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ABSTRACT

This econometric study deals with the economic effects of human capital. The importance of competences acquired by formal education of the white collar workers is assessed in a traditional economic growth framework augmented with human capital by estimating a Cobb-Douglas production function. The object is, however, to investigate the microfoundations of growth, and this is done by using firm level data on biggest Finnish industrial corporations. Also the formation of human capital and the idea of competence rent are tested for.

Quite significant results are obtained from the regressions. Human capital indicators enter the production function positively. Especially the technical competences are important for growth. However, the effects of R&D and doctoral level employees remain ambiguous, probably due to the exceptional role played by state-owned enterprises in Finland. On the other hand, abundant technical competences are detrimental to profitability. It seems that technically oriented employees are more willing to take risks in expanding the firm's activities, but this happens at the expense of rate of return on investment. Other human capital indicators are in positive relation with profitability.

KEY WORDS: Human Capital, Economic Growth, Industrial Change

SUMMARY

This study analyses empirically the economic effects of human capital. The importance of education in creating managerial and technical competences that have economic relevance is considered. In addition, if education improves the employees' abilities to learn continuously, then it facilitates the creation of specific business competences.

The main concern are the strategic effects on firm performance of the competences of white collar employees, researchers and managers with different levels of formal education. The approach is thus micro-based. The skills of the white-collar employees are mainly used outside the physical production process in activities like research and product development, organization and administration, marketing etc.. These functions may in fact be the source of most of the labor costs in the value chain of the product in modern corporations.

In this study, the importance of competences acquired in formal education is assessed in a traditional growth framework augmented with human capital, by estimating a Cobb-Douglas production function. The object is to investigate the microfoundations of growth, and this is done by using firm level data on largest Finnish industrial corporations.

The main outcome of the regression analyses is that the educational level contributes significantly to corporate growth. Thus human capital is an essential component in theories of growth either as a factor of production or as a non-rival organizational knowledge input. Almost 90 % of the variation in the growth of turnover among 33 firms was explained with the production function augmented with human capital level and industry dummies.

The level of human capital seems to be relevant for firm growth, instead of the growth rate of human capital. This fact lends support to the (tacit) knowledge aspect of human capital. Human capital is not used in production the way other inputs are, but rather it may be associated with increasing returns due to its at least partial shareability, and also complementarities for example in the human capital levels of the members of a team.

Technical competence capital appeared also to have a significant positive relationship with growth. However, the more employees with a degree in technical or natural sciences the firm had, the less profitable it was. One possible explanation is, that technically oriented people are more willing to take risks in expanding the operations, but this happens at the expense of immediate return on investment.

The coefficient of the share of employees with a post-graduate degree, as well as the R&D intensity, had a negative sign, contrary to prior beliefs. Research oriented strategies were not very productive in terms of growth during the 1980s in Finland. This may be a result of the very long lags in the effects of investment in R&D, or the fact that quite often the state enterprises chose this kind of strategy, and their growth performance is blurred because of other goals than profit or growth maximizing, for example employment or regional policies.

Also the accumulation of human capital in firms is analysed in the study. Does the human capital level result from economic success and not the other way round? This would mean that as firms grow and get more profitable, they can afford to hire more highly educated people.

According to the rough estimations performed, human capital accumulation is not explained by economic performance, which increases our confidence in the growth regression results. Instead, convergence in general educational levels is found, in the sense that firms with an originally low level increase it fastest. Human capital accumulation also seems to happen simultaneously with accumulating technical competences.

Competence rent is the supra-normal rate of return that the firms are able to obtain due to the monopolistic position acquired with competences or knowledge that other firms do not have. With more competent employees, especially in research and development activities, a firm may be more successful in developing new products or methods of production. Thus the rate of return should be positively related to the human capital level in a firm. This proposition received some support from the data. The general human capital created by education was positively correlated with the profitability of firms.

On the whole, the regression results showed that the level of human capital stock was more important than its rate of change in determining the growth rate of firms. This could be due to the positive effect human capital may have on innovativeness and also on the ability to adopt knowledge created by others. Since adding the educational level into the firm growth models improved clearly the empirical results, we may conclude, that education is an important part in the creation of general human capital.

