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THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY
Lönnrotinkatu 4 B 00120 Helsinki Finland Tel. 609 900 Telefax 601 753
World Wide Web: http://www.etla.fi/

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Aija Leiponen

COMPETENCES, INNOVATION AND PROFITABILITY OF FIRMS

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ABSTRACT: This empirical study investigates the impact of competencies and knowledge capital on the economic performance of firms. A panel data-set of Finnish manufacturing firms is used in order to assess the effects of education and innovation on profitability. Also differences in the determinants of profitability between innovating and non-innovating firms are studied.

The main findings include, that educational competence indicators are significantly associated with profitability. Complementarities between different levels and fields of education turn out to have the most important effects. For example, the positive effect of post-graduate level employees is conditioned by a sufficient amount of employees with general skills acquired in higher education. Research is economically beneficial only if there are enough general competencies, which help to use the results of R&D in the markets.

Interactions are also detected between innovativeness and competencies. Estimating the determinants of profitability separately for innovating and non-innovating firms reveals that somewhat different factors influence their economic performance. In particular, educational competencies are more relevant for innovators. Innovating firms are also not so much affected by market related factors like concentration and market share.

KEY WORDS: Education, competencies, innovation, profitability

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TIIVISTELMÄ: Tässä empiirisessä tutkimuksessa tarkastellaan osaamisen ja tietopääoman vaikutuksia yritysten taloudelliseen menestymiseen. Suomalaisia teollisuusyrityksiä sisältävän tilastollisen aineiston avulla arvioidaan koulutustasojen ja -alojen sekä innovaatioiden yhteyttä kannattavuuteen. Lisäksi selvitetään innovoivien ja ei-innovoivien yritysten kannattavuustekijöiden eroja.

Osoittautuu, että korkea koulutustaso parantaa kannattavuutta. Erityisen mielenkiintoista on, että eri koulutusmuuttujat näyttävät täydentävän toisiaan. Esimerkiksi tutkijakoulutuksen saaneiden myönteinen vaikutus yritysten kannattavuuteen riippuu korkeakoulutettujen osuudesta yrityksessä. Tutkimus on siten taloudellisesti hyödyllistä vain, jos yrityksessä on riittävästi yleisempää osaamista, jonka avulla tutkimus- ja kehitystuloksia hyödynnetään markkinoilla.

Tulokset viittaavat myös koulutustason ja innovatiivisuuden yhteyksiin. Patentoitujen innovaatioiden kannattavuusvaikutukset riippuvat korkea- ja tutkijakoulutettujen työntekijöiden määristä. Estimoitaessa kannattavuustekijöitä erikseen innovoiville ja ei-innovoiville yrityksille havaitaan, että koulutuksella hankittu osaaminen on tärkeämpää innovatiivisten yritysten kannattavuudelle. Innovoijat eivät myöskään näytä olevan niin riippuvaisia markkinoiden rakenteesta.

ASIASANAT: Koulutus, osaaminen, innovaatiot, kannattavuus

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Yhteenveto - Finnish summary

Tässä tutkimuksessa tarkastellaan aineettoman tietopääoman vaikutuksia yritysten taloudelliseen menestymiseen. Tietämyksen kertyminen ja innovointi ovat tärkeimpiä talouskehitystä ylläpitäviä voimia. Tutkimuksessa arvioidaan muodollisella koulutuksella hankitun osaamisen ja innovaatioiden yhteyttä yritysten kannattavuuteen. Ekonometristen estimointien avulla selvitetään, selittävätkö osaamismittarit merkitsevästi kannattavuuskehitystä yrityksissä. Toisaalta kiinnostavia ovat eri koulutustasojen ja -suuntien vaikutukset ja vuorovaikutukset. Lisäksi tutkitaan innovoivien ja ei-innovoivien yritysten kannattavuustekijöiden eroja, erityisesti koulutuksen suhteen.

Lähtökohtana on, että yrityksen kehitystä tulisi tarkastella dynaamisen osaamisen kertymisprosessina. Dynaaminen osaaminen tarkoittaa kykyä oppia, ratkaista ongelmia ja löytää uusia ongelmia ratkaistavaksi. Kun yrityksen toimintaympäristö muuttuu teknologisen kehityksen tai kilpailuolosuhteiden muuttumisen vuoksi, tarvitaan yrityksissä oppimis-, sopeutumis- ja innovointikykyjä. Osaamisstrategian on tuettava teknologia- ja kilpailustrategioita. Siksi osaamista on jatkuvasti kehitettävä, muuttuvissa oloissa yritys ei voi luottaa vanhaan tietämykseen.

Koulutuksen merkitys osaamisen kehittymisessä liittyy paitsi suoranaisiin ammattitaitoihin, myös oppimiskykyihin. Koulutus antaa parhaimmillaan kommunikaatio- ja vuorovaikutustaitoja, kykyjä hakea ja vastaanottaa tietoa sekä luoda uutta tietoa. Oppimisen ja ongelmanratkaisun harjoittelu koulutuksessa helpottaa oppimista ja innovointia työssä. Koulutus saattaa siis vaikuttaa dynaamiseen osaamiseen, ja siten yrityskohtaisen tietämyksen kertymiseen. Yrityskohtaista tietämystä ei voida hankkia markkinoilta, vaan se on kehitettävä sisäisesti. Menestyvissä yrityksissä tietämyksen kertyminen on nopeaa ja sen hyödyntäminen joustavaa.

