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Information and communication technologies, human capital, workplace organization and labour productivity: A comparative study based on firm-level data for Greece and Switzerland

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ABSTRACT

This paper describes a comparative empirical study of the effect of information and communication technology (ICT) capital, human capital and new organizational practices on labour productivity in Greek and Swiss firms. We use firm-level data collected in 2005 through a common questionnaire administered to samples of similar composition (e.g. similar firm sizes, similar sectors), from which we construct econometric models with similar specifications for Greece and Switzerland. The analytical framework is based on a firm-level production function. We find statistically significant positive effects for physical capital, ICT capital, human capital and "employee voice"-oriented organizational practices for both samples. We also identify considerable differences: Swiss firms are more mature and more efficient than Greek firms at creating, using and combining these 'new' production factors.

1. Introduction

In the modern economy, in addition to traditional production factors (physical capital, labour), there are some 'new' factors that are becoming very important, such as human skills (often referred to as 'human capital'), workplace organization (often referred to as 'organizational capital'), information and communication technologies (ICT), and knowledge. In most developed and developing countries firms make big investments to acquire and use these new production factors; thus, their contribution to and impact on firm performance is of critical importance. There has been considerable research about the impact of ICT investments on firm performance but until recently, there has been very little empirical evidence of a positive contribution of ICT investment on firm performance. This lack of empirical evidence has given rise to the 'ICT Productivity Paradox' (Brynjolfsson, 1993). More recent research in this area has produced evidence of the positive contribution of ICT investment to several measures of firm performance (see, e.g., OECD, 2004), probably reflecting improvements in the exploitation of ICT by firms. In addition, the contribution of human capital to economic growth at the aggregate, sector and firm levels has been researched and recognized (e.g., Barro, 1999; Middendorf, 2006), and there is an increasing 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, 2002).

There is also some acknowledgement in the literature of the existence of complementarities between ICT capital,

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human capital and new organizational practices, all of which are of critical importance for firm performance. These complementarities have been regarded as a fundamental characteristic of an emerging new 'firm paradigm' in the modern economy (Milgrom and Roberts, 1990).

However, although there are some similarities among the conclusions made by these studies, there are also several differences, which (at least to some extent) might be due to variations in sample composition (the samples of the above studies come from different sectors and industries), the variables and model specifications, and the nature of the investigations (cross-sectional versus longitudinal). Further empirical research is required, therefore, into the impact of ICT capital, human capital and new organizational practices, and their combined effect on firm performance. To this end, this paper describes a comparative empirical study of the effects of ICT capital, human capital, new organizational practices and their combined use, controlling for knowledge capital, on labour productivity in Greek and Swiss firms. The analytical framework is based on a firm-level production function. Both the Greek and the Swiss parts of this study are based on firm-level data collected in 2005, through the same questionnaire, from samples of similar composition (firm size classes and sectors), and they use the same variables and model specifications; thus, they are comparable.

The contribution of this study to the empirical literature is three-fold. First, ours is the first completely comparative empirical study of the research areas outlined above, in two quite different countries, that gives particular attention to the issue of complementarity. Second, it is the first study of this type with a focus on Greece, whose economy is quite different from the economies of the highly developed countries, which have been the subject of most of the empirical studies in this area. Third, this study explicitly takes account of possible endogeneity problems in the right-hand side variables in a cross-section.

The structure of this paper is as follows: Section 2 presents the conceptual framework of the study; Section 3 provides a review of the relevant empirical literature. the Greek and Swiss data are described in Section 4. Section 5 presents and compares the patterns of ICT use, new organizational practices and human capital in Greece and Switzerland. Section 6 describes how the variables are constructed and the specification of the two types of econometric models used in this study. The results of the econometric estimates for both samples are presented and discussed in Section 7. Finally, we summarize the results and compare the findings for Greece and Switzerland in Section 8.

2. Conceptual framework

2.1. The new firm model

Since the early 1990s, we have witnessed a constellation of important changes to the production process, such as the extensive use of computer-aided production technologies, advances in ICT, emergence of new ideas about how to organize firms, changes in the skill requirements for labour and changes in employee preferences toward more flexible working conditions. Based on these changes, many authors have begun to postulate a shift to a new "firm paradigm". Some focus mainly on technological changes, and others find the introduction of new organizational practices a central characteristic of this "paradigm change". There is another group of authors who concentrate primarily on the shift in firm demand to high-skilled labour since the late 1980s, and analyze the determinants of this shift. In this section, we briefly review some of this literature.

Milgrom and Roberts (1990, p. 511), focusing mainly on manufacturing, proclaim the replacement of the "mass production model by the vision of a flexible multiproduct firm that emphasizes quality and speedy response to market conditions while utilizing technologically advanced equipment and new forms of organization". Changes in production techniques and their implications for firm efficiency and performance constitute the main thrust of their theoretical analysis. Lindbeck and Snower (2000, p. 353) 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 later paper, Lindbeck and Snower (2003) elaborate the idea of the "firm as a pool of factor complementarities", thus identifying factor complementarity as a determinant of a firm's boundaries. Bresnahan et al. (2002) take the relative demand of skilled-labour as the 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 common characteristic that is central in all these types of studies is the existence of complementarities among several factors which mutually enhance their impact on firm performance.

2.2. Role of ICT

The benefits of ICT for a firm include savings on inputs, general cost reductions, greater flexibility and improvements in product quality. The new technology may save on labour or on some specific labour skills; it may also reduce capital needs through, for example, increased utilization of equipment and reduction in inventories or space requirements. This new technology may also lead to higher product quality or better product development conditions. Moreover, the new technology may also increase the flexibility of the production process, allowing for 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 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 readily 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 are difficult and costly. These adjustment difficulties lead to variations across firms in the use of ICT, its organizational complements and resulting outcomes.

2.3. Role of new organizational practices

Theories have been developed to explain why new high-skill and high-involvement workplaces might be more effective (see, e.g., Ichniowski et al., 2000). These can be grouped 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, worker performance increases. The second group of theories focus on changes in the structure of organizations that improve efficiency. (See also Aghion et al., 1999, p. 1650, for a discussion of the characteristics of recent developments in the structure of European and US companies.) Here, we concentrate more on this second group. Those 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 at the same time 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.)

In terms of organizational practices, there are interdependencies with other factors and inputs. Some of the changes in 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" (p. 173).

2.4. Role of human capital

The shift toward skilled workers appears to have accelerated in the last 20 years. While many factors have contributed to this increase, most authors think that this effect is primarily attributable to skill-biased technical change. The size, breadth and timing of the recent shift in labour demand have led many to seek skill-biased technical change in ICT. the largest and most widespread new technology of the recent years (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 they also produce large quantities of data which can be adequately utilized only by high-skilled workers, managers and professionals.

2.5. Role of complementarities

The use of ICT, new organizational practices and human capital builds a "complementary system" of activities (Bresnahan et al., 2002, p. 341ff; Milgrom and Roberts, 1995, p. 191ff). According to Milgrom and Roberts (1990, p. 514) "the term 'complement' is used not only in the traditional sense of a specific relation between pairs of inputs but also in a broader sense as a relation among groups of activities." For example, modern advanced manufacturing techniques consist of a bundle of technology elements implying considerable complementarities among these technology elements; a standard illustration refers to the use of CAD which leads to complementarities with other programmable manufacturing equipment. But complementarities are considered also with respect to organization and human capital. Lindbeck and Snower (2003) further elaborate on the idea of factor complementarity, which is identified as a central element in the determination of a firm's boundaries, distinguishing among four types of complementarities: two kinds of inter-factor complementarity (technological and informational complementarity), intra-factor complementarities (leading to increasing returns to scale) and complementarities among factors in the production of additional products (leading to increasing returns to scope). In this study, we restrict our analysis to inter-factor complementarities.