YHTEENVETO

Tutkimuksessa selvitetään inhimillisen pääoman taloudellisia vaikutuksia. Tavoitteena on arvioida koulutuksen avulla luotavan yleisen ja teknisen osaamisen taloudellista merkitystä. Jos koulutus tämän lisäksi parantaa työntekijöiden kykyä oppia jatkuvasti, se vauhdittaa myös yrityskohtaisen osaamisen syntymistä.

Tärkeimpänä tutkimuskohteena ovat toimihenkilöiden, tutkijoiden ja johtoportaan koulutuksella luodun osaamisen strategiset vaikutukset yrityksen taloudelliseen menestymiseen. Lähestymistapa on siten mikrotaloudellinen. Toimihenkilöiden taidot vaikuttavat yleensä fyysisen tuotannon ulkopuolella esimerkiksi tutkimus- ja tuotekehitystoiminnassa, tuotannon organisoinnissa, sekä hallinnossa ja markkinoinnissa. Näiden toimintojen työvoimakustannukset saattavat itse asiassa muodostaa suurimman osan koko yrityksen arvoketjun työvoimakustannuksista.

Muodollisella koulutuksella luodun osaamisen merkitystä tarkastellaan perinteisen talouskasvuteorian mukaisesti ottaen mukaan inhimillinen pääoma. Estimoimalla Cobb-Douglas -tuotantofunktion parametrejä selvitetään talouskasvun perusteita. Estimoinneissa käytetään yrityskohtaisia tilastoja suurista suomalaisista teollisuusyrityksistä.

Regressioanalyysien tärkeimpänä tuloksena voidaan pitää sitä, että koulutustaso näyttää vaikuttavan tilastollisesti merkitsevän myönteisesti yrityksen kasvuun. Inhimillinen pääoma on siten olennainen osa kasvuteorioita, joko tavallisena tuotannontekijänä tai organisaatiossa vaikuttavana osittain jaettavana tietopanoksena. Lähes 90 % tarkasteltujen teollisuusyritysten kasvueroista voitiin selittää inhimillisellä pääomalla ja toimialadummyilla laajennetulla tuotantofunktiolla.

Inhimillisen pääoman taso, ei sen kasvuvauhti, näyttää liittyvän yritysten kasvuun. Tätä seikkaa voidaan tulkita korostamalla sitä, että inhimillinen pääoma on osittain tiedon kaltaista, eli jaettavaa ja vajavaisesti omistettavaa. Inhimillistä pääomaa voitaisiin siis ainakin osittain jakaa organisaation jäsenien kesken. Inhimillistä pääomaa ei tällöin käytetä tuotannossa samaan tapaan kuin muita tuotannontekijöitä, vaan siihen voi liittyä jaettavuuden vuoksi kasvavia tuottoja ja komplementaarisuuksia työryhmän jäsenten kesken.

Teknisellä osaamisella oli myös merkitsevä positiivinen vaikutus kasvuun. Sen sijaan tekniikan tai luonnontieteiden alueella koulutettujen osuus liittyi selvästi negatiivisesti yrityksen kannattavuuteen. Mahdollisesti teknisesti suuntautuneiden henkilöiden tavoitteet ja toimintatavat poikkeavat muiden koulutusalojen henkilöistä. Teknis-tieteelliset

henkilöt ovat ilmeisesti halukkaampia ottamaan riskejä liiketoiminnan laajentamiseksi, mutta tämä saattaa tapahtua välittömän tuoton kustannuksella.

Tutkijatason koulutuksen saaneiden osuus samoin kuin T&K-investoinnit olivat negatiivisessa yhteydessä kasvuun, toisin kuin ennakolta odottaisi. Tutkimuspainotteiset strategiat eivät olleet 1980-luvulla Suomessa kovin menestyksekkäitä ainakaan kasvun kannalta. Tämä saattaa johtua T&K-investointien vaikutusten hyvin pitkistä viiveistä. Toisaalta valtionyhtiöt valitsivat varsin usein tämäntyyppisen toimintatavan, ja niiden kasvua hidastivat osittain muut kuin liiketaloudelliset tavoitteet, esimerkiksi työllisyys- ja aluepoliittiset näkökohdat.

Tutkimuksessa testataan myös koulutuspääoman muodostumista yrityksiin. Johtuuko korkea koulutustaso taloudellisesta menestyksestä eikä päinvastoin? Tämä tarkoittaisi, että yritysten kasvaessa ja niiden kannattavuuden parantuessa niillä olisi varaa palkata korkeammin koulutettuja ihmisiä.