Tutkimuksessa tarkastellaan empiiristä mallia, jonka mukaan yrityksen kannattavuus riippuu osaamisesta ja innovatiivisuudesta, sekä yritys- ja toimialakohtaisista tekijöistä. Käytettävä aineisto koostuu suomalaisten teollisuusyritysten otoksesta ja sisältää tietoja niiden koulutustasoista ja -aloista, innovaatioista ja kotimaassa haetuista patenteista sekä taloudellisesta kehityksestä. Otoksessa on 209 yritystä 15 eri toimialalta, ja aikasarjat ulottuvat vuodesta 1985 vuoteen 1993.

Estimointitulosten mukaan koulutusmuuttujat ovat merkitseviä kannattavuuden selittäjiä. Erityisen tärkeäksi osoittautuu tutkija- ja korkeakoulutettujen vuorovaikutus. Tutkijakoulutetut lisäävät kannattavuutta vain, jos yrityksessä on riittävästi korkeakoulutettuja. Tämä viittaa siihen, että tutkimus- ja kehitystoiminnan taloudellinen hyöty riippuu yleisestä osaamistasosta yrityksessä. Samantyyppinen vuorovaikutus havaitaan teknisen koulutuksen ja tutkijakoulutuksen saaneiden välillä. Myös teknisen tai luonnontieteellisen korkeakoulutuksen saaneilla on kannattavuutta parantava vaikutus.

Innovatiivisuus ja koulutus näyttäisivät täydentävän toisiaan. Patenttien taloudellinen hyöty riippuu estimointien mukaan korkea- ja tutkijakoulutettujen määristä. Tarkkoja vaikutussuhteita ei kuitenkaan voida selvittää tällä suppealla aineistolla. Tuote- ja prosessi-innovaatioilla on lisäksi erisuuntaiset vaikutukset kannattavuuteen. Tuotein-novaatioiden negatiivinen yhteys saattaa johtua siitä, että niitä tekevät yritykset ovat pienempiä ja elinkaarensa alussa, jolloin kannattavuuden sijasta pyritään kasvuun ja markkinoiden valloitukseen. Prosessi-innovaatiota puolestaan tekevät yleensä suuremmat yritykset, joiden huomio on kannattavan toiminnan ylläpitämisessä. Lisäksi tieto prosessi-innovaatioista ei leviä kilpailijoille niin helposti kuin tuoteinnovaatioista.

Koska innovaatiot osoittautuivat tärkeiksi kannattavuuden selittäjiksi, selvitettiin myös, onko innovoivien ja ei-innovoivien yritysten, ja toisaalta tuote- ja prosessi-innovoivien yritysten välillä eroja kannattavuuden määräytymisessä. Tulosten mukaan koulutuksella on selvästi suurempi vaikutus innovoivien yritysten kannattavuuteen. Ainoastaan teknisellä tai luonnontieteellisellä korkeakoulutuksella on yhteys ei-innovoijien kannattavuuteen, kun taas tämän lisäksi korkea- ja tutkijakoulutus sekä niiden vuorovaikutus ovat tärkeitä innovoiville yrityksille. Ei-innovoivat yritykset ovat suuremmassa määrin markkinakohtaisten tekijöiden armoilla, mutta innovoijat nojautuvat työntekijöidensä osaamiseen.

Myös tuote- ja prosessi-innovoijien välillä havaitaan joitakin eroja kannattavuustekijöissä. Ensinnäkin patentointi on tärkeämpää tuote-innovoijille. Korkeakoulutetut lisäävät prosessi-innovoijien kannattavuutta, kun tuoteinnovaatioita tekeville yrityksille korkea- ja tutkijakoulutettujen vuorovaikutus on olennaista.

Tutkimuksen mukaan siis koulutuksella mitattu osaaminen sekä innovaatiot vaikuttavat merkittävästi yritysten kannattavuuteen. Eri koulutustasojen ja -alojen toisiaan täydentävät vaikutukset ja erilaisia innovaatioita tekevien yritysten toisistaan poikkeavat kannattavuustekijät olivat tärkeimpiä tuloksia. Osaamisen ja innovaatiotoiminnan yhteyden tarkempi selvittäminen edellyttää ajallisesti pidempien ja monipuolisempien yritysaineistojen muodostamista.

1 Introduction

This study examines the effects of the intangible knowledge capital on firms' economic performance. By trying to measure human competencies and knowledge in firms we attempt to obtain a more coherent view of the dynamics of firm performance, because accumulation of knowledge is a fundamental determinant of economic performance of firms in the long-run. In this study we estimate the effects of competencies acquired through education and innovation on profitability of firms. We want to find out, whether competence measures gain significance in explaining profitability. We are also interested in the effects of different types and levels of competencies, and their interactions. I addition, we aim to shed light on are the differences in profitability and, in particular, the determinants of profitability between innovating and non-innovating firms.

