds for all these organizational factors, but is stronger for information sharing than it is for decentralized decision making or incentive pay programmes.

Finally, in a study of 112 Taiwanese firms, Chang et al. (2012) found a positive relationship between organizational capabilities (openness capability, autonomy capability, integration capability, and experimentation capability) and radical innovation performance.

In sum, given the heterogeneity of the reviewed studies with respect to data structure and model specification, there exists a remarkably stable finding that refers to the positive relationship between the decentralization of decision making, delegation of responsibility and information sharing (between managers and employees), on the one hand, and innovation performance, on the other.

2.4. Human Capital and Innovation

2.4.1. Conceptual Background. The relationship between human capital and innovation has already been intensively investigated both theoretically and empirically in the first-generation models of endogenous growth (Aghion and Howitt 1998; Barro 1999; Romer 1990). Besides being the "engine of innovation", human capital is also a key determinant of knowledge absorptive capacity that enables firms not only to generate new knowledge but also to understand and adopt external new knowledge and technology (Vandenbussche, Aghion, and Meghir 2006). Based on a review of previous relevant literature, the study by Vinding (2006) argued that high-educated employees contribute through their daily tasks to knowledge accumulation of the organization. Furthermore, through their relationships with other individuals with similar competencies outside the firm, they facilitate access to external networks of knowledge, and through their high levels of knowledge, they recognize and value useful new external knowledge (knowledge absorptive capacity).

2.4.2. Related Literature. In the empirical part of his study, Vinding (2006) found that the share of high-educated employees is positively correlated with a firm's ability to innovate. In a further study, Lopez-Garcia and Montero (2012) argued that a firm's knowledge, which is of critical importance for its innovation activity, is embedded in its human capital. Furthermore, the latter is a critical determinant of firm's ability to absorb and assimilate external knowledge. Based on data from 769 manufacturing and services Spanish firms during 2003–2007, the empirical part of this study came to the conclusion that the share of skilled labour and provision of on-the-job training affect the innovative capacity of a firm through their impact on a firm's knowledge absorptive capacity.

2.5. Research Hypotheses

The above discussion of the literature shows that there are some common testable hypotheses with respect to the direct effects of ICT, new organizational practices, and human capital on innovation performance:

- *Hypothesis 1: There are direct positive effects of ICT (of both the internal information systems, and the e-sales and e-procurement information systems) on innovation performance.*
- *Hypothesis 2: There are direct positive effects of organizational factors on innovation performance.*
- *Hypothesis 3: There are direct positive effects of human capital on innovation performance.*

3. Data

Both the Swiss survey and the Greek survey were conducted in autumn 2005. The reference period for the qualitative data is 2003–2005 unless otherwise stated (see the definition of variables in Table 2). The reference year for the quantitative variable is 2004. The idea was to construct a firm sample to allow a comparison of entities with respect to industry affiliation and firm size. In this sense, the Greek sample is not representative of the entire Greek business sector, but only of the part that can be compared with the Swiss business sector in terms of industries and firm size classes. This way, the part of the Greek economy that is more technologically developed, showing an industry structure that is similar to the Swiss economy, is taken into consideration in this comparison between the two countries. Otherwise, the comparison would not refer to firm behaviour but would be dominated by the differences with respect to industry structure, even if it controlled for industry and firm size. Our sampling design does not lead to a representative sample of the entire Greek economy. However, our intention was not to have a representative sample of Greek firms with a majority of small pensions, hotels, restaurants, and small retail business, which might not need much ICT and organizational innovations for their functioning, but rather to concentrate on the part of the corporate economy that could apply ICT and organization to improve performance and competitiveness.

In both surveys, we used the same questionnaire in different languages, which included questions on the incidence and within-firm diffusion of several ICT technologies (Internet, intranet, extranet, e-sales, e-procurement) and new organizational practices (teamwork, job rotation, employee involvement, decentralization), employees' formal education, and basic economic data (sales, value of intermediate inputs, investment expenditure, number of employees, etc.).[2]

Table 2. Definition of variables

Variable	Definition
Dependent variables	
INNOPD	Introduction of product innovations (yes/no)
INNOPC	Introduction of process innovations (yes/no)
RD	R&D expenditures yes/no
LINNL	Natural logarithm of sales of innovative products (new and considerably modified products) per employee
LRDL	Natural logarithm of R&D expenditures per employee
Independent variables	
DEM	Expectations with respect to demand development in the next three years; five-level ordinal variable (level 1: "strong decrease"; level 5: "strong increase")
HQUAL	Share of employees with tertiary-level formal education
Market environment	
IPC	Intensity of price competition; five-level ordinal variable (level 1: "very weak"; level 5: "very strong")
INPC	Intensity of non-price competition; five-level ordinal variable (level 1: "very weak"; level 5: "very strong")
NCOMP	Switzerland: Interval variable: up to five competitors; 6–10; 11–15; 16–50; >50; Greece: number of main competitors
Use of ICT	
ICT	Sum of the standardized values of the variables INTERNET and INTRANET; where:INTERNET: six-level ordinate variable for the intensity of *internet use*: share of employees using the 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 *intranet use*: share of employees using the Intranet in daily work: 0: 0%; 1: 1–20%; 2: 21–40%; 3: 41–60%; 4: 61–80%; 5: 81–100%
E_S	Sales through the Internet (online sales) as a percentage of total sales
E_P	Procurement through the Internet as a percentage of total procurement
Workplace organization	
ORG1	Sum of the standardized values of the three variables ORG1_1, ORG1_2, and ORG1_3
ORG1_1	Ordinate variable measuring how widespread is *teamwork* inside a firm on a five-point Likert scale (1: "very weakly widespread"; 5: "very strongly widespread"); teamwork: project groups, quality circles, semi-autonomous teams, etc.
ORG1_2	Ordinate variable measuring how widespread *job rotation* is inside a firm on a five-point Likert scale (1: "very weakly widespread"; 5: "very strongly widespread"); teamwork: project groups, quality circles, semi-autonomous teams, etc.
ORG1_3	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
ORG2	Sum of the standardized values of the 8 variables ORG2_1 to ORG2_8
ORG2_1	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
ORG2_2	Ordinate variable measuring the distribution of decision competences to determine work *pace* (1: "primarily managers"; 5: "primarily employees")
ORG2_3	Ordinate variable measuring the distribution of decision competences to determine the *sequence* of the tasks to be performed (1: "primarily managers"; 5: "primarily employees")
ORG2_4	Ordinate variable measuring the distribution of decision *competences to assign tasks* to the employees (1: "primarily managers"; 5: "primarily employees")
ORG2_5	Ordinate variable measuring the distribution of decision competences to determine the way of performing tasks (1: "primarily managers"; 5: "primarily employees")