Tehtyjen regressioanalyysien perusteella koulutustasoa ei voida kuitenkaan selittää taloudellisella menestyksellä, mikä lisää luottamusta edellisiin tuloksiin. Sen sijaan havaitaan, että yritykset, joissa koulutustaso oli matala periodin alussa, ovat kasvattaneet sitä nopeimmin, eli yritysten koulutuspääomatasot ovat samankaltaistuneet. Teknisen koulutuspääoman nousu selittää myös hyvin suuren osan yleisestä koulutustason kehityksestä. Yleinen koulutustaso on noussut yhtä aikaa teknisen osaamisen kanssa.

"Osaamisvoitto" (competence rent) on normaalia suurempi tuottoaste, jonka yritykset keräävät osaamisen tai tiedon avulla luomansa monopoliaseman ansiosta. Taitavien työntekijöiden avulla, erityisesti tutkimuksessa ja kehityksessä toimivien, yritys saattaa olla muita menestyksekkäämpi uusien tuotteiden ja tuotantomenetelmien kehittämisessä. Tuottoasteen pitäisi siis periaatteessa olla positiivisessa riippuvuussuhteessa yrityksen inhimillisen pääoman tason kanssa. Tälle ajatukselle löytyi aineistosta jonkin verran tukea. Koulutuksella luotu yleinen inhimillinen pääoma korreloi positiivisesti yritysten sijoitetun pääoman tuoton kanssa.

Kokonaisuutena regressioanalyysien mukaan inhimillisen pääoman varannon koko oli tärkeämpää kasvun kannalta kuin tämän varannon kasvu. Tämä saattaa johtua inhimillisen pääoman suotuisista välillisistä vaikutuksista innovatiivisuuteen ja myös kyyyn omaksua muiden kehittämää tietoa ja teknologiaa. Koulutustason ottaminen mukaan yrityksen kasvumalleihin paransi selvästi niiden selityskykyä, joten muodollinen koulutus näyttää olevan olennainen osa inhimillisen pääoman luomista.

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1 Introduction

1.1 Background of the Study

In what ways does human capital affect economic development in the long run and how is human capital created? These questions have become very important as the economies and societies grow increasingly knowledge intensive. The production processes as well as the products themselves contain all the more information and know-how. According to some estimations, 35-60% of the capital stock (net worth) of an industrial firm is composed of intangible factors like technical knowledge, marketing know-how, human embodied (educational) capital etc. (Eliasson 1990: 290). Despite this, the question of the determinants and consequences of human capital that create this intangible value, remains mostly unanswered in economics, although the economic growth literature as well as industrial economics frequently refer to it. The object of this study is to add to the measuring and understanding of the implications of human capital on firm performance, and thus on economic growth.

Education is often considered an important factor of growth on macroeconomic level, and in numerous empirical growth regressions it has clearly been a significant explanator of international growth differences (e.g. Barro 1991). In addition, in the OECD countries, higher education in particular explains growth differences (Leiponen 1993).

Industrial economics deals especially with the effects of research and development on market concentration and firm performance as what comes to immaterial capital, whereas in most cases human capital is implicitly referred to without further analysis. For example, the abilities of the researchers are supposed to affect the productivity of firms' R&D. Also the managerial "talent" is often referred to as a company success factor (a classical example is Marris 1963). Where these abilities come from, and what their explicit effects are, have not been clarified.

Human capital has also been investigated in the human capital theory. There the focus is mainly on the profitability of education and seniority in an individual perspective, in terms of career or salary, not how they improve firm performance. Besides, human capital theory relies on quite strict assumptions about the perfectness of the labor market, and thus the strategic nature of human capital for a firm is not taken into consideration. For example, the so called lemons problem, i.e. the firm and the individual having asymmetric information about the individual's skills, may be a significant problem for firms in recruiting people, and thus an important market imperfection (Eliasson 1994).

Labor skills are in most cases taken as given in neoclassical economic growth literature. Instead, in the theory of endogenous growth, the abilities of researchers, workers etc. are taken into account to some extent, following and expanding the contributions by Arrow (1962) and Uzawa (1965). Arrow considered learning by doing as an important factor improving the productivity of physical capital, and Uzawa modelled the investment in education in the neoclassical growth framework.