In a qualitative analysis (Leiponen 1996a) making use of the same data-set of Finnish manufacturing firms, innovating firms are consistently more profitable than the non-innovating ones. Now we investigate if taking competencies and a set of control variables into account changes this picture. The analysis is carried out with dynamic panel data approach.

In the next section we discuss the appreciative theoretical framework underlying the analysis. Section 3 presents the empirical model and the method of estimation. The data-set used is described in section 4. Section 5 discusses the results and section 6 concludes.

2 Dynamic Competencies and Firm Performance

It has been argued, that there are generic differences between innovating firms and non-innovating ones (Geroski et al. 1993). This proposition leads to viewing *innovation as a process* of accumulating internal capabilities and knowledge. Accumulated knowledge creates a firm-specific effect, which renders the evolution process of innovating firms different from that of the non-innovators.

Digging further into the implications of knowledge in economic dynamics, we maintain that firm evolution should be viewed as a *process of accumulating dynamic competencies*. By dynamic competencies we mean the capabilities to learn, to solve problems, and in particular, to find new problems to solve (cf. Dosi and Marengo 1994). Dynamic competencies are built with the help of simpler (static) skills related to technical details, communicative abilities and so forth, which are used in an organization to acquire relevant new information, understand it, and apply it in interaction with other members of the organization. There is a strong organizational aspect related to competencies. Dynamic competencies are to a significant extent firm-specific, and therefore have to be developed internally. Moreover, accumulation of organizational knowledge is inevitably slow and gradual, as it is based on collective learning.

However, accumulation of dynamic competencies is by no means automatic. Initially, the firm's management has to be visionary enough to perceive business opportunities, which necessitate investment in knowledge. This means, that the firm takes on an innovative, or knowledge-intensive strategy. It decides to invest in R&D, which enables it to develop technological knowledge internally, and to absorb it from the outside (Cohen and Levinthal 1989). Simultaneously, the firm has to take care that the human resources available are capable of using, applying, producing and marketing the firm's products and technologies.

Moreover, the employees must possess dynamic competencies. As the operating environment evolves for instance as a result of technological progress and changes in the competitive conditions, the abilities to learn, adapt, and innovate are called for. Technological and market evolution set about a process of creative destruction of knowledge, so the firm cannot rely on knowledge created in the past. Competence strategy has to go hand in hand with the technological strategy and the evolution of the market, and the competence base needs to be continuously upgraded.

The notion of dynamic competencies differs slightly from the view of the generic differences between firms (Geroski et al.) and also the evolutionary approach to firm dynamics (Nelson and Winter 1982 and their followers). First, the firm has some degree of deliberation in determining its knowledge strategy. Second, during the evolution process, the firm has to keep investing in competencies, in order to renew its knowledge base if it desires to continue on an innovative path. In short, there is some room for strategic choice. Nevertheless, a successful strategy has to take into account the path-dependencies, which constrain and define the set of profitable opportunities available.

Accumulation of dynamic competencies results from deliberate investment in knowledge, which has to be integrated in the organization through learning. Learning, in turn, is a more automatic kind of a consequence of the interaction in and the operation of the organization. Learning can also be facilitated by training, organizational design and other types of investment. The way of organizing activities has an important bearing on the incentives and flows of communication, and hence interaction and learning. Dynamic competencies are then manifested in successful innovation, efficient learning, and in the abilities to adjust to external stimuli and to perceive technological or business opportunities.

Knowledge strategy influences also the demand for skills and knowledge. We argue, along the lines of Cohen and Levinthal (1989), that relevant prior knowledge is useful for assimilating new knowledge. The same applies for the abilities to learn and solve problems. Prior experience in learning and solving problems during schooling facilitate learning on the job. Thus, the view advanced in this study is that education provides employees with a set of basic technical, communicational and social skills, but most importantly, it may enhance the learning abilities. Thus the role of education in the accumulation of dynamic competencies is to give a set of tools and a solid base for further learning. Education, often used as an indicator of "human capital" should not be viewed as a "factor of production," but rather as a "factor of learning." In addition, dynamic competencies imply more efficient learning in a multitude of directions. A wide basis of general knowledge renders it easier to adopt a new direction of learning.

Learning abilities also enhance the efficiency of adaptation, or dynamic efficiency (c.f. North 1990). This enables the firm to react and adjust swiftly to changes in the environment. In particular, efficiency of adaptation is crucial in times of severe economic conditions. As it turns out, innovating firms are indeed better able to cope with adverse economic shocks (Geroski et al. 1993, Leiponen 1996a).

3 The Empirical Model and the Method of Estimation

We now proceed to formulate the model for the empirical analysis. In the innovation - performance studies the models explaining profitability usually include variables describing the market structure and R&D effort or innovation outcome. Our model augments this approach with indicators of the efficiency of knowledge accumulation, measured by levels and fields of educational stock in the firm. The model asserts that a firm's profitability is a function of its knowledge assets, firm-specific characteristics and industry-specific characteristics. The stock of knowledge is measured here by educational indicators, survey-based innovation output measures and patents.