Recent theoretical developments analyze more in depth the conditions that are necessary for complementarity between (a) ICT and decentralization and (b) ICT and skill-upgrading. Acemoglu et al. (2006) develop a framework to analyze the relationship between the diffusion of new technologies and the decentralization of decision-making within firms. They show that firms that more recently adopted a new technology and which therefore are closer to the technological frontier, firms that are younger, and firms in more heterogeneous environments are more likely to choose decentralization. Borghans and ter Weel (2006) analyzed the differences in the division of labour across firms as a result of computer technology adoption. The use of computer technology can lead to productivity gains either directly, e.g., through reduced production time or indirectly through improved communication possibilities among employees. Direct productivity gains induce skill upgrading, while in firms that realize productivity gains from improved communication, specialization increases and skill requirements fall. Thus, the net result of these two opposite effects is observed. In both the above-mentioned studies the theoretical predictions are backed by some empirical evidence.

2.6. Production function framework

The above discussion of the literature shows that there are some common testable hypotheses with respect to the contributions of ICT, new organizational practices and human capital to firm efficiency and performance. These features can be combined within a production function

Table 1
Summary of the empirical literature.

Study	ICT	ORG	HC	Complementarity
USA				
Black and Lynch (2000)				
Cross-section	Positive	Positive	n.s.	n.s.
Longitudinal	Positive	Positive	n.s.	n.s.
Capelli and 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 and Kaiser (2001)				
Cross-section	Positive	Positive	n.c.	n.s.
Wolf and 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 and 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 available (for such cases in which the corresponding variables are included in the models, but the results are not explicitly presented).

framework that includes both classical (labour and traditional physical capital) and new (ICT capital, organization capital and human capital) production factors (see Brynjolfsson and Hitt (2000) for a recent survey of the empirical literature in this area):

- Hypothesis 1: there are considerable *direct* positive effects of ICT, organization and human capital, respectively, on firm performance;
- Hypothesis 2: there are considerable *indirect* positive effects of ICT, organization and human capital on firm performance which can be traced back to the complementarities among them.

3. Summary of related empirical literature

We review empirical studies that investigate the simultaneous impacts of ICT, organizational capital and human capital (or two of these components) on business performance. The choice of the studies reported in Table 1 was based on the following criteria: recent publication, consideration of at least two of the three variable blocks technology, organization and human capital in the model specification, firm-level analysis, coverage of all sectors of the economy. For a recent survey of this literature see Addison (2005).

We can see that most of these studies find a statistically significant positive effect for ICT and organizational capital, but only a few find the same effect for human capital. Note that this latter comment applies to most of the USA studies. With respect to the direct effects, Swiss firms tend to pay more attention to human capital than to organization, relative to other countries' firms. Only two of the USA studies find statistically significant complementarities between ICT and organizational capital, and also between ICT and human capital. The Australian study shows the existence of complementarities primarily between ICT and human capital, and – although somewhat weaker – between ICT and organizational capital. In the European studies, there is a tendency to find complementarities between ICT and human capital, and between organizational and human capital.

Overall, the results of these studies are indicative but not completely comparable because some of the observed differences can be traced back to variations among the sectors and the industries covered in the studies, to the specification of the independent variables, and to the nature of the investigations (cross-sectional versus longitudinal).

4. Data

Both our surveys were conducted in autumn 2005. The reference period for the qualitative data is the period 2003–2005 unless otherwise stated (see Table 3). The reference year for the quantitative variable is 2004.

4.1. Swiss data

The data for the Swiss part of this study were collected through a survey of Swiss enterprises. The questionnaire used in the study 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, employee involvement), employee vocational education and job-related training, as well as questions asking for basic economic data for 2004 (sales, value of intermediate inputs, investment expenditure, number of employees, etc.).[2] The survey was based on a disproportionately stratified (with respect to firm size) random sample of firms having at least 20

[2] The questionnaire was based substantially on similar questionnaires used in earlier surveys (see EPOC, 1997; Francois et al., 1999; Vickery and Wurzburg, 1998; Statics Canada, 1999). Versions of the questionnaire in German, French and Italian are available at http://www.kof.ethz.ch.

Table 2
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[a]	25.9	24.3
Job rotation[a]	7.7	3.6
Change in 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[b]		
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

[a] Percentage of firms reporting values 4 and 5 of an ordinate variable measuring how widespread is *team-work* and job rotation resp. inside a firm on a five-point Likert scale.

[b] Percentage of firms reporting values 4 and 5 of an ordinate variable measuring the distribution of decision competencies to determine work *pace, the sequence of tasks, etc. inside a firm* an on a five-point Likert scale.

employees, covering all relevant industries in the business sector and 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).[3] Responses were received from 1895 firms, or 38.7% of the firms in the underlying sample. With a few exceptions (over-representation of paper and energy industries, under-representation of hotels, catering and retail trade), the response rate did not vary much across industries and size classes. Columns 3 and 4 of Table A.1 in Appendix A, show the structure of the dataset for the Swiss part of this study, in terms of 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 (team-work, job rotation). A careful examination of the data from these 1895 firms led to the exclusion of 185 cases with contradictory or non-plausible answers, leaving 1710 valid answers that were used for the analyses presented in the following sections. Table A.2 in Appendix A presents some descriptive statistics of the basic variables for the Swiss dataset (see Table 3 for their specification).

4.2. Greek data

The data in the Greek part of this study were similarly collected through a survey of Greek enterprises, employing the same questionnaire that was used in the Swiss part of the study. The questionnaire was translated into Greek and pre-tested by three experienced experts employed by ICAP, one of the largest business information and consulting companies in Greece, and by two postgraduate students with experience in information systems research, from the University of the Aegean. Based on their feedback, we developed the final version of the questionnaire. Three samples of 300 Greek firms each were randomly selected from the ICAP database (which included approximately 135,000 Greek firms from all industries), all of which were 'similar' to the Swiss sample firms. All three samples included firms from the same industries and size classes, and the proportions of industry and size classes were the same as in the Swiss sample. The questionnaire was sent by post to the firms in the first sample; after three weeks non-responding firms were contacted by phone. Firms that refused to participate in the survey were replaced by similar firms (i.e. from the same industry and size class) from the second sample; in the few cases where we exhausted the corresponding firms in the second sample, we exploited the firms in the third sample. Following the above procedure, which was aimed at maintaining the proportions of industries and size classes, we finally achieved responses from 281 firms. After examination of the returned completed questionnaires we excluded 10 cases with contradictory or non-plausible answers; the remaining 271 valid responses were used for the analyses.

Columns 1 and 2 of Table A.1 in Appendix A show the structure of the final dataset used for the Greek part of the study, by industry and firm size class. A non-response analysis was performed (survey of a sample of the non-respondents); this analysis did not indicate any serious selectivity bias with respect to the use of ICT, new organizational practices, vocational education or job-related training. For the 271 firms we also retrieved some economic data for 2004 from the ICAP database were not collected through the questionnaire. For all of these Greek firms, therefore, we achieved the same economic data as were collected for the firms in the Swiss dataset through the Swiss questionnaire, with one difference: the Swiss questionnaire collected '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'. However, since both these variables are good measures of the 'traditional capital' the firm uses, we believe

[3] Table A.1 shows only 26 industries; the Swiss sample included "watches", "telecommunication" and "computer services" as separate industries, which were combined respectively with "electronics/instruments", "transport" and "other business services" to make the industry classifications comparable with the Greek data.