In models of endogenous growth, knowledge and technology are often the engines of growth, and therefore the factors producing knowledge are important and interesting. For example, in Paul Romer's already classical article (1990) technological progress is dependent on the amount of the highest level human capital, the researchers, in the economy. According to Romer the firms invest in R&D because they have an economic incentive to do so: monopoly profits. Hence, technological development is the result of a conscious and risky investment. However, the amount and quality of human capital is still treated as an exogenous variable. The exogeneity is in fact only shifted one step further, from exogeneity of technological change to that of the amount of human capital in the economy.

In his important article about the investment in education, Robert Lucas (1988) analyzes the accumulation of human capital in education and production (learning-by-doing). In his model there is no imperfect competition, the externalities due to the properties of human capital are assumed to be Marshallian. Yet higher quality human capital might be regarded as an object of strategic investment just as R&D is. There are significant and persistent differences in educational levels among firms, hence the skill distribution is not taken from the labor market as given.

1.2 The Objectives of the Study

The object of this study is to analyze the strategic effects of differently educated employees and researchers on firm performance. What is the educational level in Finnish corporations and how is it related to their success or failure in expanding their businesses? The study is related to empirical growth studies since a production function is estimated, but also to industrial economics due to the underlying ideas about innovation and technological change.

The paper is organized as follows. In the second chapter the properties and effects of human capital in economic dynamics are discussed. The third chapter presents the production function to be estimated. The data is presented in chapter 4 and regression analyses are carried out in chapter 5, both cross-sectionally and with the panel data approach. Chapter 6 draws conclusions and summarizes the discussion.

2 How Does Human Capital Affect the Economy?

This study follows Eliasson (1994) in the sense that the approach to growth is micro-based. The dynamics of rent creation and destruction of firms through competition in the market is an essential part of growth explanation. Hence, the main object of study is the firm that operates in the market, making use of physical and immaterial assets to create profit and expand the business.

The total factor productivity is created by the immeasurable tacit knowledge factor of production. This knowledge component includes, among other things, organizational and individual competences acquired by learning-by-doing, and individual skills and abilities. These skills can partly be upgraded in activities like education and training, and partly they are innate (talent). The competences of this sort are difficult to trade or measure, and also hard to imitate or learn in case the receiver competence is lacking. By receiver competence we mean the ability to appropriate diffusing knowledge. For example, without any technical education it is hard to learn how to use a very complicated machine. Thus, there exist diminishing returns to learning. The diminishing returns are caused by failures in attempting to acquire high level knowledge or competences (Eliasson 1994).

In what follows it is presumed that more educated people are more competent and thus more productive than less educated. Education is then a useful means of increasing the production efficiency, the abilities of the labor force are accumulated in education. It is not only a way to filter the talented and skillful people to top positions in the economy.

The firms can choose the educational level of their workers. Even if in the economy at a given point in time the educational structure of the labor force is fixed and changes quite slowly, the firms can invest in more or less educated labor. Employing more educated people means higher labor costs, the decision to invest in education is similar to the one about investing in R&D or in physical capital.

Competences embodied in individuals and teams enable rates of return above the market interest rate. In the finance theory this is called a risk premium. This risk can also be thought of as resulting from the uncertainty in creating and acquiring economically meaningful knowledge or skills, as mentioned earlier. This "excess" rate of return makes it possible to expand the scale of activities of a firm.

The human capital externality creates in part the potential excess rate of return, but at the same time gives rise to a free-rider problem. The externality stems from the properties of human capital and knowledge, in particular partial shareability and complementarity of knowledge of members in a team. Knowledge is non-rival since more than one person can use it simultaneously, which makes it at least partially shareable. Shareability may be partial because of the mentioned difficulties in diffusing and appropriating knowledge. The complementarity of the competences of team members leads to synergies or increasing returns in the sense that a whole team may be more valuable to the firm than its members separately. Different kinds of skills and knowledge may be needed to fulfil a task, and one person may not be able to master all of them.

Free-rider problem may arise in a large business organization because of the partial shareability of human capital. Incentives to innovate and upgrade may be diminished if the returns to development effort do not accrue to the innovating unit but are spread evenly across the organization. The management has to take this into account and compensate the unit in question for the upgrading effort, but at the same time exploit the useful effects of the externality.