The empirical model is

profitability=f(competencies, innovation,

firm characteristics, industry characteristics)

The model is estimated in differences to cancel out firm-specific fixed effects. Among the firm characteristics there are some predetermined explanatory variables, which have to be instrumented. These are affected by previous economic performance of the firm, due to which their endogeneity is controlled for. As it turns out, instrumentation of the predetermined variables is very important. It increases considerably the significance of the results.

The analysis is carried out with the generalized method of moments (GMM), a two-stage weighted least squares estimator for panel data utilizing instrumental variables, as it was presented by Arellano and Bond (1991). The fact that our model includes a lagged dependent variable, fixed effects and predetermined explanatory variables, implies that some of the explanatory variables are endogenous, and there is autocorrelation. Moreover, using this type of firm data may give rise to heteroscedasticity. GMM, however, enables consistent estimation of dynamic models in spite of heteroscedasticity and autocorrelation, which would blur the results if a method like least squares fixed effects was used. Furthermore, GMM is particularly suitable for short panels.

Our basic model reads

(1) $$\pi_{i,t} = \alpha\pi_{i,t-1} + \beta' X_{i,t} + \eta_i + \delta_t D_t + \varepsilon_{it}$$

where $\pi_{i,t}$ denotes profitability of firm i in period t and $X_{i,t}$ are the explanatory variables. α, β and δ are parameter vectors to be estimated, η_i is a firm-specific fixed effect, D_t are time dummies to capture macroeconomic shocks, and ε is a serially uncorrelated[1] white noise error term.

more specifically,

(2) $$\begin{aligned}\pi_{i,t} &= \alpha\pi_{i,t-1} + \beta_1 COMP_{i,t} + \beta_2 INN_{i,t} + \beta_3 FIRM_{i,t} \\ &+ \beta_4 INDUSTRY_{i,t} + \eta_i + \delta_t D_t + \varepsilon_{it}\end{aligned}$$

where notation is as presented previously. Vectors COMP and INN consist of our measures for competencies and innovations respectively. FIRM and INDUSTRY vectors include a set of available proxies to control for firm and industry-specific differences in performance (see table 1 for the variables).

Carrying out the estimation in differences allows us to get rid of the time-invariant individual effects:

(3) $$\Delta\pi_{i,t} = \alpha' \Delta\pi_{i,t-1} + \beta' \Delta X_{i,t} + \delta' \Delta D_t + \Delta\varepsilon_{it}$$

The Arellano - Bond method constructs the instrumental variable matrix Z_i utilizing all the linear moment restrictions. The lagged values of the dependent variable become valid instruments thanks to the second-order uncorrelation of error terms. π_i dating from t-2 and before are valid instruments for $\pi_{i,t}$. $\pi_{i,t-1}$ is not valid because it is an explanatory variable for $\pi_{i,t}$ and therefore both $\pi_{i,t-1}$ and $\pi_{i,t}$ correlate with $\varepsilon_{i,t-1}$. Similarly for the predetermined explanatory variables $X^p_{i,t}$, the lagged values are used as instruments, and there is one more period to be exploited than with the dependent variable. $X^p_{i,t-1}$ is a

[1] because the model is an AR(1) process, only second-order serial uncorrelation is required.

valid instrument for $X^p_{i,t}$, because it correlates with $X^p_{i,t}$ but not with ε_{it}. The differences of the strictly exogenous variables $X^e_{i,t}$ that are valid instruments are in the last column.

(4)

$$Z_i = \begin{bmatrix} \pi_{i,1} & X^p_{i,1} & X^p_{i,2} & 0 & 0 & 0 & 0 & 0 \ldots & 0 \ldots & 0 & 0 \ldots & 0 & :\Delta X^e_{i,3} \\ 0 & 0 & 0 & \pi_{i,1} & \pi_{i,2} & X^p_{i,1} & X^p_{i,2} & X^p_{i,3} \ldots & 0 \ldots & 0 & 0 \ldots & 0 & :\Delta X^e_{i,4} \\ . & . & . & . & . & . & . & . & . & . & . & . & : \\ . & . & . & . & . & . & . & . & . & . & . & . & : \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \ldots \pi_{i,1} & \ldots \pi_{i,(T-2)} & X^p_{i,1} & \ldots X^p_{i,(T-1)} & :\Delta X^e_{i,T} \end{bmatrix}$$

The crucial assumption regarding the consistency of estimates is exactly the second-order serial uncorrelation of error terms. This will be tested and reported in the estimation results. Also, the validity of instruments is checked with the Sargan test of overidentifying restrictions.

4 The Data

The data-set is compiled by Statistics Finland, and consists of firm-level statistics on the levels of education and financial state of a sample of Finnish firms in 15 different manufacturing industries. These data are combined with domestic patent applications and an innovation survey carried out in 1991. The resulting data-set contains time-series of 209 firms for the period 1985-1993 for financial variables and patent data, and 1987-1993 for educational variables (see table 1 below). For more about the data and a descriptive analysis, see a companion paper (Leiponen 1996a).