Table 3
Definition of model variables

Variable	Definition and measurement
Basic model	
LogCL	Logarithm of gross investment expenditure per employee 2004
LogASSETN	Logarithm of assets value per employee at the 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 periods 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 intranet 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 periods 2000–2005: 1: increase; 2: no change; 3: decrease
COMP_OVERALL	Three-level ordinate variable measuring the change of the distribution of decision competencies 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 competencies to determine work pace (1: 'primarily managers'; 5: 'primarily employees')
COMP_WORKSEQ	Ordinate variable measuring the distribution of decision competencies 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 competencies to assign tasks to the employees (1: 'primarily managers'; 5: 'primarily employees')
COMP_WORKWAY	Ordinate variable measuring the distribution of decision competencies to determine the way of performing tasks (1: 'primarily managers'; 5: 'primarily employees')
COMP_PRODUCTION	Ordinate variable measuring the distribution of decision competencies to solve emerging production problems (1: 'primarily managers'; 5: 'primarily employees')
COMP_CUSTOMER-CONTACT	Ordinate variable measuring the distribution of decision competencies to contact customers (1: 'primarily managers'; 5: 'primarily employees')
COMP_CUSTOMER	Ordinate variable measuring the distribution of decision competencies to solve emerging problems with customers (1: 'primarily managers'; 5: 'primarily employees')
Compact model	
ICT	Sum of the standardized values of the variables INTERNET and INTRANET
ORG1	Sum of the standardized values of the variables TWORK, JROT and LEVEL
ORG2	Sum of the standardized values of the variables COMP_OVERALL, COMP_PRODUCTION and COMP_CUSTOMER
HUMAN	Sum of the standardized values of the variables logQUAL and logTRAIN
ICT*ORG1	Interaction term of the variables ICT and ORG1
ICT*ORG2	Interaction term of the variables ICT and ORG2
HUMAN*ORG1	Interaction term of the variables HUMAN and ORG1
HUMAN*ORG2	Interaction term of the variables HUMAN and ORG2
ICT*HUMAN	Interaction term of the variables ICT and HUMAN
Middle-sized firms	50–249 employees
Large firms	250 employees and more

All qualitative variables are referring to the reference periods 2003–2005 unless otherwise mentioned.

that this is not a problem. Table A.2 in Appendix A presents some descriptive statistics for the basic variables for the Greek dataset (see Table 3 for their specification).

5. Patterns of use: ICT, new organizational practices and human capital in Greece and Switzerland

We calculated descriptive statistics for both the Greek and Swiss data, the most important of which are shown in Table 2, and also in the above-mentioned Table A.2, Tables A.3a and A.3b in Appendix A, which enable us to draw some conclusions about the patterns of use of ICT, and about new organizational practices and human capital in Greece and Switzerland, and allow us to make some comparisons between them.

For ICT capital, there are remarkable differences between the patterns of Internet usage (which is 'outward-looking' aimed at linking the firm to the outside world) and intranet usage (which is 'inward-looking' aimed at linking employees and organizational units within the firm). As we can see from Table 2, 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 firms with 1–20% of their employees using the Internet (52.1% in Greece and 37.8% in Switzerland). The percentage of the firms characterized by extensive Internet diffusion, that is, having more than 60% of their employees using Internet, is much smaller (16.3% in Greece and 26.4% in Switzerland). Comparison of 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 internet use in those Swiss firms that have introduced the technology is higher than that in the Greek firms (Table A.2 shows that the mean of this variable is 3.380 for Switzerland and 2.948 for Greece).

There is a considerable percentage of firms in both countries that did not have an intranet (24.4% in Greece and 43.5% in Switzerland). The class with the highest relative frequency in both countries is again firms with 1–20% of their employees using intranet (27.4% in Greece and 15.1% in Switzerland), but this is a lower relative frequency than the corresponding class (1–20%) for internet usage in both countries. The percentage of the firms with extensive intra-firm diffusion of intranet technology, that is, 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 without an intranet is higher in Switzerland than that in Greece (43.5% and 24.4%, respectively) and the intensity of use of intranet by Greek firms is higher than for Swiss firms (Table A.2 shows that the mean of this variable is 2.668 for Switzerland and 3.015 for Greece). We can also see that Greek firms' level of use of internet and intranet on average is similar (Table A.2 shows that the averages for the corresponding variables are 2.948 and 3.015, respectively), while in Swiss firms a more 'outward-looking' use of ICT is observed: internet use is higher than intranet use (the averages of the corresponding variables are 3.380 and 2.668, respectively).

For human capital, we can see from Table 2 that the mean percentage of employees with tertiary level vocational education is 26.2% for Greek firms and 20.8% for Swiss firms; the share of employees receiving job-related training is 26.8% for Swiss firms and 23.3% for Greek firms. So, comparison between the two countries again produces a 'mixed' conclusion: of the two forms of human capital examined, Swiss firms offer more job-related training to their employees than do Greek firms, while the latter employ more tertiary level personnel than the former.

For the new organizational practices associated with the new forms of 'work design' presented in Tables 2 and 8, we can see that the most frequently adopted is team-work (with 25.9% of Greek firms and 24.3% of Swiss firms showing extensive diffusion of 'team-work' at level 4 – "strongly widespread" – or 5 – "very strongly widespread"). The results are much lower for 'decrease in the management levels' (by 9.0% of the Swiss firms and 3.7% of the Greek firms) and 'job rotation' (by 7.7% of the Greek firms and 3.6% of the Swiss firms). Comparison between the two countries again gives a 'mixed' conclusion; the percentage of firms that decreased in their management levels is higher for Swiss firms than for Greek firms, while the reverse is true for the adoption of job rotation. We can also conclude from Tables 8 and 2 that the level of adoption of team-work is higher in Swiss than that in Greek firms (Table A.2 shows that the mean of this variable is 2.218 for Switzerland and 1.925 for Greece).

If we compare Switzerland and Greece in terms of 'employee voice'-related new organizational practices, it is clear that Swiss firms' adoption of such practices is much higher than in Greek firms. In a considerable percentage of firms in both countries there has been a shift since 2000 in the overall distribution of competencies towards employees (in 33.6% of the Swiss firms and 24.0% of the Greek firms). The highest level of decentralization is in competencies related to contacting customers (with 25.1% of the Swiss firms and 18.1% of the Greek firms reporting the two higher values, 4 and 5, of the ordinate variable measuring the diffusion of this type of decentralization inside the firm on a five-point Likert scale), followed by decentralization in decisions about how various tasks are performed (15.2% and 4.8%, respectively), then the sequence of tasks (13.8% and 2.2%, respectively), and then the work pace (12.3% and 9.9%, respectively).

In terms of the knowledge capital, we can see from Table A.2 that investment per employee in research and development (R&D) in Swiss firms is much higher than in Greek firms.

Finally, we examine the time lag between the introduction of new technology and/or new organizational practices and the effects on productivity. We have some information on the (approximate) time of adoption of internet and intranet and on team-work and job rotation for the Swiss case; 89.4% of all firms having internet and 75.4% of all firms having intranet in 2005 had introduced the new technology before 2003.[4] The respective figures for the introduction of team-work and job rotation before 2000 are 65.5% and 58.3%, respectively.[5]

Thus, the time lags for both technology and organization seem to be sufficiently long to result in some effect on productivity. However, we cannot be sure that a thorough exploitation of possible technology and organization effects took place in the observed period.

6. Model specification and variable construction

6.1. 'Basic' model

Throughout this study, we use the logarithm of annual value added (sales revenue minus value of intermediate inputs) per employee as the dependent variable. As independent variables in the "basic models", we used measures of "ICT capital", "organizational capital", "human capital" "physical capital" and "knowledge capital". To measure technology input, particularly ICT input ("ICT capital"), we used intensity of use of two important ICT, Internet (linking to the outside world) and intranet (linking within the firm), quantified by the respective share of employees using these technologies in their daily work. The firms were asked to report this share not by a precise figure but within a range of 20 percentage points on a six-level scale: 0%, 1–20%, 21–40%, 41–60%, 61–80% and 81–100%. Based on these data, we constructed two ordinal variables, i.e. one for Internet and one for intranet, taking values 0 to 5, thus covering the whole range from 0% to 100% (see Table 3). 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 the technology or some kind of simple hardware measure (e.g. number of personal computers installed).