(*Continued*)

Table 2. (*Continued*).

Variable	Definition
ORG2_6	Ordinate variable measuring the distribution of decision competences to solve emerging production problems (1: "primarily managers"; 5: "primarily employees")
ORG2_7	Ordinate variable measuring the distribution of decision competences to contact customers (1: "primarily managers"; 5: "primarily employees")
ORG2_8	Ordinate variable measuring the distribution of decision competences to solve emerging problems with customers (1: "primarily managers"; 5: "primarily employees")
Controls	
Medium-sized firms	Dummy variable for medium-sized firms: 50–249 employees (in full-time equivalents)
Large firms	Dummy variable for large firms: 250+ employees (in full-time equivalents) and more
Reference group for firm size: small firms (5–49 employees)	

3.1. *Swiss Data*

The data used in the Swiss part of this study were collected as part of a survey of Swiss enterprises. 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 (of the whole 29 industries and, within each industry, three industry-specific firm size classes with full coverage of the upper class of large firms).[3]. Answers were received from 1803 firms, that is, 38.7% of the firms in the underlying sample. The response rates did not vary much across industries and size classes, with a few exceptions (over-representation of the paper and energy industries, and under-representation of hotels, catering, and the retail trade). Columns 3 and 4 of Table A1 in the Appendix show the structure of the data set we used for the Swiss part of this study by industry and firm size class. 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 (teamwork, job rotation). A careful examination of the data of these 1803 firms led to the exclusion of 93 cases with contradictory or non-plausible answers. However, missing values for certain variables meant that only 1591 observations could be utilized.

3.2. *Greek Data*

The data used in the Greek part of the study were also collected through a survey of Greek enterprises, which was based on a sample similar to that of the Swiss part of the study in terms of proportions of firm sizes and industries. However, the sampling method was different. Three samples of 300 Greek firms each were randomly selected from the database of ICAP, one of the largest business information and consulting companies in Greece, which consists of approximately 135,000 Greek firms from all industries. All three samples included firms from the same industries and sizes as in the Swiss sample (similar industry and size proportions). Firms that refused to participate in this survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample, except in a few cases where firms in the second sample were exhausted and we proceeded to the third sample. Following the above procedure, which aimed to maintain the proportions of industry and size classes, we finally received responses from 281 firms. After examining the returned completed questionnaires, 10 were excluded because of contradictory or non-plausible answers, and the remaining 271 valid responses were used for our analyses. Columns 1 and 2 of Table A1 in the Appendix shows the structure of the final data set used for the Greek part of the study by industry and firm size class. We also retrieved some economic data from the ICAP database for 2004 that were not collected through the questionnaire. So for all the Greek firms, we finally obtained the same economic data that were collected for the firms in the Swiss data set. However, due to missing values for certain variables, only 265 observations could be used in the econometric estimations.

4. Model Specification and Econometric Method

4.1. Model Specification

4.1.1. Dependent Variables. In view of the complexity of the innovation process, which is characterized by several stages, ranging from basic research to market penetration with new products, an approach relying on a single measure of innovation may leave out important relationships and produce results that are not robust (see, e.g. Kleinknecht, Van Montfort, and Brouwer 2002). For this reason, we used several innovation variables; their definitions are shown in Table 2. First, we investigated two binary (yes/no) variables (INNOPD and INNOPC) for innovation output, assessing whether the firm has introduced any product/service innovation or process innovation, respectively, in the last three years. Second, we also used two metric variables: the natural logarithm of R&D expenditures per employee (LRDL) and the natural logarithm of sales coming from innovative products (new or significantly improved ones) per employee (LINNL). A separate model was estimated for each of these four dependent variables.

4.1.2. Independent Variables. As measures for the internal use of ICT for supporting firm's internal functions and processes, we used the intensity of use of two important technologies: the Internet (linking to the outside world) and the Intranet (linking within the firm), quantified by the share of employees using the Internet and Intranet, respectively, in their daily work. The firms were asked to report this share not as a precise figure but within a range of 20 percentage points on a six-point scale: 0%, 1–20%, 21–40%, 41–60%, 61–80%, and 81–100%. Based on these data, we constructed two ordinal variables, that is, one for the Internet and one for the Intranet, taking the values 0 to 5, thus covering the whole range from 0% to 100% (see Table 2). The idea behind this variable was that a measure of the diffusion of a particular technology within a firm would be a more precise proxy for the use of ICT than the mere incidence of this technology or some kind of simple hardware measure (e.g. number of installed personal computers). In general, we expected (for the reasons explained in Section 2.2) a positive correlation of these technology variables with the innovation indicators. In order to be able to measure the overall effect of ICT, we constructed a composite indicator for ICT that was calculated as the sum of the standardized values (average 0; standard deviation 1) of the underlying variables for the Internet and the Intranet. As a consequence, this variable is by its construction a pseudo-metric variable, the estimated coefficients of which cannot be quantitatively (in the narrow sense of the word) interpreted (for a similar approach, see also Arvanitis and Loukis 2009; Bresnahan, Brynjolfsson, and Hitt 2002).