Competences can be divided into general and specific competences, which relate to their appropriability by different firms. General competences are useful to many firms, specific ones only for the firm in which they were created. Because the employees may quit the firm that has invested in upgrading their skills, too few general competences may be created. The uncertainty about the employee staying with the firm reduces the firm's incentives to invest in his skills.

Formal education produces general competences. It also increases the efficiency of production of specific competences in firms, because the accumulation of general and specific competences is sequential (Ballot 1994) and individuals with more schooling have a higher probability of obtaining on-the-job training (Lynch 1992). Formal education both widens and deepens the competence base available to firms in the labor market. Competences define also the technological trajectory of the firm, since technology and competences are complementary to a large extent.

Innovations are central to the competition among firms. They are created by human capital, and enable the generation of quasi-rent. This rent is, however, eroded with time in the process of creative destruction, but only in the longer run. It takes time because building competences or accumulating human capital is a time-consuming and risky process.

There are innovations brought about at all levels of economic activity. Usually mainly those produced in R&D, classified often into product or process innovations, are considered, but in fact innovations in organization, marketing etc. may be at least as important in terms of economic performance. Innovations are produced at every level by creative people. This creativity or innovativeness may be enhanced by education, training and incentives to innovate. The probability of innovation is increased with human capital, because the rate of learning is accelerated.

3. The Model

3.1 Production Function Approach

As in standard growth studies, the growth of a firm's production is supposed to be a function of several production factors, the demand and other external factors are not taken into account. This of course does not reflect correctly the reality, since the strategic situation in an industry, consumer preferences, total demand in the economy and also the availability of financial resources constraint the expansion of businesses.

The production function approach to the growth of a firm means thus analyzing the growth of supply taking demand and financial constraints, as well as managerial objectives, as given. Managerial constraint, in the sense that efficiency of a given number of managers declines with accelerating business expansion, is controlled for in the human capital factor to some extent.

The following production function is for most parts equivalent to a standard growth model. As in Benhabib and Spiegel (1994), the technology available to a firm (A) is assumed to be a function of three factors. Exogenous rate of technical progress (c), the human capital level of the firm (H) and its own resources devoted to R&D (RD) increase the rate of change of technology. The exogenous progress is supposed to include both the change in the general level of technology in the economy and in the international technological level in the industry in question.

Technological progress is of the form

(1) $$A(H, RD, t) = A_0 e^{(c+\eta H+\rho RD)t}$$

The rate of change is thus

(2) $$\frac{A'}{A} = c + \eta H + \rho RD$$

If the production function is assumed to be Cobb-Douglas

(3) $$Y = A(H, RD) K^{\alpha} H^{\beta} L^{\gamma}$$

Then the growth rate is

(4) $$\frac{Y'}{Y} = c + \eta H + \rho RD + \alpha \frac{K'}{K} + \beta \frac{H'}{H} + \gamma \frac{L'}{L}$$

where c is constant, and α, β, γ, ρ and η are assumed to be positive parameters. Time derivatives are denoted by the prime. The growth of a firm is thus explained by exogenous technological change, human capital level, own R&D effort and the growth of physical and human capital, and labor.

The level of knowledge capital (H and RD) affects growth, because knowledge and technology are not ordinary factors of production, but subject to externalities. The externalities arise from the properties of knowledge as a good: non-rivalry and non-excludability (see Romer 1990). There might be a critical level that has to be exceeded before innovations are produced. The same applies for R&D. A certain scale is necessary for the activity to be productive. The level of human capital stock is important, since it increases the probability of innovation and also facilitates adoption of knowledge and technology from outside.

3.2 Competence Rent à la Eliasson

According to Eliasson (1994) the total factor productivity (TFP) and thus the competence level are in a positive relationship with the rate of return. Innovations are created by the competent human capital, and they lead to market power and a rate of return greater than the market interest rate. This is called the competence rent. This quasi-rent is eroded in the long run, but lasts long enough to cause differences in firm performance across firms.

The TFP includes a competence input that enables successful risk taking and exploiting of market imperfections. In the production function specification from the previous section (equations 3 and 4) the shift produced by this competence input is described by $c+\eta H+\rho RD$. Hence, these factors should show correlation with the (excess) rate of return. This correlation will be empirically assessed using the cross-sectional data in section 5.1.2.