4 In addition, we know from an earlier study that 78.0% of the firms in the sample had introduced Internet before 2000 (see Arvanitis et al., 2002). Unfortunately, we do not have similar data for Greece.

5 46.3% of all Greek firms using team-work adopted this organizational form before 1999, and 67.2% before 2001. With respect to job rotation: 52.4% adopted it before 1999, 71.0% before 2001.

We would expect a generally positive correlation of these technology variables with labour productivity.

The measurement of organizational inputs, here restricted to inputs related to workplace organization, is still open to discussion, since there is no final agreement among applied economists about the exact definition of "organizational capital" (see Black and Lynch (2002) and Lev (2003) for a discussion of this matter; see also Appelbaum et al. (2000, chapter 7) for definitions of high-performance work system variables). In order to choose the variables related to changes in and/or introduction and use of new organizational practices at 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 management levels within the firm, the existence and diffusion of job rotation, 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 employees, greater autonomy and discretion in the structure of their work, such as individual job enrichment schemes, decentralization of decision competencies that give employees more decision making autonomy. Based on the above definitions, we regard 'organizational capital' in this study to consist 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 below. Thus, we constructed the following three- or five-level ordinate variables covering most of the above-discussed aspects of organizational capital (see Table 3):

(i) to measure "work design" practices: intensity of the use of team-work (project groups, quality circles, semi-autonomous teams), intensity of the use of job rotation, increase/stability/decrease in number of management levels;
(ii) to measure "employee voice": overall shift in decision competencies from managers to employees within a firm and distribution of decision competencies between managers and employees within a firm with respect to (a) work pace, (b) sequence of the tasks to be performed, (c) assignment of tasks, (d) way of performing tasks, (e) solving emerging production problems, (f) contacts with customers and (g) resolution of emerging problems with customers.

We expect an overall positive correlation of the organizational variables with average labour productivity, but we do not have signage expectations for every variable.

To measure human capital we use two variables: 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 initiated or supported by the firm) (see Table 3). According to standard analysis (see, e.g., Barro and Lee, 1994) we expect a positive correlation of these variables with labour productivity.

We also control for physical capital (measured by the logarithm of annual gross investment expenditure per employee for the Swiss sample and by the logarithm of assets value per employee for the Greek sample), knowledge capital (measured by the logarithm of annual R&D expenditure per employee), firm size, and sector affiliation. Firm size controls can also serve as an approximation for firm age controls (young firms are mostly small), thus taking account of 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 can be seen as controlling for the heterogeneity of a firm's environment, a further factor influencing the technology-decentralization relationship according to Acemoglu et al. (2006).

6.2. 'Compact' model

In the basic models, two variables for Internet and intranet serve as proxies for "ICT capital", 11 organizational variables are used to approximate "organizational capital" and two variables are proxies for "human capital". In order to assess the relative significance of each of these three variable blocks for labour productivity, it is necessary to construct comparable overall measures of these three "types of capital". To this end, we constructed four composite indices: one based on the two technology variables (variable ICT), one based on the two human capital variables (HUMAN), one for the three organizational variables measuring "work design" (ORG1) and one for the eight organizational variables measuring "employee voice" (ORG2). These composite indices were calculated as the sum of the standardized values (average 0; standard deviation 1) of the underlying variables (see Table 3). Based on these, we estimated "compact" models with the logarithm of annual value added per employee as the dependent variable, and the above composite indices ICT, HUMAN, ORG1 and ORG2 as independent variables, plus variables for physical capital and R&D intensity and also the control variables.

Another reason for specifying this "compact" model was to enable the investigation of the complementarity between technology, human capital and the two forms of organizational capital; the composite indices are considered as metric variables, and interaction terms for these variables can be inserted in the model to investigate the corresponding complementarities (see Section 7).

7. Empirical results

7.1. 'Basic' model

7.1.1. Greek results

Table 4a presents OLS estimates for the basic model based on the Greek data (see Table A.3a in Appendix A for the correlation matrix of the model variables). One problem was related to the high correlation between the two technological variables measuring the intensity of

Table 4a
Basic model: average labour productivity log (value added per employee) 2004[a] (OLS estimates); Greece.

Explanatory variables	(1)		(2)		(3)		(4)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogASSETN	0.114***	0.174	0.126***	0.194	0.118***	0.181	0.130***	0.202
	(0.040)		(0.039)		(0.041)		(0.040)	
LogQUAL	0.168***	0.160	//		0.206***	0.197	//	
	(0.072)				(0.071)			
LogTRAIN	//		0.089*	0.120	//		0.111**	0.150
			(0.049)				(0.049)	
LogRDL	0.015	0.040	0.021	0.060	0.009	0.024	0.016	0.043
	(0.023)		(0.023)		(0.024)		(0.024)	
INTERNET	//		//		0.104*	0.127	0.144***	0.176
					(0.055)		(0.005)	
INTRANET	0.126***	0.202	0.145***	0.233	//		//	
	(0.043)		(0.040)					
Middle-sized firms	0.035	0.016	0.009	0.004	0.059	0.027	0.027	0.012
	(0.155)		(0.159)		(0.156)		(0.160)	
Large firms	−0.030	−0.013	−0.127	−0.053	0.013	0.005	−0.084	−0.035
	(0.173)		(0.176)		(0.172)		(0.176)	
Services firms	0.107	0.049	0.081	0.037	0.141	0.065	0.111	0.051
	(0.137)		(0.138)		(0.138)		(0.139)	
Constant	8.371***		8.860***		8.606***		8.736***	
	(0.446)		(0.435)		(0.457)		(0.450)	
N	252		255		251		254	
DF	7		7		7		7	
SER	1.023		1.026		1.030		1.033	
F	5.819***		5.474***		5.055***		4.660***	
R^2adj	0.118		0.109		0.102		0.105	

Explanatory variables	(5)		(6)		(7)		(8)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogASSETN	0.114***	0.174	0.118***	0.179	0.112***	0.172	0.111***	0.170
	(0.041)		(0.040)		(0.040)		(0.040)	
LogQUAL	0.125*	0.119	0.143*	0.136	0.137*	0.131	0.148*	0.141
	(0.076)		(0.074)		(0.073)		(0.074)	
LogTRAIN	//		//		//		//	
LogRDL	0.007	0.018	0.008	0.023	0.009	0.024	0.018	0.032
	(0.024)		(0.024)		(0.024)		(0.024)	
INTERNET	//		//		//		//	
INTRANET	0.104**	0.167	0.116***	0.186	0.108**	0.174	0.116***	0.187
	(0.045)		(0.043)		(0.043)		(0.043)	
TWORK	0.017	0.028	0.020	0.033	0.011	0.018	0.026	0.042
	(0.040)		(0.038)		(0.038)		(0.039)	
JROT	0.012	0.016	-0.007	-0.010	0.014	0.019	0.003	0.004
	(0.047)		(0.045)		(0.046)		(0.046)	
LEVEL	0.000	0.000	-0.002	0.001	-0.010	-0.004	-0.020	-0.008
	(0.157)		(0.153)		(0.153)		(0.154)	
COMP_OVERALL	0.021	0.010	//		//		//	
	(0.130)							
COMP_WORKPACE	−0.038	−0.037	//		//		0.110*	0.105
	(0.077)						(0.067)	
COMP_WORKSEQ	−0.076	−0.060	0.153*	0.120	//		//	
	(0.093)		(0.079)					
COMP_WORKASSIGN	−0.026	−0.016	//		//		//	
	(0.119)							
COMP_WORKWAY	−0.121	−0.101	//		0.182**	0.152	//	
	(0.097)				(0.078)			
COMP_PRODUCTION	0.003	0.003	//		//		//	
	(0.082)							
COMP_CUSTOMER-CONTACT	−0.010	−0.011	//		//		//	
	(0.072)							
COMP_CUSTOMER	−0.004	−0.004	//		//		//	
	(0.091)							