In addition, we used also two variables that measured the intensity of use of two important external environment-oriented applications of ICT associated with e-commerce: E_S (quantified as the percentage of a firm's sales conducted through the Internet) and E_P (quantified as the percentage of firm's purchases conducted through the Internet; see Table 2).

Much attention has been given in the literature to the question of measurement of organizational inputs, but there is no agreement among applied economists on the exact definition of "organizational capital" (for a discussion of this matter, see Black and Lynch 2005; Lev 2003; for definitions of high-performance work system variables, see also Appelbaum et al. 2000, ch. 7). For this study, we build on the definition by Black and Lynch (2001), who distinguished three components of organizational capital: "work design", "employee voice", and "workforce training". The first component, "work design", refers to practices such as the existence and intensity of use of job rotation and teamwork, the change of the number of management levels within the firm, and the change of the level of cross-functional cooperation. The second component, "employee voice", is associated with practices that give employees greater autonomy in their work, such as decentralization of decision competencies, and so on. 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. Our questionnaire contained information for the following variables measured on a five- or three-point Likert scale that cover most of the aspects of organizational capital discussed above (see Table 2):

(i) For measuring "work design" practices: intensity of use of teamwork (project groups, quality circles, semi-autonomous teams), intensity of use of job rotation, change 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 managers 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 problems with production, (f) contact with customers, and (g) solving emerging problems with customers. Table A3 in the Appendix shows some descriptive information for these seven dimensions of decentralization of decision making. In Swiss firms, delegation of competences to employees with respect to contact with customers, the way of performing tasks, the sequence of tasks to be performed, and work pace are found more frequently than solving problems with

customers or production and the assignment of tasks. These four more dominant modes of decentralization are used intensively in 12–25% of the firms. In Greek firms, decentralization is found considerably less frequently than it is in Swiss firms. Only in the case of competence delegation with respect to contact with customers is an intensive use of this mode reported by 18% of firms. Otherwise, the respective percentages of reporting firms are less than 10%.

Two composite indicators were used in empirical testing: one for the three organizational variables measuring "work design" (ORG1) and one for the eight organizational variables measuring "employee voice" (ORG2; for a similar approach based on the same data in the context of productivity models, see Arvanitis and Loukis 2009). These composite indices were calculated as the sum of the standardized values (average 0; standard deviation 1) of the underlying variables (see Table 2). We expected a positive correlation of the above two composite organizational variables with innovation indicators (for the reasons explained in Section 2.3).

Finally, human capital was measured by the share of employees with a vocational education at the tertiary level (universities, business and technical colleges, etc.; HQUAL). We expected a positive correlation of this variable to the innovation indicators (for the reasons explained in Section 2.4).

A set of variables are also included corresponding to some important innovation determinants that previous research has identified: R&D input, demand expectations, price and non-price competition, market concentration (see, e.g. Van Beers et al. 2008; Cohen 2010; Kleinknecht 1996). In particular, two variables are used for the R&D input: a binary variable, R&D yes/no, and R&D expenditures per employee (LRDL). Further, the demand expectations variable (DEM) assesses to what extent the firm expects an increase of demand on the relevant product markets in the medium term (next three years). The two competition variables (IPC and INPC) assess the intensity of price and non-price competition, respectively, in a firm's most important market, while the market concentration variable (NCOMP) measures the number of main competitors in a firm's most important market. In accordance with earlier studies, positive effects on innovation were expected for the R&D variables, the demand variable, the two variables measuring the intensity of competition, the variable that measures the number of principal competitors, and firm size (for Switzerland, see Arvanitis 2008; for Greece, see Arvanitis, Loukis, and Diamantopoulou 2013).[4]

Finally, we controlled for firm size and industry affiliation (Swiss firms) and sector affiliation (Greek firms). In the Greek estimations, we controlled only for sector affiliation because the low number of available observations did not allow a more thorough control at industry level.

Descriptive statistics (means and standard deviations) of our dependent and independent variables for Switzerland and Greece are shown in Table A2 in the Appendix. The correlations among the independent variables are shown in Table 3a and b.

Table 3a. Independent variables: correlation matrix – Switzerland

	R&D	LRDL	DEM	IPC	INPC	NCOMP	HQUAL	ICT	ORG1	ORG2	E_P	E_S	Medium-sized firms	Large firms
R&D	1.000													
LRDL	0.880	1.000												
DEM	0.148	0.153	1.000											
IPC	0.031	0.018	−0.081	1.000										
INPC	0.157	0.171	0.099	0.041	1.000									
NCOMP	−0.131	−0.144	−0.077	0.171	−0.019	1.000								
HQUAL	0.162	0.214	0.127	−0.060	0.064	−0.036	1.000							
ICT	0.148	0.192	0.125	−0.008	0.011	−0.085	0.490	1.000						
ORG1	0.209	0.194	0.102	0.038	0.046	−0.060	0.111	0.154	1.000					
ORG2	0.122	0.137	0.097	−0.019	0.107	−0.095	0.183	0.292	0.133	1.000				
E_P	0.060	0.069	0.030	0.058	0.027	0.036	0.076	0.172	0.053	0.009	1.000			
E_S	−0.041	−0.056	0.007	0.008	−0.003	0.011	−0.031	0.084	−0.027	0.010	0.140	1.000		
Medium-sized firms	−0.005	0.004	0.002	−0.021	0.014	−0.021	−0.051	−0.029	0.035	−0.043	−0.030	−0.030	1.000	
Large firms	0.167	0.159	0.113	0.037	0.099,	−0.105	0.085	0.203	0.123	0.130	−0.025	0.043	−0.509	1.000