4. The Data

4.1 Variables and Correlations

The education data set comprises educational levels (the highest level attained) of white-collar workers in a selection of Finnish industrial firms. The data are collected from the wage inquiries undertaken by the Confederation of Finnish Industry and Employers. There are 33 industrial corporations in the data set, and the time period is from 1980 to 1990.[1] Originally the 50 biggest firms in 1980 were chosen, but due to mergers and unavailability of data the number decreased to 33.

There are data only from the Finnish units of the firms in question. Thus the data describe only the educational level of white-collar workers employed in the Finnish units, and its impact on the firms' performance in terms of growth and profitability. However, this should not be a too serious shortcoming, since during the 1980s most Finnish industrial firms still had the headquarters and R&D units in Finland, as well as most of the production. Only gradually towards the end of the decade some of the firms had over half of their workforce outside Finland.

The educational indicators used are the following:

Proportion of white-collar workers in a firm that have completed

- **- upper secondary education (vocational college, matriculation)**
- **- higher education (third level education): HIGH**
- **- licenciate or doctoral level (post-graduate degrees): DOC**
- **- any level of technical or scientific education : T**

- **Human capital index: H**
- **The annual growth rate of the human capital index: H'**

The human capital index is constructed for each firm and each year from the numbers of workers of the three educational levels by weighting them with average wage differences during the period (see table 1 below), adding up these "competence-corrected" numbers of white-collar workers, and then dividing by total number of white collar workers in the firm. The relative average wage levels are calculated from wage data for white collar workers in Finnish industry (compiled by the Confederation of the Finnish Industry and Employers).

[1]The educational data include only the years 1980, 1985 and 1990

Table 1. Relative wage differences by educational level among white-collar workers

Year	Secondary education	Third level education	Doctoral level degree
1980	1	1.54	2.44
1985	1	1.44	1.98
1990	1	1.47	1.91

Source: Calculated from wage data compiled by the Confederation of Finnish Industry and Employers

The educational level has changed in the Finnish industry quite rapidly during the 1980s. Particularly the share of employees with doctoral level education has increased very fast. Also the share of employees with third level education has gone up. Although the total number of domestic employees has decreased during the decade, the numbers of educated people have risen in these firms. This can be interpreted as an increasing demand for human capital due to growing knowledge intensity of their operations. The table 2 below describes the change in the educational level.

Table 2. Educational level in a selection of Finnish corporations (33 companies)

	1980	1985	1990	Growth 1980-1990
Total number:				
Upper secondary	33444	34007	33983	2%
Third level	12177	15118	16614	36%
Doctoral level	386	512	660	71%
H-index	53138	56791	59666	12%
Technical	25897	28722	29744	15%
Educated employees as a percentage of total number of white collar workers:				
H-index	97.2	100.8	105.7	9%
Secondary	61.2%	60.4%	60.2%	-2%
Third level	22.3%	26.9%	29.5%	32%
Doctoral level	0.71%	0.91%	1.17%	66%
Technical	47.4%	51.0%	52.7%	11%

The economic indicators (deflated with industry-specific price indices when appropriate) then include:

- **Turnover**
- **Average annual growth rate of turnover through the 1980s: GROWTH**
- **Average annual investment in fixed assets in proportion to turnover: INV**
- **Fixed assets: K**
- **Total workforce, both blue-collar and white-collar workers: L**
- **Average annual growth rate of the total workforce: L'**
- **Workers in foreign subsidiaries in proportion to total employment: INT**
- **Average annual R&D investments in proportion to turnover: RD**

Thus the turnover represents the scope of production, and the growth of a firm is equal to the growth of its turnover. The growth rate variables and the averages through the period are used in the cross-sectional regressions in section 5.1, and the annual figures in the panel data regressions in section 5.2.

The correlations between regression variables are in the table 3 below. The level of human capital index (H) and the share of employees with a third level education are very correlated with the share of technically educated (T). Proportional R&D expenditure is correlated with the shares of higher educated and doctoral level educated. Furthermore, the growth of labor varies almost one to one with the turnover growth.