(*continued on next page*)

Table 4a (*continued*)

Explanatory variables	(5)		(6)		(7)		(8)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
Middle-sized firms	0.056	0.025	0.056	0.025	0.040	0.018	0.059	0.027
	(0.161)		(0.157)		(0.156)		(0.158)	
Large firms	−0.039	−0.016	−0.015	−0.006	−0.062	−0.026	−0.011	−0.005
	(0.178)		(0.173)		(0.173)		(0.174)	
Services firms	0.125	0.057	0.096	0.044	0.136	0.062	0.122	0.056
	(0.145)		(0.138)		(0.138)		(0.138)	
Constant	9.926***		8.499***		8.495***		8.570***	
	(0.900)		(0.551)		(0.544)		(0.547)	
N	252		252		252		252	
DF	18		11		11		11	
SER	1.031		1.023		1.020		1.025	
F	2.622***		4.062***		4.247***		3.956***	
R^2adj	0.104		0.118		0.124		0.114	

[a] 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 10% level; heteroscedasticity-robust standard errors (White procedure).
** Denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).
*** Denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

Internet and intranet use. When both were included in the same model as independent variables, one had a statistically significant coefficient, while the other did not; however, if one of these variables was removed from the model, the coefficient of the other became significant, since they are both characterized by high correlation with the dependent variable (labour productivity). The problem was the same for the two human capital variables measuring the share of employees with tertiary education and the share of employees receiving job-related training. These effects are indicated in the first four models (1–4) in Tables 4a and A.3b.

For these reasons, model 5 in Table 4a includes only one of these two technological variables as an independent variable (intensity of intranet use, which is more highly correlated with the dependent variable than the intensity of Internet use), and only one of the two human capital variables (share of employees with tertiary education, which is more highly correlated with the dependent variable than the share of employees receiving job-related training), the 11 organizational variables, the knowledge capital and the physical capital variables (and also the control variables). Since the correlations among the organizational variables are also high, we estimated eleven variants of this model, each of them having only one of these organizational variables. In only three of these eleven models does the organizational variable have a statistically significant coefficient. As shown in Table 4a, these are the three models for the level of decentralization of decision competencies concerning the sequence of tasks to be performed, how tasks are performed, and work pace (models 6, 7 and 8, respectively).

From the models in Table 4a, we can see that the coefficients of the two technological variables measuring the intensity of Internet and intranet uses are positive and statistically significant, which means that the higher intensity of the use of these technologies in a firm results in higher labour productivity (with the intensity of intranet use having the stronger effect on labour productivity as mentioned above). Also, both human capital variables have statistically significant positive coefficients (with the share of employees with tertiary education having the stronger effect as mentioned above). The physical capital variable also has a statistically significant positive coefficient, but the coefficient of the knowledge capital variable is not significant.

In terms of the three organizational variables representing "work design" in the Table 4a models, we can see that they do not have a statistically significant effect on labour productivity. Similarly, there is no significant effect for the overall delegation of competencies from managers to employees; of the other seven organizational variables representing "employee voice," only three have a statistically significant effect on labour productivity: those measuring the extent of decentralization from managers to employees of decision competencies with respect to sequence of tasks to be performed, how tasks are performed, and work pace.

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

7.1.2. Swiss results

Table 4b presents the OLS estimates of the basic model based on the Swiss data (see Table A.4a in Appendix A for the correlation matrix of the model variables). We can see that the coefficients of the two technological variables measuring the intensity of the 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 firm's employees, the higher will be labour productivity, all other things being equal. Also, both proxy variables for human capital, as expected, have statistically significant positive coefficients. The strongest effect is from formal education, but job-related training is also important. Further, we obtained the expected positive effects for physical and knowledge capital.

Table 4b
Basic model: average labour productivity (log (value added per employee)) 2004[a] (OLS estimates); Switzerland.

Explanatory variables	(1)		(2)		(3)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogCL	0.033*** (0.009)	0.123	0.033*** (0.009)	0.122	0.034*** (0.009)	0.127
LogQUAL	0.043** (0.013)	0.094	0.041*** (0.013)	0.091	0.040*** (0.013)	0.088
logTRAIN	0.032** (0.010)	0.077	0.031*** (0.010)	0.075	0.034*** (0.010)	0.083
logRDL	0.013** (0.004)	0.097	0.014*** (0.004)	0.106	0.014*** (0.004)	0.104
INTERNET	0.027** (0.011)	0.082	0.023** (0.011)	0.068	0.026** (0.011)	0.076
INTRANET	0.031*** (0.009)	0.112	0.031*** (0.009)	0.115	0.030*** (0.009)	0.109
TWORK	0.002 (0.007)	0.008	0.003 (0.007)	0.008	0.002 (0.007)	0.007
JROT	−0.014 (0.010)	−0.032	−0.016* (0.009)	−0.037	−0.016 (0.010)	−0.036
LEVEL	0.033 (0.035)	0.023	0.032 (0.036)	0.023	0.026 (0.036)	0.018
COMP_OVERALL	0.007 (0.022)	0.007	0.001 (0.022)	0.002	0.008 (0.022)	0.008
COMP_WORKPACE	−0.002 (0.016)	−0.004	//		//	
COMP_WORKSEQ	−0.002 (0.014)	−0.004	//		//	
COMP_WORKASSIGN	−0.005 (0.016)	−0.008	//		//	
COMP_WORKWAY	−0.014 (0.013)	−0.027	//		//	
COMP_PRODUCTION	0.002 (0.015)	0.003	//		//	
COMP_CUSTOMER-CONTACT	0.027** (0.013)	0.065	0.038*** (0.010)	0.090	//	
COMP_CUSTOMER	0.020 (0.016)	0.039	//		0.038*** (0.011)	0.076
Middle-sized firms	0.010 (0.014)	0.019	0.005 (0.014)	0.009	0.006 (0.014)	0.012
Large firms	0.022* (0.013)	0.054	0.021 (0.013)	0.051	0.020 (0.013)	0.049
High-tech manufacturing	0.038 (0.042)	0.033	0.041 (0.042)	0.035	0.045 (0.042)	0.039
Low-tech manufacturing	0.087** (0.039)	0.078	0.087** (0.039)	0.077	0.092** (0.038)	0.082
Modern services	0.187*** (0.057)	0.129	0.188*** (0.057)	0.128	0.202*** (0.057)	0.137
Traditional services	0.021 (0.041)	0.018	0.025 (0.041)	0.021	0.041 (0.040)	0.035
Constant	10.926*** (0.118)		10.919*** (0.111)		10.914*** (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	

[a] 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 10% level; heteroscedasticity-robust standard errors (White procedure).
** Denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).
*** Denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

On the contrary we do not find any statistically significant effects for the three organizational variables representing "work design" (except for a weak negative effect of the variable for job rotation in model 2 in Table 4b). Also we find no indications of a significant effect for the overall delegation of competencies from managers to employees. Finally, in order to exclude the possibility of multi-collinearity, the eight "employee voice" variables, measuring

Table 5a
Compact model: average labour productivity (log (value added per employee)) 2004[a] (OLS estimates); Greece.