Table 3b. Independent variables: correlation matrix – Greece

	R&D	LRDL	DEM	IPC	INPC	NCOMP	HQUAL	ICT	ORG1	ORG2	E_P	E_S	Medium-sized firms	Large firms
R&D	1.000													
LRDL	0.833	1.000												
DEM	−0.095	−0.092	1.000											
IPC	−0.025	0.026	0.082	1.000										
INPC	0.100	−0.032	0.093	0.349	1.000									
NCOMP	−0.042	−0.043	−0.011	0.002	0.034	1.000								
HQUAL	0.095	0.048	−0.066	0.003	0.159	−0.047	1.000							
ICT	0.139	0.118	−0.153	0.036	0.070	−0.042	0.524	1.000						
ORG1	0.141	0.137	−0.047	0.054	0.033	0.006	0.026	0.066	1.000					
ORG2	0.146	0.143	−0.166	0.150	0.101	−0.012	0.286	0.377	−0.038	1.000				
E_P	0.097	0.040	−0.056	−0.020	0.103	0.046	0.013	0.060	0.032	0.002	1.000			
E_S	−0.002	−0.015	−0.024	−0.002	0.092	−0.024	0.114	0.169	0.041	0.085	0.256	1.000		
Medium-sized firms	−0.021	−0.061	0.046	−0.082	−0.011	−0.056	0.124	0.072	0.079	−0.014	0.087	0.011	1.000	
Large firms	0.281	0.229	−0.123	0.028	0.040	−0.059	−0.005	0.140	0.044	0.077	0.003	0.038	−0.501	1.000

4.2. Econometric Issues

In order to test the research hypotheses presented in Section 2.5, the following innovation model was estimated for each of the four innovation variables that were used (see Section 4.1.1):

$$INNOV_i = b_0 + b_1 DEM_i + b_2 IPC_i + b_3 INPC_i + b_4 NCOMP_i + b_5 HQUAL_i + b_6 R\&D_i (LRDL_i) + b_7 ICT_i + b_8 ORG1_i + b_9 ORG2_i + b_{10} E\_P_i + +b_{11} E\_S_i + controls + e_i \quad (1)$$

(for firm i)

In cases where the dependent variable is a binary (0, 1) variable (i.e. for the dependent variables INNOPD and INNOPC), the appropriate estimator is a probit estimator (see also Section 4.2.2 below). In cases where the dependent variable is a truncated variable (with low bound zero; i.e. for the dependent variables LRDL and LINNL), the appropriate method of estimation is a tobit estimator.[5]

Further, we also estimated versions of the above model containing *interaction terms* between the variables HQUAL, ORG1, ORG2, and ICT. We constructed six interaction variables covering all possible combinations of the four factors. We inserted these interaction terms separately in the innovation equations and estimated the expanded models again.

4.2.1. Testing for Endogeneity. There is a potential endogeneity problem with respect to the determinants of innovation performance in equation (1) due to the fact that both the dependent and the independent variables are cross-section data that are simultaneously measured. We concentrated our testing of endogeneity on those right-hand variables that are relevant for the investigation of our research questions. These are the variables for technology (ICT, E_P, and E_S), workplace organization (ORG1 and ORG2), and human capital use (HQUAL). We tested endogeneity by applying the procedure by Rivers and Vuong (1988). Instrument equations were estimated separately for each of the relevant right-hand variables mentioned above for all innovation indicators and for each country. The instruments used were variables at the two-digit-industry level that might be considered to be exogenous to the single firm.[6] Generally, we tested 24 estimates (six different right-hand variables for four innovation indicators) for each country. The search for appropriate instruments was difficult and not successful in every case. For the Swiss data, we could not find an instrument for the variable E_P. For the Greek data, no instruments could be found for ORG2 and partly for HQUAL (one case) and E_P (two cases) and HQUAL (one case). In 16/20 cases that could be effectively tested for the Swiss data, the coefficients of the residuals (predicted instrumented variables minus original variable) were statistically insignificant at the 10% test level. Therefore, for these cases, we could not find any evidence for endogeneity in our estimates. In four cases, all referring to the variable LRDL with respect to ICT, ORG1, ORG2, and E_S, the coefficient of the residual was statistical significant. In all 17 cases that could be effectively tested for the Greek data, no evidence for endogeneity could be found. The detailed results are available upon request. Overall, our test results were not robust and thus were not conclusive, primarily due to the non-availability of appropriate instruments in our cross-section samples. For this reason, we refrain from any further discussion of the test results.

As a consequence, the question of causality remains open. Thus, we cannot exclude that firms use ICT more intensively or adopt new organizational forms more frequently just because they are innovative and not the other way around. Our estimates of the innovation equations have to be seen primarily as an extensive analysis of the correlations between the determinants (that are considered as structural characteristics that change only slowly over time) and the innovation indicators. Nevertheless, some robust regularities emerged, which, if interpreted in view of our hypotheses presented in Section 2.5, and their theoretical and empirical support outlined in Sections 2.2, 2.3 and 2.4, could possibly indicate the direction of causal links.

4.2.2. Interdependence of INNOPD and INNOPC. Many firms reported both the introduction of product and process innovations; others only reported product or process innovations. Thus, there might exist an interdependence of firms' decisions to introduce product and process innovation. For this reason, we estimated a bivariate probit model in order to test the influence of potential interdependency on our estimates. We found no significant differences to the estimates of separate probit models that are presented below.

4.2.3. Multicollinearity. Table 3a and b shows the correlations between the independent variables. We examined the possibility of multicollinearity for correlations higher than 0.2 by dropping one of the correlated variables and estimating once more the respective equation. There was no severe case of multicollinearity in the Greek estimates. For the Swiss estimates, there is some hint that this is the case for the variables R&D and ORG2 in the estimates for INNOPC (column 2 in Table 4) and for the variables HQUAL and LRDL in the estimates for LINNL (column 4 in Table 4). As a consequence, the coefficients of ORG2 and HQUAL may be underestimated in the respective estimates shown in Table 4.