Table 3. Correlations

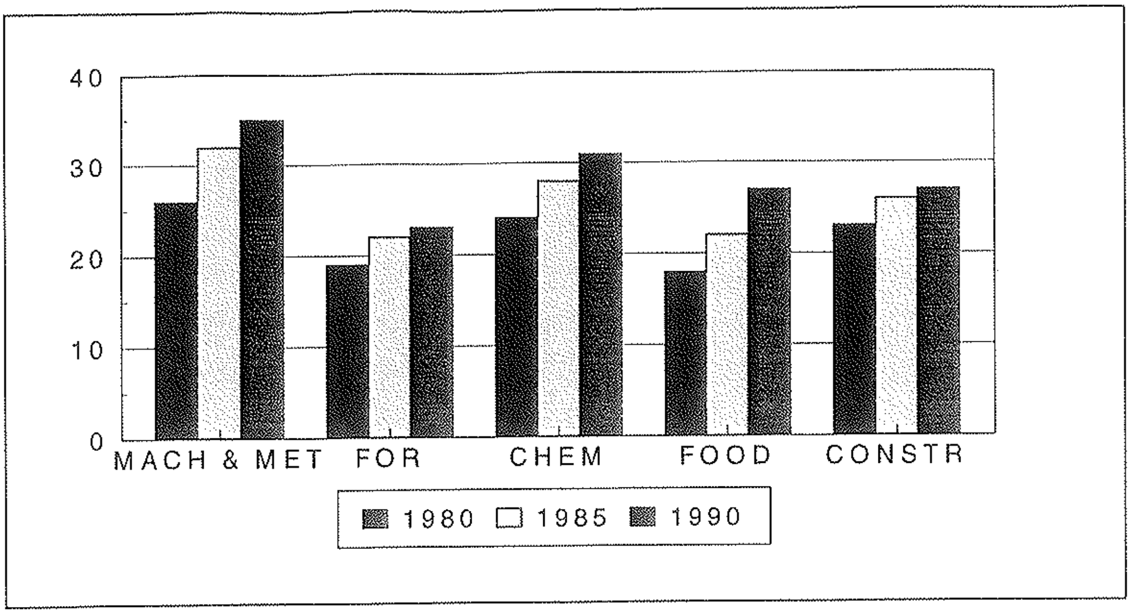
	INV	L'	H	H'	HIGH	DOC	T	RD
GROWTH	0.15	0.82	0.14	-0.3	-0.0006	0.05	0.06	0.11
INV	1	0.09	-0.07	0.005	-0.34	0.04	-0.22	0.17
L'		1	-0.09	0.02	-0.09	0.22	-0.29	0.17
H			1	-0.52	0.78	0.38	0.74	0.37
H'				1	-0.13	-0.27	-0.32	-0.03
HIGH					1	0.19	0.62	0.37
DOC						1	-0.09	0.31
T							1	0.1
RD								1

4.2 Educational Differences Across Industries

The 33 corporations can be classified into six industrial groups, dummy variables used in the regressions are in parentheses: Machinery (MACH), other metal and engineering (MET), pulp and paper (FOR), food (FOOD), chemical (CHEM; including one pharmaceutical company) and construction (CONSTR). In addition there are a few diversified firms that form their own reference group.

There seem to be significant differences across industries in the educational levels of white collar workers. The machine industry had the highest proportion of workers with third level education both in 1980 and in 1990. It also increased this number quite fast, 40% in the 10 year period. The food industry increased the proportion of third level educated people relatively rapidly, but the starting level was low. In the biggest industrial group in Finland, the pulp and paper producers, both the level and the growth rate of higher educated employees were low.

Figure 1. Shares of white-collar workers with third level education by industry



The share of employees with a post-graduate degree was relatively high in base metal and chemical industries during the whole period. These are research intensive businesses, which is reflected in this indicator. The demand for researchers grew rapidly in most industries, notably in food, chemical, and pulp and paper industry. However, the demand for researchers in food industry is somewhat biased because of one firm engaging in pharmaceuticals production also.

The proportion of technical/scientific people among white-collar workers was very high (60% in 1990) in the metal and engineering industry, where it also increased by 14% during the period. Also in the construction companies the demand for these type of competences increased very fast (15% in the period). The food industry is clearly different from the others in this respect: the necessary competences relate more to marketing than to technology.