Explanatory variables	(1)		(2)		(3)		(4)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogASSETN	0.119*** (0.040)	0.182	0.112*** (0.040)	0.171	0.118*** (0.040)	0.181	0.117*** (0.040)	0.179
LogRDL	0.004 (0.024)	0.012	0.003 (0.024)	0.007	0.004 (0.024)	0.011	0.004 (0.024)	0.011
HUMAN	0.093* (0.049)	0.143	0.095* (0.049)	0.145	0.091* (0.049)	0.141	0.101** (0.050)	0.156
ICT	0.098** (0.043)	0.160	0.101** (0.044)	0.166	0.101** (0.045)	0.165	0.095** (0.043)	0.156
ORG1	0.009 (0.036)	0.015	0.013 (0.036)	0.022	0.009 (0.036)	0.016	0.017 (0.037)	0.029
ORG2	0.030* (0.015)	0.130	0.032** (0.016)	0.137	0.030* (0.016)	0.130	0.030* (0.016)	0.129
ICT*ORG1	//		-0.034* (0.019)	-0.105	//		//	
ICT*ORG2	//		0.007 (0.009)	0.047	//		//	
ICT*HUMAN	//		//		-0.005 (0.022)	-0.015	//	
HUMAN*ORG1	//		//		//		-0.022 (0.021)	-0.063
HUMAN*ORG2	//		//		//		0.009 (0.008)	0.065
Middle-sized firms	0.016 (0.159)	0.009	0.008 (0.159)	0.003	0.016 (0.160)	0.007	0.007 (0.160)	0.003
Large firms	-0.079 (0.173)	-0.032	-0.087 (0.173)	-0.036	-0.085 (0.176)	-0.035	-0.092 (0.174)	-0.038
Services firms	0.097 (0.137)	0.044	0.058 (0.139)	0.026	0.099 (0.138)	0.045	0.078 (0.138)	0.036
Constant	9.580*** (0.444)		9.668*** (0.446)		9.599*** (0.452)		9.600*** (0.447)	
N	251		251		251		251	
DF	9		11		10		11	
SER	1.015		1.011		1.017		1.014	
F	5.104***		4.564***		4.581***		4.375***	
R^2adj	0.128		0.135		0.125		0.129	

[a] Calculated in full-time equivalents; reference group for sector dummies: manufacturing; reference group for firm size dummies: firms with less than 20 employees; standard errors in brackets.
* Denote statistical significance at the 10% level; heteroscedasticity-robust standard errors (White procedure).
** Denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).
*** Denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

the extent of decentralization of particular competencies from managers to employees, were inserted separately in the estimation equation. Only two of these were found to have positive and statistically significant coefficients: the variables measuring the decentralization of competencies for contacting customers, and the decentralization of competencies for solving customers' problems (see, respectively, models 2 and 3 in Table 4b). Therefore, we can conclude that an overall shift of competencies towards employees is perhaps too unspecific to have a positive performance impact. It is clear-targeted delegation of specific competencies from managers to employees, with respect to contacting customers and solving customers' problems that could enhance productivity. On the whole, the organizational variables are correlated less strongly with the dependent variable (and explain less of its variance) than with the technological variables.

In sum, for Switzerland we found statistically significant positive effects for all the individual variables belonging to the variable blocks of technology and human capital, and for physical and knowledge capital variables, but for only two of the eleven variables measuring aspects of the organizational capital.

8. 'Compact' model

8.1. Econometric methodology

We tested extensively for the possibility of endogeneity in the right-hand variables in the compact version of our model. For this purpose, we used the methodology developed by Rivers and Vuong (1988) to test for right-hand variable endogeneity and to correct for it, if found. For the Swiss case, as the first step we estimated instrument equations for all right-hand variables (ICT, ORG1, ORG2, HUMAN, logCL, LogRDL) and inserted the residuals of these equations separately into the productivity equations (see Table A.5 in Appendix A). According to the Rivers/Vuong

Table 5b
Compact model: average labour productivity (log (value added per employee) 2004[a] (OLS/Rivers-Vuong estimates); Switzerland.

Explanatory variables	(1)		(2)		(3)		(4)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogCL	0.032***	0.119	0.033***	0.123	0.033***	0.125	0.033***	0.123
	(0.009)		(0.009)		(0.009)		(0.009)	
LogRDL	0.014***	0.103	0.014***	0.101	0.015***	0.108	0.013***	0.096
	(0.004)		(0.004)		(0.004)		(0.004)	
HUMAN	0.362***	1.179	0.037***	0.122	0.038***	0.123	0.037***	0.120
	(0.083)		(0.008)		(0.008)		(0.008)	
RES1	−0.327***	0.982	//		//		//	
	(0.083)							
ICT	0.050***	0.179	0.215***	0.762	0.050***	0.177	0.049***	0.174
	(0.009)		(0.045)		(0.008)		(0.009)	
RES2	//		−0.167***	−0.504	//		//	
			0.046					
ORG1	−0.003	−0.001	−0.000	−0.000	−0.214***	−0.802	−0.001	−0.002
	(0.006)		(0.006)		(0.081)		(0.006)	
RES3	//		//		0.214***	0.778	//	
					(0.080)			
ORG2	0.004*	0.039	0.004*	0.039	0.005**	0.047	0.070***	0.655
	(0.002)		(0.002)		(0.002)		(0.018)	
RES4	//		//		//		-0.066***	-0.594
							(0.018)	
Middle-sized firms	−0.039**	−0.077	−0.024	−0.049	0.057***	0.115	0.003	0.006
	(0.019)		(0.017)		(0.021)		(0.013)	
Large firms	−0.036*	0.088	0.030	−0.073	0.087***	0.212	−0.003	−0.006
	(0.020)		(0.020)		(0.025)		(0.015)	
High-tech manufacturing	−0.154**	−0.135	−0.139**	−0.122	0.249***	0.218	−0.084	−0.073
	(0.063)		(0.067)		(0.091)		(0.056)	
Low-tech manufacturing	0.150***	0.135	0.032	0.029	0.236***	0.211	0.030	0.027
	(0.046)		(0.040)		(0.073)		(0.041)	
Modern services	−0.166*	−0.112	−0.238*	−0.162	0.378***	0.256	0.034	0.023
	(0.100)		(0.131)		(0.090)		(0.070)	
Traditional services	0.038	0.033	−0.087*	−0.074	0.112**	0.095	−0.122**	−0.102
	(0.042)		(0.051)		(0.054)		(0.058)	
Constant	10.63***		11.52***		11.09***		11.45***	
	(0.187)		(0.099)		(0.111)		(0.089)	
N	1710		1710		1710		1710	
DF	13		13		13		13	
SER	0.447		0.448		0.449		0.448	
F	28.5***		28.8***		29.6***		28.2***	
R^2adj	0.202		0.199		0.195		0.199	

[a] Calculated in full-time equivalents; RES1 to RES4: the residuals of the first-step OLS estimates of the variables HUMAN, ICT, ORG1 and ORG2, respectively; 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 10% level; heteroscedasticity-robust standard errors (White procedure).

** denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).

*** denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

Table 6
Compact model with interaction terms: average labour productivity (log (value added per employee) 2004[a] (OLS estimates); Switzerland.