5. Empirical Results

5.1. Swiss Results

The estimates of the models for the Swiss data are presented in Table 4. The composite indicator for the internal use of ICT correlates significantly positively only with the likelihood of the introduction of process innovation. There is no significant correlation with respect to the introduction of product innovation and the sales of innovative products per employee that reflect the intensity of product innovation. A positive correlation is also found for the variable R&D expenditures per employee. A plausible interpretation of these findings is that ICT contribute to innovation activities of Swiss firms enablers of innovative practices that increase a firm's overall efficiency (given that process innovation reflects efficiency improvement). Further, more intensive ICT use seems to be associated to a higher R&D intensity, presumably because

Table 4. The impact of ICT and e-sales, e-procurement, human capital, and workplace organization on innovation input and innovation output: Swiss firms

	INNOPD	INNOPC	LRDL	LINNL
	Product innovation yes/no Probit estimates	Process innovation yes/no Probit estimates	R&D expenditures per employee Tobit estimates	Sales of innovative products per employee Tobit estimates
DEM	0.015	0.012	0.231**	0.385***
Demand development	(0.011)	(0.013)	(0.115)	(0.152)
IPC	0.016**	0.021**	0.143	0.394***
Intensity of price competition	(0.008)	(0.011)	(0.098)	(0.129)
INPC	0.027***	0.006	0.340***	0.367***
Intensity of non-price competition	(0.009)	(0.011)	(0.092)	(0.129)
NCOMP	−0.019***	0.006	−0.101	−0.250***
Number of competitors	(0.006)	(0.008)	(0.071)	(0.094)
HQUAL	−0.000	−0.001	0.019***	−0.003
Share of employees with tertiary-level education	(0.001)	(0.001)	(0.006)	(0.008)
R&D	0.439***	0.387***		
R&D activities yes/no	(0.010)	(0.018)		
LRDL				0.734***
R&D expenditures per employees				(0.032)
ICT	−0.003	0.015**	0.121***	0.025
	(0.006)	(0.007)	(0.062)	(0.088)
ORG1	0.009*	0.019***	0.176***	0.234***
Team-work, job rotation, number of management levels	(0.005)	(0.006)	(0.050)	(0.065)
ORG2	0.005***	0.002	0.061***	0.071***
Decentralized decision-making	(0.002)	(0.002)	(0.020)	(0.029)
E_P	−0.001	0.051**	0.250	0.353
Turnover share of e-procurement	(0.018)	(0.022)	(0.192)	(0.261)
E_S	0.030	0.033	0.092	0.025
Turnover share of e-sales	(0.022)	(0.027)	(0.239)	(0.322)
Medium-sized firms	0.001	0.037	0.312	0.203
	(0.020)	(0.025)	(0.231)	(0.311)
Large firms	0.046*	0.103***	1.126***	0.796**
	(0.026)	(0.031)	(0.258)	(0.355)
Industry dummies	Yes	Yes	Yes	Yes
Const.	−1.806***	−1.663***	−9.982**	−8.507***
	(0.296)	(0.260)	(1.502)	(1.513)
N	1687	1687	1687	1687
N left-censored at zero			965	737
Pseudo R^2	0.427	0.170	0.099	0.096
Wald χ^2	715.9***	318.9***		
F-test			54.2***	62.9***

Notes: Average marginal effects; heteroskedasticity-robust standard errors in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.
Controls for 29 industries; reference industry: construction; reference firm size class: small firms (5–49 employees).

ICT increases the efficiency of R&D, for example by enabling the more efficient storage and higher accessibility and exchange of knowledge as well as the more efficient R&D cooperation with external partners (Kleis et al. 2012). The evidence does not support the assumption of ICT as enablers of product innovation, for example through the identification of customers' needs and development of efficient design capabilities for new products (Kleis et al. 2012).

Further, we could not find any significant correlation for e-sales (E_S), but a positive and significant correlation was found for e-procurement (E_P) in the estimates for process innovation and the sales of innovative products per employee. The main reason for not finding a significant correlation for e-sales might have been that in 2005, e-sales were not widespread in the Swiss business sector. The average share of e-sales in 2005 manufacturing was 5% in manufacturing and 3% in business services (Arvanitis et al. 2007). At that time, most firms, even innovative ones, did not expect that sales, particularly sales of consumer goods, could increase substantially through e-commerce. Therefore, hypothesis 1 is only partially supported for ICT for the Swiss results, and not supported for e-sales information systems.

The organizational variables for "work design" (ORG1) and "employee voice" (ORG2) show significant positive marginal effects for all innovation indicators (with the exception of ORG2 in the estimates for process innovation). The marginal effect of "work design" (reduction of formal hierarchy, increase of work flexibility through workgroups and job rotation) is significantly larger than that for "employee voice" (delegation of responsibility from managers to employees). The positive decision-delegation effect is also in accordance with a large part of empirical literature (see Section 2.3). Therefore, hypothesis 2 is supported by the Swiss results.

Human capital matters primarily for R&D activities, as measured by R&D expenditures per employee. Therefore, hypothesis 3 is partially supported by the Swiss results.

As indicated by the magnitude of the marginal effects, ORG1 shows the largest effect – among the three examined factors (technology, organization, human capital) that we focus on in this study – on innovation performance for all four innovation indicators. The extensive capabilities for exchange of information, knowledge and ideas among firm employees of different business functions (e.g. sales, marketing, manufacturing, R&D) offered by teamwork, job rotation, and reduction of managerial levels seemingly constitute important drivers of innovation.

For the Swiss firms, the coefficients of 21/24 possible interaction terms for all four innovation equations were statistically insignificant; three of them were significantly negative at the 10% test level (see supplementary material). Two of these negative coefficients refer to the interaction between HQUAL und ORG1 in the estimates for INNOPC and LRDL, and one to the interaction between ICT and ORG1 in the estimates for LINNL. It seems that the enhancing effects of the combination of ICT and human capital, for example, that are found in productivity models for the production process do not appear in the context of innovation activities. The negative interaction between organizational measures (such as team work and job rotation) and HQUAL and ICT in the estimates for INNOPC, LRDL, and LINNL, respectively, could be interpreted as a hint that the use of certain organizational forms that might be fruitfully combined with high employee qualification or ICT, for example, in the production process (see, e.g. Arvanitis and Loukis 2009) does not lead to similar positive interaction effects in the innovation process, which might need a more loose framework in order to be creative.