The dependent variable *profitability* is measured with net profit margins (NET). There exist competence indicators mainly in two dimensions, the levels of education on the one hand, and technical versus other types of skills on the other. Also some interaction terms are considered. Interactions are expected to be found both between different levels and fields of skills, and innovation and higher level skills.

Innovation is described by three dummy variables for firms undertaking either product innovation, process innovation or both. The domestic patent applications are used as an alternative indicator of successful innovation.

Table 1. Variables

Vector	Variable	Definition
COMPETENCE	HIGH	Share of employees with higher education degree, %) (1987-93)
	POST	Number of employees with post-graduate degree (1987-93)
	TECH	Share of employees with technical or natural scientific degree, % (1987-93)
	HITECH	- " - higher technical or natural scientific degree, % (1987-93)
	POST*HIGH	Interaction terms
	PAT*POST	- " -
	POST* TECH	- " -
	PAT*HITECH	- " -
INNOVATION	PROD	Dummy variable for new products launched successfully in markets between 1989-1991 (1991)
	IMPR	Dummy for significant product improvements realized between 1989-1991 (1991)
	COMPR	Dummy variable for firms realizing both product and process innovation ("comprehensive innovation")
	PAT	Number of domestic patent applications (1985-1993)
FIRM	SALES	Sales turnover, million FIM (1985-1993)
	MS	Market share, %(1987-1993)
	KINT	Capital intensity: machinery, equipment etc in the balance sheet in proportion to sales, % (1985-1993)
INDUSTRY	CON3	3 firm concentration ratio in the industry, % (1987-1993)
	$KINT_I$	Capital intensity in the industry, % (1987-1993)
PROFITABILITY	NET	Net profit margin (net profit in proportion to sales), % (1985-1993)

Firm-specific differences in for instance growth strategies are taken into account with three indicators: sales, market share and capital intensity. Industry-specific effects are controlled for with concentration ratio and capital intensity, and in addition with industry dummy instruments. Time dummies are used as well, but they are not reported in the table 2 below. Sales and capital intensity are instrumented. Market share is unavailable for the year 1985 due to a change in statistical practices with respect to classification of industries, otherwise it would have been instrumented as well.

5 Estimation Results

5.1 All firms

By and large, according to the results in table 2, competence variables are significantly associated with profitability. One of the most robust outcomes is that higher educated employees complement doctoral level researchers. The positive effect of POST on profit margins is conditioned by a large enough share of higher educated employees (HIGH).

The interaction term is positive and very significant. A sufficient amount of people with general competencies are necessary to make R&D activities, in which the POST employees tend to work, economically successful. Workers in other activities have to be capable of utilizing the results of R&D. A similar kind of interaction can be found with the technical skills and doctoral employees (POSTTECH). General technical skills (TECH) alone do not show up with a significant impact on profits.

Instead, higher technical skills (HITEC) are a significantly positive determinant of profitability. Moreover, higher technical skills and research skills (POST) interact clearly with innovation activities. This is revealed by the strongly negative coefficients on PATPOST and PATHITEC. However, the nature of the interaction cannot be properly determined with our data. The results here suggest that there need to be enough general skills, in the form of higher education or higher technical education, compared to the extent of the patenting activity, in order that the research skills (POST) have a positive impact on profitability.

The innovation dummies show some intriguing behavior. The comprehensive innovation dummy (COMPR) is consistently a positive and significant determinant of profitability. However, separating the effects of product and process innovation reveals that product innovation tends to have adverse effects on profit margins, whereas process innovation is strongly positively related to them. A possible explanation for the negative result concerning product innovation are the different phases in a life-cycle of a firm (see Klepper 1996). Firms at an early stage in the cycle may be more concerned with creating new products and expanding, even to the detriment of profits, than fine-tuning their processes and improving efficiency and profitability. However, we have no information about the age of firms for instance, and cannot control for these effects. Nevertheless, size and market share of the firm are taken into account, sales variable reflecting the size is also instrumented, which should control to some extent for the life-cycle related differences between small and large firms.

The results with respect to process innovation are quite different. It has a rather stable and strongly positive effect on profitability throughout the specifications. This could also reflect the fact that process innovations are more likely to be accumulated as organizational knowledge than product innovations, and hence they are more easily protectable and excludable. Instead, profits arising from product and other marketable innovations are more transitory and erode faster due to more rapid knowledge diffusion (Cohen and Klepper 1996).