Explanatory variables	(1)		(2)		(3)	
	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient	Original coefficient	Standardized coefficient
LogCL	0.033***	0.124	0.034***	0.128	0.034***	0.126
	(0.009)		(0.009)		(0.009)	
LogRDL	0.014***	0.100	0.013***	0.097	0.013***	0.097
	(0.004)		(0.004)		(0.004)	
HUMAN	0.037***	0.119	0.040***	0.131	0.041***	0.134
	(0.010)		(0.009)		(0.010)	
ICT	0.054***	0.191	0.027*	0.096	0.052***	0.184
	(0.009)		(0.016)		(0.009)	
ORG1	−0.001	−0.004	−0.002	−0.007	−0.011	−0.040
	(0.006)		(0.006)		(0.012)	
ORG2	0.005**	0.047	0.006**	0.052	−0.001	−0.011
	(0.002)		(0.003)		(0.004)	
ICT*ORG1	−0.001	−0.008	//		//	
	(0.003)					
ICT*ORG2	−0.002	−0.029	//		//	
	(0.002)					
ICT*HUMAN	//		0.008*	0.099	//	
			(0.004)			
HUMAN*ORG1	//		//		0.003	0.039
					(0.004)	
HUMAN*ORG2	//		//		0.002*	0.071
					(0.001)	
Middle-sized firms	0.013	0.027	0.016	0.031	0.015	0.030
	(0.013)		(0.013)		(0.013)	
Large firms	0.028**	0.068	0.029**	0.071	0.029**	0.070
	(0.012)		(0.012)		(0.012)	
High-tech manufacturing	0.042	0.037	0.047	0.041	0.041	0.036
	(0.043)		(0.042)		(0.042)	
Low-tech manufacturing	0.081**	0.073	0.084**	0.075	0.082**	0.073
	(0.039)		(0.039)		(0.039)	
Modern services	0.198***	0.135	0.188***	0.128	0.190***	0.129
	(0.058)		(0.059)		(0.057)	
Traditional services	0.026	0.022	0.030	0.025	0.028	0.023
	(0.041)		(0.041)		(0.041)	
Constant	11.32***		11.29***		11.29***	
	(0.079)		(0.079)		(0.079)	
N	1710		1710		1710	
DF	14		13		14	
SER	0.450		0.450		0.450	
F	28.3***		30.6***		28.5***	
R^2adj	0.186		0.187		0.187	

[a] 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 10% level; heteroscedasticity-robust standard errors (White procedure).
** Denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).
*** Denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

test, the statistical significance (at the 5% test level) of the coefficients of the residuals indicates that the respective variables correlate with the residuals of the productivity equation. Therefore, the coefficients of these variables in the estimates without the residuals of the instrument equations are biased and have to be corrected.[6] This is the case for the variables ICT, ORG1, ORG2 and HUMAN. Thus, we present the estimates for the productivity equation including the residuals of the respective instrument estimates in Table 5b. We adopted the same procedure for the Greek estimates, but in that case the coefficients of the residuals of the instrument equations inserted in the productivity equation were not statistically significant, thus no correction was needed.

8.2. Greek results

Table 5a presents the estimates of the "compact" model based on the Greek data (see Table A.4a in Appendix A for the correlation matrix of the model variables). We note that the composite indices for information technology (ICT), human capital (HUMAN) and the organizational variables representing "employee voice" (ORG2), and the variable for 'traditional' physical capital have significant

[6] We chose this procedure because it allows an explicit test for endogeneity and correction of any eventual biases. We also conducted an instrument variables estimation which yielded similar results.

positive coefficients, while the composite indicator comprising the three variables representing the new forms of "work design" (ORG1) and the variable for knowledge capital (logarithm of R&D expenditure per employee) do not. The relative importance of these production factors with respect to labour productivity, as measured by the magnitude of the corresponding standardized regression coefficients (see column 2, model 1 in Table 5a), leads to the following ranking: first, traditional capital, second, ICT, third, human capital and finally 'employee-voice' oriented new organizational practices.

Next, we construct three more models by inserting the above "compact" model interaction terms between the composite variables for technology, organizational and human capital, which are considered metric variables, in order to examine whether there is complementarity between them. In the first of these models, we add the ICT*ORG1 and ICT*ORG2 terms (shown in Table 5a as model 2), in the second model we add the term ICT*HUMAN (model 3 in Table 5a), and in the third model we add the terms HUMAN*ORG1 and HUMAN*ORG2 (model 4 in Table 5a). We find that none of these interaction terms has a statistically significant coefficient, except for the interaction term of the technology variable with the new forms of "work design" variables (ICT*ORG1), which has a weak negative coefficient (with 8% significance). These results (taking also into account the corresponding results for the Swiss sample presented next) show that Greek firms have not learned how to combine ICT, human capital and new organizational practices effectively, e.g. how to use ICT to support and improve new organizational practices, and how to use the highly educated personnel and training to support and improve new organizational practices, how to exploit the better capabilities offered by their ICT systems.

8.3. Swiss results

The estimates for the "compact" model using the Swiss data are presented in Table 5b (see Table A.4b in Appendix A for the correlation matrix of the model variables). We can see that the composite indices for technology (ICT), human capital (HUMAN) and the organizational variables representing "employee voice" (ORG2) and also the variables for 'traditional' capital (logarithm of gross investment expenditure per employee) and the knowledge capital (logarithm of R&D expenditure per employee) have significant positive coefficients. Their relative importance with respect to labour productivity, as measured by the magnitude of the standardized regression coefficients of these variables, leads to the following ranking: first, human capital; second, technology; third, 'employee-voice' oriented new organizational practices; fourth, 'traditional' capital and finally knowledge capital. We find a negative effect for the composite indicator comprising the three variables measuring "work design" (ORG1) that can be traced back to the negative effect of job rotation (see Table 4b).

In the next step, we insert in the "compact" model the following interaction terms of the composite variables for technology, organization and human capital, which are considered as metric variables: ICT*ORG1 and ICT*ORG2 (Table 6, model 1), ICT*HUMAN (Table 6, model 2), HUMAN*ORG1 and HUMAN*ORG2 (Table 6, model 3). We find that only the coefficients of the interaction term of the technology variable and the human capital variable, and the coefficient of the human variable and the organizational variable for decision decentralization, are positive and statistically significant. These results can be interpreted as hinting at the existence of complementarity between ICT and human capital, and between human capital and decision decentralization, respectively, which means that in Swiss firms, the combination of ICT use and human capital as well as of human capital and decision decentralization enhances performance beyond the direct effects of each of these factors individually. The former effect, in particular, has to be seen as a net effect, given the opposite forces behind the influence of ICT on productivity as postulated in Borghans and ter Weel (2006) and discussed in Section 2. The latter effect seems to be economically plausible, because the existence of high skills is a precondition for the efficient application of decision decentralization in an enterprise.

9. Summary and conclusions

In this paper, based on the firm-level data, we have presented a comparative empirical study of the effects of ICT capital, human capital and new organizational practices, and their combined use, controlling for physical and knowledge capital, on labour productivity in Greece and Switzerland. Our analytical framework was a firm-level production function. The Greek and the Swiss parts of this study are comparable because they are based on the same questionnaire and samples of similar composition (in terms of firm sizes and sectors), and they both use the same variables and model specifications. We should emphasize that because our results are based on firm samples that are structurally similar in terms of firm size and industry, differences related to the quite different industry structures of the two countries (e.g., Switzerland having a high share of banks and pharmaceutical industries, Greece having a high share of textiles and clothing) are cancelled out. Below, we summarize the empirical results and discuss the similarities and differences between the two countries.

9.1. Similarities

For both samples, we found statistically significant positive effects for physical capital, ICT, human capital (HUMAN) and "employee voice" oriented organizational practices (ORG2); no effect (Greek case) or even a negative effect (Swiss case) was found for "work design" oriented organizational changes (ORG1). Also for both countries, the intranet effect was stronger than the Internet effect, meaning that the use of ICT for the improvement of intra-firm information, communication and coordination processes has a higher payoff, measured in labour productivity gains, than does the use of ICT for the improvement of the corresponding inter-firm processes.