As expected, we find a positive correlation of both variables measuring R&D input. In (partial) accordance with earlier results, we find a positive correlation for the intensity of price as well as non-price competition for three out of four innovation indicators (see also Arvanitis 2008). Contrary to our expectation (positive effect of "free competition"), the variable for the number of competitors – that measures market concentration – shows a negative sign in the estimates for product innovation (INNOPD; LINNL), which means that the more competitors a firm has, the smaller the likelihood or the intensity of product innovation (dominance of the Schumpeterian effect that posits that firms in strong oligopolistic or monopolistic markets are more likely to be innovative). As in earlier works, in this study, we also found positive correlations for demand perspectives and for large firms.

5.2. Greek Results

The results of the estimates for the Greek firms are found in Table 5. The variable for ICT correlates positively with both product and process innovation, and with sales of innovative products per employee, but not with R&D expenditures per employee, which are quite low in Greece.[7] This finding indicates that Greek firms are able to exploit the innovation potential of ICT, which pervade and influence all processes, products, and services of a firm. They appear to have realized that ICT capabilities offer important opportunities for overcoming traditional fundamental inefficiencies and weaknesses in their innovative activities with respect to processes, products, and services. The correlation of ICT with innovation is weaker in the Swiss firms, at least with respect to product innovation, presumably due to the fact that Swiss firms, which have already been highly innovative in the pre-ICT era and did not show strong inefficiencies and weaknesses, could not reap so much benefit out of ICT with respect to innovation as Greek firms could.

As in the Swiss case, we found no significant correlations for e-sales, presumably for the same reasons as in Switzerland. Likewise, for the Greek firms, no correlation was found for e-procurement. Therefore, for the Greek business sector, hypothesis 1 is only partially supported for ICT and not supported for e-sales and e-procurement.

A further interesting finding refers to the effect of the organizational variable ORG1 (associated with new work designs), which is significantly positive correlated with the propensity to introduce a product, as well as with the R&D expenditures per employee. An interpretation of this finding could be that Greek firms seem to realize that organizational means such as teamwork, job rotation, and reduction of the number of management levels could be conducive for innovation. There is also a tendency for a positive correlation with ORG2 (delegation of responsibility from managers to employees), but this effect is not robust. ICT effects and organizational effects (referring to work design) as measured by the marginal effects are of similar magnitudes for product innovations.

Table 5. The impact of ICT, e-sales, e-procurement, human capital, and workplace organization on innovation input and innovation output: Greek firms

	INNOPD	INNOPC	LRDL	LINNL
	Product innovation yes/no Probit estimates	Process innovation yes/no Probit estimates	R&D expenditures per employee Tobit estimates	Sales of innovative products per employee Tobit estimates
DEM	0.007	−0.005	−0.210	1.410***
Demand development	(0.029)	(0.030)	(0.211)	(0.535)
IPC	0.049*	0.030	−0.027	0.942*
Intensity of price competition	(0.027)	(0.027)	(0.193)	(0.519)
INPC	−0.014	−0.008	−0.118	−0.059
Intensity of non-price competition	(0.025)	(0.025)	(0.173)	(0.437)
NCOMP	−0.000	−0.000	−0.000	−0.004**
Number of competitors	(0.000)	(0.000)	(0.000)	(0.002)
HQUAL	0.000	−0.001	0.006	0.003
Share of employees with tertiary-level education	(0.001)	(0.001)	(0.010)	(0.024)
R&D	0.331***	0.248***		
R&D activities yes/no	(0.050)	(0.052)		
LRDL				0.390***
R&D expenditures per employees				(0.142)
ICT	0.031*	0.032*	0.035	0.604**
	(0.018)	(0.018)	(0.125)	(0.312)
ORG1	0.025*	0.017	0.202**	−0.083
Team-work, job rotation, number of management levels	(0.015)	(0.015)	(0.098)	(0.263)
ORG2	0.007	−0.002	0.078*	−0.261**
Decentralized decision-making	(0.007)	(0.006)	(0.042)	(0.108)
E_P	0.002	0.001	−0.000	−0.005
Turnover share of e-procurement	(0.002)	(0.002)	(0.011)	(0.061)
E_S	−0.001	0.004	0.021	0.036
Turnover share of e-sales	(0.003)	(0.004)	(0.013)	(0.034)
Medium-sized firms	0.056	0.133**	0.458	0.671
	(0.064)	(0.065)	(1.476)	(1.133)
Large firms	0.068	0.179***	1.589***	1.546
	(0.072)	(0.071)	(0.452)	(1.101)
Sector dummies	Yes	Yes	Yes	Yes
Const.	−1.473**	−1.071**	−1.019	8.815***
	(0.477)	(0.463)	(3.185)	(2.763)
N	265	265	265	261
N left-censored at 0			187	59
Pseudo R^2	0.184	0.163	0.058	0.024
Wald χ^2	57.7***	52.4***		
F-test			5.5***	2.7***

Notes: Average marginal effects; heteroskedasticity-robust standard errors in brackets;.
$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.
Reference sub-sector: construction; reference firm size class: small firms (5–49 employees).

Human capital shows no significant correlation with innovation activities of Greek firms, which may be interpreted as a further hint for the relative backwardness of Greek firms with respect to innovation. Due to the existence of numerous employees with tertiary-level education, who are engaged in jobs with low qualification requirements, it is not surprising that human capital does not correlate with R&D activities in our estimates.

Therefore, to summarize, hypotheses 1 and 2 are partially supported by the Greek results, while hypothesis 3 is not supported.