Table 2. Estimation results for net profit margins (N=209)

	Variable	(1) Coeff. (t-stat)	(2) Coeff. (t-stat)	(3) Coeff. (t-stat)	(4) Coeff. (t-stat)	(5) Coeff. (t-stat)	(6) Coeff. (t-stat)	(7) Coeff. (t-stat)
	CONST	-1.159*	-2.438*	-2.013*	-1.439	-2.078*	-1.816*	-2.268*
		(-2.326)	(-3.309)	(-2.290)	(-1.475)	(-2.297)	(-2.084)	(-3.316)
	NET_{t-1}	0.081	0.112	0.056	0.048	0.058	0.056	0.122*
		(1.372)	(1.829)	(0.874)	(0.740)	(0.874)	(0.895)	(2.065)
INN	INNO		2.194*					2.087*
			(2.265)					(2.186)
	PROD			-5.512*	-6.181*	-4.297*	-4.925*	
				(-3.698)	(-4.510)	(-4.022)	(-3.586)	
	PROC			5.895*	5.976*	5.196*	4.957*	
				(4.454)	(5.040)	(4.763)	(4.073)	
	PAT_{t-1}	0.054*	0.029	0.078*	0.178*	0.189*	0.228*	0.172*
		(2.734)	(1.236)	(3.882)	(4.391)	(3.598)	(3.425)	(2.772)
COMP	HIGH	0.305	0.407	0.208	0.179			
		(1.078)	(1.421)	(0.733)	(0.660)			
	POST	-0.453*	-0.707*	-0.093	-1.377*	-1.023	-0.842	-1.294*
		(-2.241)	(-2.391)	(-0.217)	(-2.103)	(-1.362)	(-1.810)	(-4.545)
	TECH	0.040	0.056			0.037		
		(0.489)	(0.675)			(0.440)		
	HITEC						0.769*	0.891*
							(2.639)	(3.080)
	POSTHIGH	0.037*	0.043*	0.023*	0.096*		0.061*	0.069*
		(4.530)	(3.822)	(2.058)	(3.438)		(3.533)	(5.477)
	PATPOST				-0.006	-0.004		
					(-4.098)	(-3.287)		
	POSTTECH					0.043		
						(2.085)		
	PATHITEC						-0.007*	-0.006*
							(-5.093)	(-5.286)
FIRM	MS	1.128*	1.149*	1.875*	1.659*	1.361*	1.823*	1.318*
		(3.608)	(4.041)	(4.715)	(3.996)	(3.335)	(4.742)	(3.561)
	SALES	0.001	0.001	0.001	-0.001	-0.0003	-0.0001	0.0002
		(1.013)	(1.456)	(1.579)	(-1.003)	(-0.435)	(-0.256)	(0.460)
	KINT	-0.222*	-0.237*	-0.189*	-0.218*	-0.195*	-0.185*	-0.237*
		(-5.807)	(-5.475)	(-4.702)	(-5.013)	(-4.736)	(-4.231)	(-5.418)
INDUSTRY	CON3	0.081	0.087	0.053	0.055	0.082	0.079	0.101*
		(1.771)	(1.908)	(1.147)	(1.209)	(1.731)	(1.722)	(2.176)
	$KINT_1$	-0.046	-0.092*	-0.073	-0.066	-0.077*	-0.097*	-0.106*
		(-1.437)	(-2.567)	(-1.877)	(-1.701)	(-2.024)	(-2.572)	(-2.947)
Test statistics (d.f.)	2nd order serial correlation	-0.547 (153)	-0.49 (153)	-0.137 (153)	-0.198 (153)	-0.500 (153)	-0.118 (153)	-0.361 (153)
	Wald test for joint significance	254.93 (11)	228.88 (12)	237.40 (12)	188.79 (13)	258.27 (13)	160.63 (13)	178.62 (12)
	Sargan's test	33.39 (35)	29.01 (34)	27.65 (33)	28.97 (33)	30.68 (33)	28.11 (33)	29.10 (34)

In any case we cannot immediately confirm the hypothesis of Geroski et al (1993) that innovation is associated with better performance, due to accumulated internal capabilities. Accumulation of capabilities is a coevolutionary process involving both internally developed and externally acquired knowledge and competencies. Educational competence variables may be as relevant proxies for the accumulation of internal capabilities as the innovation variables.

The coefficient of the lagged dependent variable, NET_{-1}, is positive (although not significant). This implies that firms that have been performing well tend to do so also in the future. There does not seem to exist any strong mechanism balancing the profits, at least not in the short run.

Of the economic control variables, firm capital intensity (KINT) and capital intensity in the industry ($KINT_I$) are significantly negatively associated with profits. This may capture the poor productivity of the heavy investment carried out in many Finnish industrial firms in the late 1980s. As expected, profits increase with market share and the concentration of the industry.

The overall validity of our model is good, according to the Wald test of joint significance. In all the cases reported in table 2 we have assumed NET_{-1}, SALES and KINT to be predetermined, and they have been instrumented in the optimal way (see equation 4). Additional instruments are calculated for the industry dummies. These turned out to be very important. Without controlling for endogeneity, the significance of the whole estimation and many individual coefficients disappears. It is of crucial importance to take the implications of endogeneity into account.

The validity of instruments is tested with the Sargan test. Under the null hypothesis of valid instruments the Sargan test statistic is asymptotically distributed as a chi-square. In all specifications we can accept the null within a 95% confidence interval. The null hypothesis of the second-order autocorrelation test is no autocorrelation, and the statistic is asymptotically distributed as N(0,1). The critical value for 95% confidence in having no serial correlation is +/-1.96, and our estimations do not come close to these limits. The estimates should thus be consistent.