9.2. Differences

There are considerable differences between the firms in the two countries. First, the relative importance of these effects, as measured by the standardized coefficients of the compact model, is not the same for both samples. For the Greek firms, we found the following: physical capital > ICT > human capital > "employee voice" practices (ORG2). For the Swiss firms, the respective ranking is human capital > ICT > "employee voice" practices (ORG2) > physical capital ≈ R&D. We remark that in the Swiss firms the impact of human capital, ICT capital and organizational capital associated with "employee voice" practices is higher than the impact of "traditional" physical capital, while in Greek firms these three "new" production factors have on the contrary a lower impact on labour productivity than does physical capital. For Greek firms, physical capital ("tangibles") is (still) very important, more so in fact than ICT, which has both a tangible (hardware) component and an intangible (software) component; also the "intangibles" (human capital, R&D) are less important for achieving better economic performance in Greek firms, while the R&D variable has no effect on productivity. Even though there are more employees with tertiary level education in Greek firms than in Swiss firms (see Section 5), human capital is evidently more efficiently utilized in Swiss firms.[7] On the whole, "intangibles" have a high impact on the economic performance of Swiss firms (strong effects of human capital, ICT capital and organizational capital associated with "employee voice" practices; clearly positive effect of R&D), but in the case of Greek firms, a much lower impact on the economic performance. Therefore, it can be concluded that Swiss firms are more efficient and mature in creating and using these "new" production factors than are Greek firms.

Second, the "employee voice" effect on labour productivity, which, as already mentioned, is significantly positive for firms in both countries, is based on the different types of employee competencies. In Greek firms this effect is related to the decentralization of competencies related to working conditions (work pace, work performance, work sequence), while in Switzerland it is related to the decentralization of competencies having to do with the work content (contacts with customers, solving problems related to customers). These differences can be interpreted as reflecting different management philosophies and different levels of employee autonomy. Co-operation between management and employees with respect to working conditions is required mostly for very routine activities and production processes, and is characteristic of Greek firms. Employee competence relating to work content is relevant to less routine activities requiring greater individual initiative from employees, as is often the case in Swiss firms.

Third, there are differences between firms of the two countries with respect to complementarity effects between ICT capital, human capital and organizational capital. We could not find any interaction effects for the Greek firms in our sample, while there was evidence of two interaction effects (between human capital and ICT, and between human capital and "employee voice" oriented organizational practices) for the Swiss firms. Therefore, although the use

[7] The Swiss dual education system based on the firm-based apprenticeships for a wide spectrum of professions allows more efficient utilization of human capital than the "polarized" Greek education system which produces poorly-qualified people or university graduates who are generally overqualified for the jobs they do.

Table A.1
Composition of the datasets by industry and firm size classes.

	Greeece		Switzerland	
	N	Percentage	*N*	Percentage
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, insurances	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 and more	78	28.8	361	21.1
Total	281	100.0	1710	100.0

Table A.2
Descriptive statistics.

Variable	Greece		Switzerland	
	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 A.3a
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 A.3b
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

of ICT in Greek firms leads to positive productivity effects, the full potential of this technology is not utilized because human capital is not efficiently combined with it. Similarly, the decentralization of some competencies has positive productivity effects, but this potential is not fully exploited due to inefficient combination with human capital. Swiss firms, on the other hand, seem to be able to exploit the potential of technology and decentralization through the combination of these factors with appropriate human skills, which in turn enables a higher level exploitation of ICT and a more successful decentralization of competencies.

The results of this study have interesting policy implications, given that the governments of most countries need to exercise some kind of industrial policy, although that applies more to Greece than to Switzerland. In addition to providing firms with subsidies, loans, tax reductions and other incentives for investment in ICT, human capital skills, new organizational practices and R&D, government should provide all firms (and especially SMEs) with knowledge (e.g., guides and examples of national and international best practice) about the efficient creation, use and exploitation of these "new" production factors, and their appropriate combination.

Table A.4a
Correlation matrix: compact model, Greece.

	LogASSETN	LogRDL	ICT	HUMAN	ORG1
LogRDL	0.114	1			
ICT	−0.030	0.108	1		
HUMAN	0.111	0.116	0.504	1	
ORG1	0.047	0.134	0.066	0.121	1
ORG2	0.025	0.145	0.375	0.393	−0.035

Table A.4b
Correlation matrix: compact model, Switzerland.

	LogCL	LogRDL	ICT	HUMAN	ORG1
LogRDL	0.175	1			
ICT	0.088	0.257	1		
HUMAN	0.147	0.233	0.446	1	
ORG1	0.066	0.192	0.148	0.206	1
ORG2	0.096	0.172	0.288	0.245	0.121

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Appendix A

See Tables A.1–A.5.

Table A.5a
First step instrument estimates; Switzerland.

Explanatory variables	LogCL	LogRDL	ICT	ORG1	ORG2	HUMAN
EXP_IND	−0.011***	//	−0.009***	//	−0.035***	−0.011***
	(0.003)		(0.002)		(0.007)	(0.003)
JOBR_IND	−0.016*	0.045***	−0.020***	0.024***	//	//
	(0.008)	(0.010)	(0.006)	(0.007)		
COMP_WORKSEQ_IND	−0.056***	0.084***	0.025**	//	0.082**	//
	(0.016)	(0.019)	(0.012)		(0.038)	
COMP_CUSTOMER_CONTACT_IND	0.017*	//	0.023***	//	0.053**	//
	(0.009)		0.008		(0.021)	
Middle-sized firms	0.198***	0.458***	0.248***	0.195***	0.201	0.164***
	(0.045)	(0.069)	(0.033)	(0.050)	(0.130)	(0.044)
Large firms	0.275***	0.732***	0.352***	0.266***	0.466***	0.192***
	(0.036)	(0.058)	(0.031)	(0.040)	(0.102)	(0.034)
High-tech manufacturing	1.528***	4.063***	2.183***	0.636***	4.984***	1.491***
	(0.299)	(0.252)	(0.217)	(0.176)	(0.695)	(0.237)
Low-tech manufacturing	1.423***	1.292***	1.196****	0.318*	2.880***	0.378**
	(0.242)	(0.253)	(0.171)	(0.184)	(0.548)	(0.182)
Modern services	0.865***	1.806***	3.169***	0.639***	3.935***	1.747***
	(0.183)	(0.243)	(0.137)	(0.168)	(0.489)	(0.153)
Traditional services	0.642***	−0.360*	1.068**	0.159	3.000***	0.234*
	(0.185)	(0.204)	(0.139)	(0.155)	(0.469)	(0.140)
Constant	8.229***	0.063	−1.388***	−1.158***	−2.756***	−2.312***
	(0.165)	(0.176)	(0.103)	(0.134)	(0.481)	(0.119)
N	1710	1710	1710	1710	1710	1710
DF	10	8	10	7	9	7
SER	2.083	3.082	1.517	1.813	4.529	1.493
F	12.8***	157.2***	102.8***	18.2***	16.7***	43.4***
R^2adj	0.044	0.286	0.283	0.061	0.073	0.149

EXP_IND: mean of export shares at the 2-digit industry level; JROT_IND: share of firms in a 2-digit industry with values 4 and 5 of the variable JROT (see Table 3); COMP_WORKSEQ_IND: share of firms in a 2-digit industry with values 4 and 5 of the variable COMP_WORKSQ (see Table 3); COMP_CUSTOMER_CONTACT_IND: share of firms in a 2-digit industry with values 4 and 5 of the variable COMP_CUSTOMER_CONTACT (see Table 3); reference group for sector dummies: construction; reference group for firm size dummies: firms with more than 20 and less than 250 employees; standard errors in brackets.

* Denote statistical significance at the 10% level; heteroscedasticity-robust standard errors (White procedure).

** Denote statistical significance at the 5% level; heteroscedasticity-robust standard errors (White procedure).

*** Denote statistical significance at the 1% level; heteroscedasticity-robust standard errors (White procedure).

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