For the Greek firms, the coefficients of 19/24 possible interaction terms for all four innovation equations were statistically insignificant; five of them were significantly negative at the 10% test level (see supplementary material). Similar to the Swiss firms, two of these negative coefficients refer to the interaction between HQUAL und ORG1 in the estimates for INNOPC and LRDL. Further, two negative coefficients indicate negative interactions between ICT and ORG1 in the estimates for INNOPD and LRDL. One such negative effect was also found for the Swiss firms. The similarity of negative interaction effects in both countries gives more power to the argument already stated above that the use of certain organizational forms that might fruitfully be combined in the production process does not lead to similar positive interaction effects in the innovation process, which might need a more loose framework in order to be creative. A fifth negative interaction was associated with the combined use of ORG1 and ORG2 in the estimates for LRDL. The accumulation of three negative interaction effects for R&D expenditures could also be interpreted as a hint of the inefficiency of R&D activities of Greek firms.

Table 6. Summary of results concerning the effects of the examined factors on innovation in Switzerland and Greece

	Switzerland	Greece
ICT	Positive for INNOPC and LRDL	Positive for INNOPD, INNOPC, and LINNL
e-sales (E_S)	Non-significant	Non-significant
e-procurement (E_P)	Positive for INNOPC and LINNL	Non-significant
"Work design" (ORG1)	Positive for all four innovation indicators	Positive for INNOPD and LRDL
"Employee voice" (ORG2)	Positive for INNOPD, LRDL, and LINNL	Positive for LRDL
Human capital (HQUAL)	Positive for LRDL	Non-significant
Demand expectations (DEM)	Positive for LRDL and LINNL	Positive for LINNL
Price competition (IPC)	Positive for INNOPD, INNOPC, and LINNL	Positive for INNOPD and LINNL
Non-price competition (INPC)	Positive for INNOPD, LRDL, and LINNL	Non-significant
Number of competitors (NCOMP)	Negative for INNOPD and LINNL	Negative for LINNL
Firm size	Positive (large firms) for all four innovation indicators	Positive (large firms) for INNOPC and LRDL

Note: Positive/negative: statistically significant at least at the 10% test level.

Finally, we note that all four "traditional" innovation determinants (demand expectation, price competition, non-price competition, and number of competitors) did not have statistically significant correlations with product and process innovation and R&D expenditure variables to the same extent as in the Swiss case. These findings imply that Greek firms do not respond to non-price competition or demand expectations with innovations in their processes, products, and services as Swiss firms do. Finally, we find a positive correlation effect for large firms, in accordance with standard evidence from other studies.

6. Conclusions

Our main results concerning the correlations of the examined factors with measures of innovation performance in Switzerland and Greece are summarized in Table 6. We concentrate on the results referring to ICT, organization, and human capital.

6.1. Conclusions for the Swiss Economy

For the Swiss firms, we conclude that ICT contribute to innovation activities (a) as enablers of innovative practices that increase a firm's overall efficiency (process innovation) and/or (b) as means for increasing the efficiency of the R&D process, for example through more efficient storage and higher accessibility of knowledge and more efficient R&D cooperation with external partners. On the contrary, the evidence does not support the hypothesis of ICT as enablers of product innovation. Further, we could not find any correlation for the variables for e-sales but only for e-procurement. The main reason might have been that at the time of data collection, both e-sales were not widespread in the Swiss business sector. The organizational variables for "work design" (ORG1) and "employee voice" (ORG2) show significant positive correlations with all innovation indicators (with the exception of ORG2 in the estimates for process innovation). Human capital matters primarily for R&D activities. We did not find any positive interaction effects between the three factors with respect to innovation performance. In three cases, we found negative coefficients of the variables for the interaction between HQUAL with ORG1 in the estimates for INNOPC and LRDL and for the interaction between ORG1 and ICT in the estimates for LINNL.

6.2. Conclusions for the Greek Economy

As already mentioned, our results refer to the part of the Greek economy that has a similar structure in terms of industry composition to that of a technologically more developed country such as Switzerland. For the Greek firms, the findings indicate that they exploit the innovation potential of ICT to make innovations at the level of both their processes and their products and services in order to overcome traditional fundamental weaknesses and inefficiencies. As in the Swiss case, we found no correlations for e-sales, presumably for the same reasons as in Switzerland. In the Greek case as well, no correlations were found for e-procurement. A further interesting finding refers to the correlation of new work designs (variable ORG1) with innovation.

Greek firms seem to realize that organizational means such as teamwork, job rotation, and reduction of the number of management levels can be conducive for innovation. There is also a tendency for a positive correlation of decentralization–delegation of responsibility (variable ORG2), but this effect is not robust. Further, for the Greek firms, we found only negative interaction effects, similar to those that were found for the Swiss firms.

6.3. Comparison of the Two Countries

A comparison of the two countries (see Table 6) reveals fewer similarities and more differences. In both countries, ICT show positive correlations with innovation measures but of a different nature. In Switzerland, ICT correlates positively with process innovation – but not with product innovation – and with R&D activity, while in Greece, ICT correlates positively with both process and product innovation (and also with the sales of innovative products per employee) – but not with R&D activity. In both countries, new workplace designs including teamwork, job rotation, and reduction of managerial levels show positive correlations with innovation. The same happens with the decentralization–delegation of responsibility practices (less in Greece than in Switzerland). However, in Switzerland, there is positive correlation of them with most examined innovation variables, while in Greece, there is a correlation only with product innovation and R&D activity – but not with process innovation. Another similarity refers to the role of firm size, which in both countries is positively correlated with innovation. On the contrary, with respect to human capital, there is a notable difference. While in Greece it does not show any correlation with innovation, in Switzerland it correlates positively with R&D activity. In general, there is a much wider range of innovation drivers in Switzerland than there is in Greece.