5.2 Innovators vs. Non-innovators

In this subsection we dig further into the nature of innovativeness. The underlying idea is, that innovation is a result of the evolution of dynamic competencies. Technological change, learning and interacting necessitate educational skills and competencies. Therefore, the whole process of innovation involves investment in skills, educated employees and R&D, and results again in faster technological change and accumulation of internal capabilities. Hence the set of skills and competencies needed for profitable business may be different for innovators as compared with non-innovators. Something of the kind was already suggested by the high significance of innovation dummies and the interactions between innovation and education in the previous section. To test this idea we study the determinants of profitability separately for innovating firms and non-innovating ones.

Table 3. Profitability of innovators vs. non-innovators

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovators (N=278)			Non-innovators (N=176)		
Variable	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)	Coeff. (t-stat)
CONST	-0.991*	-1.001*	-1.219*	0.279	0.840	0.566
	(-2.234)	(-2.190)	(-2.798)	(0.349)	(1.108)	(0.731)
NET_{t-1}	-0.040	-0.042	-0.016	0.442*	0.400*	0.312*
	(-0.903)	(-1.022)	(-0.412)	(3.466)	(3.587)	(3.043)
PAT_{t-1}	0.133*	0.136*	0.030*	-3.143*	-2.628*	-1.014*
	(6.876)	(7.177)	(2.040)	(-3.996)	(-3.281)	(-2.027)
HIGH	0.516*			-0.038		
	(2.432)			(-0.183)		
POST	-1.780*	-1.824*	-1.323	-3.335	-4.124	-5.808*
	(-3.436)	(-3.699)	(-1.934)	(-1.372)	(-1.617)	(-2.217)
HITECH		0.685*	0.650*		1.970*	1.542*
		(2.836)	(2.667)		(2.797)	(2.552)
POSTHIGH	0.080*	0.076*	0.037*	0.373*	0.332	0.262
	(4.663)	(4.882)	(2.032)	(2.020)	(1.466)	(1.059)
PATPOST	-0.006*			-6.107*		
	(-10.132)			(-4.732)		
PATHITECH		-0.006*			-0.433*	
		(-10.541)			(-3.565)	
MS	0.382	0.990	0.749	-3.072	-4.734*	-7.359*
	(0.368)	(1.092)	(1.112)	(-1.196)	(-2.337)	(-3.706)
SALES	0.006*	0.004	0.005*	-0.010	-0.006	0.030*
	(1.966)	(1.487)	(2.129)	(-0.997)	(-0.811)	(4.135)
KINT	-0.125	-0.143*	-0.091	-0.417*	-0.441*	-0.382*
	(-1.860)	(-2.355)	(-1.443)	(-14.210)	(-12.276)	(-14.039)
CON3	-0.010	-0.013	-0.031	0.382*	0.383*	0.358*
	(-0.237)	(-0.357)	(-0.770)	(4.567)	(4.822)	(4.867)
$KINT_1$	-0.082*	-0.090*	-0.097*	-0.105*	-0.096*	-0.079
	(-2.204)	(-2.623)	(-2.628)	(-2.361)	(-2.334)	(-1.902)
Second-order serial correlation	-0.781 (80)	-0.692 (80)	-0.961 (80)	-0.741 (44)	-1.149 (44)	-0.895 (44)
Wald test for joint significance	281.18 (11)	292.50 (11)	171.20 (10)	1845.95 (11)	10633.25 (11)	10520.24 (10)
Sargan test	36.053 (35)	36.66 (35)	34.48 (36)	24.15 (21)	23.71 (21)	25.92 (22)

According to the results in table 3 above, the determinants of profitability indeed differ in innovating and non-innovating firms. Here the innovators are comprehensive innovators, i.e. firms carrying out both product and process innovation, whereas the non-innovators are involved in neither.

Overall, patenting and educational competencies are more important for the profitability of innovators[2]. Previous patenting is even negatively related to non-innovators' profit rates. Only higher technical skills (HITECH) are robustly significant for non-innovators' profits. The coefficient is also clearly larger for non-innovators. The interaction term POSTHIGH is not significant for these firms.

Instead for the innovators, higher education (HIGH), higher technical skills (HITECH) and research skills (POST) are all very significant. Again, research skills necessitate enough complementary general skills in the form of higher education.

For both groups the interaction between skills and current patenting are again strong and significant, suggesting that extensive patenting activities are not necessarily profitable, but complementary competencies need to be accumulated as well.

The profitability of non-innovating firms seems to be determined mainly by other factors than competence accumulation. The autoregression term (NET_{t-1}) is significant suggesting that successful firms tend to remain successful due to factors outside our model. Interestingly, market share correlates negatively with their profit rates. Furthermore, the negative impact of firm capital intensity is strong compared to innovating firms. On the other hand, positive effects of industry concentration are more important, too.

For the group of innovators, NET_{t-1} is insignificant, indicating that a larger part of the variation is taken into account by the estimated empirical model, than for non-innovators. The size of the firm seems to be an important determinant of profitability for innovators, again pointing to the life cycle differences among firms. Market share and concentration do not come into play with respect to innovating firms' profitability.