With respect to the organizational variables, our results seem to be in line with the findings of a recent multi-country study that investigated the incidence of decentralization of decision making within the workplace (Zoghi and Mohr 2010). As these authors found, employees in Sweden, Germany, France, the Netherlands, and Ireland were most likely to be given the authority to make decisions (as in Switzerland; see Table A3 in the Appendix and Section 4.1.2). In Spain, Portugal, and Italy (as in Greece), decentralized decision making was more unusual. A further finding was that decentralized decision making was more frequently found in combination with teamwork, quality circles, and so on, but this did not hold for all countries. In this study, we also find that this is rather the case for Switzerland and not for Greece (see correlation between ORG1 and ORG2 in Table 3a and b, respectively).

In a wider sense, not necessarily derived directly from our results, the above differences can be interpreted as indicating that national context characteristics (e.g. level of economic and technological development) shape the innovation drivers considerably that positively affect firms' innovation performance. Moreover, the above results could indicate that even in national contexts that are characterized by innovation averse attitudes and lower level of economic development (which means less tradition and experience in introducing new advanced technologies, processes and products), and in which standard innovation determinants such as competition and demand do not drive innovation, ICT can be a strong innovation driver. Although Greece is characterized by lower penetration and use of ICT, and therefore lower experience in its effective exploitation, we can see that ICT constitutes an important innovation driver for its firms.

Notes

1. Other comparative studies of Swiss and Greek firms have been conducted investigating different research questions based on the same data sets (see Arvanitis and Loukis 2009, 2013).
2. To a large extent, the questionnaire was based on similar questionnaires used in earlier surveys (see Canada Statistics 1999; EPOC 1997; Francois, Favre, and Greenan 1999; Vickery and Wurzburg 1998). Versions of the Swiss questionnaire in German, French, and Italian are available at www.kof.ethz.ch. Part of the firm information gathered by this questionnaire was also used for analysing further research questions (see Arvanitis and Loukis, 2009, 2013).
3. Table A1 contains only 26 industries; the Swiss sample has "watches", "telecommunication", and "computer services" as separate industries that were put together with "electronics/ instruments", "transport", and "other business services", respectively, to make the industry classification comparable to that of the Greek data
4. This paper is based on the same data as the present paper, but it is differently specified (containing different "soft" ICT measures but not organizational variables or variables for e-commerce).
5. The zero values in LRDL and LINN come from firms that have no R&D activities or no sales of innovative products in the reference period.
6. The list of instruments used is available upon request.
7. Greek firms conduct little R&D, and there is little, if any, public promotion of private R&D. Greek total R&D expenditures amount to less than 1% of GDP; also, in Greece, there is a lack of tradition and experience in organizing R&D activities, and this leads to lower levels of effectiveness of R&D in terms of innovation development. As a consequence, firm performance in terms of innovation and productivity is also rather low.

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Appendix

Table A1. Composition of the data sets by industries and firm size classes

	Greece		Switzerland	
	N	%	*N*	%
Industry:				
Food, beverage	25	9.2	77	4.5
Textiles	6	2.2	24	1.4
Clothing, leather	7	2.6	6	0.3
Wood processing	3	1.1	27	1.6
Paper	3	1.1	24	1.4
Printing	12	4.4	52	3.0
Chemicals	12	4.4	66	3.8
Plastics, rubber	6	2.2	38	2.2
Glass, stone, clay	9	3.3	28	1.7
Metal	4	1.5	24	1.4
Metal working	7	2.6	106	6.2
Machinery	1	0.4	165	9.7
Electrical machinery	2	0.7	50	2.9
Electronics, instruments	3	1.1	122	7.1
Vehicles	2	0.7	20	1.1
Other manufacturing	5	1.8	30	1.8
Energy	3	1.1	33	1.9
Construction	14	5.2	179	10.5
Wholesale trade	52	19.2	142	8.3
Retail trade	21	7.7	102	6.0
Hotels, catering	27	10.0	56	3.3
Transport, Telecommunication	15	5.2	91	5.3
Banks, insurance	5	1.8	73	4.3
Real estate, leasing	2	0.7	11	0.6
Business services	16	5.9	151	8.8
Personal services	10	3.7	11	0.6
Firm size:				
20–49 employees	88	32.5	474	27.7
50–249 employees	105	38.7	875	51.2
≥250 employees	78	28.8	361	21.1
Total	281	100.0	1710	100.0

Table A2. Descriptive statistics

	Greece		Switzerland	
	M (*N* = 265)	*SD*	*M* (*N* = 1591)	*SD*
INNOPD	0.413	0.493	0.493	0.500
INNOPC	0.373	0.484	0.422	0.494
RD	0.353	0.479	0.381	0.486
LRDL	1.798	2.961	3.936	3.702
LINNL	8.068	4.619	5.622	5.613
DEM	2.355	0.057	3.308	0.021
IPC	3.967	1.052	3.933	1.056
INPC	3.177	1.141	3.064	1.003
NCOMP*	44.306	19.947	2.490	0.035
HQUAL	26.181	23.690	20.816	20.306
ICT	−0.006	1.808	0.000	1.788
ORG1	−0.003	1.833	0.012	1.867
ORG2	0.020	4.785	−0.001	4.693
E_P	4.478	0.882	2.774	0.248
E_S	2.343	0.560	0.974	0.137
Medium-sized firms	0.387	0.488	0.358	0.479
Large firms	0.288	0.454	0.149	0.356

Note: *Greece: number of competitors; Switzerland: interval variable.

Table A3. Descriptive statistics for decentralization variables

	Greece (*N* = 265)	Switzerland (*N* = 1591)
ORG2_2 (work pace)	9.9	12.3
ORG2_3 (sequence of tasks)	2.2	13.8
ORG2_4 (assignment of tasks)	0.4	4.8
ORG2_5 (way of performing tasks)	4.8	15.2
ORG2_6 (solving of production problems)	5.9	4.4
ORG2_7 (contact to customers)	18.1	25.1
ORG2_8 (solving problems with customers)	4.8	8.6

Note: Percentage of firms reporting values four or five of the respective ordinal variable.