To conclude, profitability of innovating firms is influenced by quite different factors than that of non-innovating firms. In particular, the role of education in the accumulation of competences is clearly more important for innovators. Economic performance of innovating firms relies to a significant extent on the competencies of the employees.

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[2] Patenting here refers to the domestic patent applications. Thus the firm may have applied for patents during 1985-1993 even if it did not innovate between 1989-1991.

5.3 Product Innovators vs. Process Innovators

This subsection examines whether there are also differences between different kinds of innovators. The profitability model is estimated separately for product innovating and process innovating firms. There is some overlap in the two groups, however. In spite of this, the results suggest that profitability of product innovators is affected by different factors than that of process innovators.

Table 4. Determinants of profitability for product and process innovators

	(1) Product Innovators (N=315)	(2) Process Innovators (N=355)
Variable	**Coeff. (t-stat)**	**Coeff. (t-stat)**
CONST	-1.062*	-1.004*
	(-2.240)	(-2.462)
NET_{t-1}	0.034	-0.067
	(0.646)	(-1.072)
PAT_{t-1}	0.188*	0.095*
	(4.381)	(4.003)
HIGH	0.366	0.747*
	(1.640)	(3.648)
POST	-1.355*	-0.407
	(-2.075)	(-1.584)
POSTHIGH	0.074*	0.035*
	(3.309)	(2.265)
PATPOST	-0.006*	-0.003*
	(-6.638)	(-3.248)
MS	0.738	0.912*
	(0.736)	(4.214)
SALES	0.004	0.0002
	(1.808)	(0.457)
KINT	-0.121*	-0.004
	(-7.078)	(-0.078)
CON3	-0.021	0.006
	(-0.485)	(0.155)
$KINT_I$	-0.065*	-0.114*
	(-2.014)	(-2.385)
Second-order serial correlation	-0.979	-0.689
	(89)	(99)
Wald test for joint significance	483.48	187.23
	(11)	(11)
Sargan test	35.09	42.87
	(35)	(35)

Firstly, the coefficients indicate that patenting is more important for product innovators, which is quite intuitive. Furthermore, higher education is more useful for process innovators, whereas the magnitude of the coefficients on research skills (POST) and the POSTHIGH interaction term are larger and more significant for product innovators.

Among the control variables, the main differences are that profitability of process innovators is more affected by market share, and firm capital intensity seems to decrease the profit margins of product innovators more seriously.

In conclusion, even with this limited and overlapping sample of firms, the result emerges that the accumulation of capabilities that affect the economic performance in product innovating firms is different from that in process innovating firms. A more thorough inspection of the innovation processes might reveal more information about the types of competencies accumulated in each, and the kind of educational skills required in them.

6 Discussion and Conclusions

Overall, the educational competencies have a considerable role in the analysis of profitability of manufacturing firms. Including competence variables improves the significance of estimations. Furthermore, there are interesting interactions between different types of competencies, and also between technical/natural scientific competencies and patenting. Educational measures seem to capture at least some aspects of internal knowledge accumulation in firms. Our interpretation is that education is useful through building organizational competence via learning on-the-job.

According to our results, general competencies acquired in education, notably higher and post-graduate education, are beneficial for the profitability of firms. However, the interaction between the number of employees with post-graduate education, which reflects the research orientation of the firm, and other types of competencies is important. In order that the post-graduate employees improve profitability, there need to be sufficiently general competencies in the firm. This is intuitive, in the sense that even very ambitious and productive research and development may not be useful, unless there are enough competencies in other parts of the organization to make use of the knowledge produced, and to enable communication and interaction between R&D and marketing, production and administration. There seem to exist substantial complementarities between different types of competencies.

Factors influencing profitability of innovating firms differed considerably from those of non-innovators. Both educational competencies and patenting were more important for innovators, whereas the profitability among non-innovators correlated mainly with previous performance, and firm- and industry-specific variables. There could also be detected some differences in the determinants of profitability of product vs. process innovators. The coefficients of research competencies and their interaction with general higher education were larger and more significant for product innovators. Instead, higher education gained more positive significance with the process innovators.

Product innovations as such did not appear to be associated with better economic performance, contrary to the results of Geroski et al. (1993). Part of the reason may be the poorer quality of our innovation data compared to that used by Geroski et al. Also the stage of the product innovating firms in the product life cycle may have contributed to this result. Nevertheless, we maintain that the fundamental source of flexibility and innovativeness, which lead to better economic performance, is knowledge accumulated with the help of dynamic competencies, not the process of innovation alone. Part of this knowledge capital can be acquired through hiring different kinds of educated employees.

However, a reasonably detailed analysis will require more accurate firm-level data on innovation processes, inputs and outputs, technology adoption and use, and competencies. In order to fully grasp the dynamics of knowledge accumulation and lags involved, longer time-series are needed. Interesting issues to consider in future work would also be the coevolution of the modes of organization and technological change, and their implications for competence accumulation.

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LÖNNROTINKATU 4 B,   FIN-00120 HELSINKI

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