5. Regression Analysis and Partial Correlations

5.1 Cross-Sectional Analysis

5.1.1 Explaining the Growth of Firms

This section analyzes the determinants of the growth of 33 firms between the years 1980 and 1990. The average growth rate of turnover is explained by the average investment share (investments in fixed assets in proportion to turnover, which describes the growth of physical assets), growth rate of employment, average R&D investments (in proportion to turnover) and the various human capital indicators presented in the previous section.

The regression results are shown in table 4 below. Investment share and employment growth have quite stable coefficients in the sense that the sign and magnitude do not change very much between different model specifications. Most of the growth in turnover seems to result from increasing the labor input. This probably reflects the typical way to grow in Finnish industry in the 1980s: through mergers and internationalization. The investment share has a relatively small coefficient, as compared to cross-country regressions (e.g. Barro 1991, Mankiw, Romer and Weil 1992). This might be interpreted as inefficient investment during the period of study, but further analysis would be necessary to verify this.

Most of the human capital level indicators appear positively as presumed. The level of the combined indicator (human capital index) shows up with a positive coefficient, but its rate of change has a statistically significant negative coefficient. This may be due to the substantial lags in the effects of human capital; the increase in human capital level would accelerate growth of turnover only after several years. This is confirmed in equations 7 and 8, where the original human capital level in the year 1980 (H80) has a positive coefficient. The negative sign could also mean that human capital is not an ordinary factor of production but that a certain level (or critical mass) is necessary for efficient production.

There is an obvious problem of multicollinearity with the different human capital indicators, especially the share of technically educated (T) and human capital index (H) or the share of workers with third level education (HIGH). These should measure different aspects of human capital, but they turned out to be very highly correlated (as in table 3).

Table 4. Cross-sectional growth regressions

Dependent variable: Average annual growth rate of turnover 1980-1990, N=33

	1	2	3	4	5	6	7	8	9
CONST	-0.12* (-1.97)	-0.03* (-1.72)	0.01 (0.49)	0.07*** (3.30)	-0.03 (-0.49)	0.05** (2.06)	-0.04 (-0.96)	-0.01 (-0.13)	0.06*** (4.89)
INV	0.10 (1.18)	0.15* (1.81)	0.11 (1.64)	0.11 (1.57)	0.05 (0.68)	0.06 (0.84)	0.05 (0.97)	0.07 (1.27)	-0.03 (-0.40)
L'	0.76*** (11.16)	0.82*** (12.42)	0.79*** (12.63)	0.78*** (12.62)	0.83*** (13.92)	0.90*** (13.41)	0.90*** (16.29)	0.90*** (16.96)	0.87*** (13.27)
H	0.15*** (2.79)				0.08 (1.67)				
T		0.14*** (4.03)	0.10*** (2.97)			0.06 (1.62)		0.05 (0.73)	
HIGH				0.09 (1.65)					
DOC				-2.44*** (-3.72)					
H80							0.13*** (2.78)	0.07 (0.77)	
DOC80						-1.77*** (-3.03)	-2.97*** (-5.58)	-2.43** (-2.65)	
H'			-1.76*** (-4.95)	-2.84*** (-6.20)	-0.59 (-0.99)	-1.74*** (-4.02)	-0.61 (-1.17)	-1.07 (-1.40)	
RD	-0.00 (-1.48)	-0.00 (-1.40)			-0.00 (-0.29)				
FOR					0.01 (1.45)	0.01 (0.83)			0.02** (2.58)
ELECT					0.02 (1.00)				
MACH					-0.01 (-0.89)		-0.02*** (-2.80)	-0.02** (-2.98)	
CHEM					-0.02 (-1.28)	-0.02 (-1.48)	-0.03* (-1.89)	-0.03* (-1.97)	-0.02 (-0.91)
FOOD					-0.04*** (-3.72)	-0.03*** (-2.88)	-0.05*** (-6.12)	-0.04** (-2.77)	-0.05*** (-4.32)
CONSTR					0.02* (2.04)	0.01 (1.40)	0.01 (0.80)	0.004 (0.49)	0.02* (1.92)
$\overline{R}^2$	0.70	0.77	0.81	0.81	0.82	0.87	0.89	0.88	0.81

Heteroscedasticity consistent t-values in parentheses
*****= 99%, ** = 95%, *=90% confidence interval, two-tailed test**

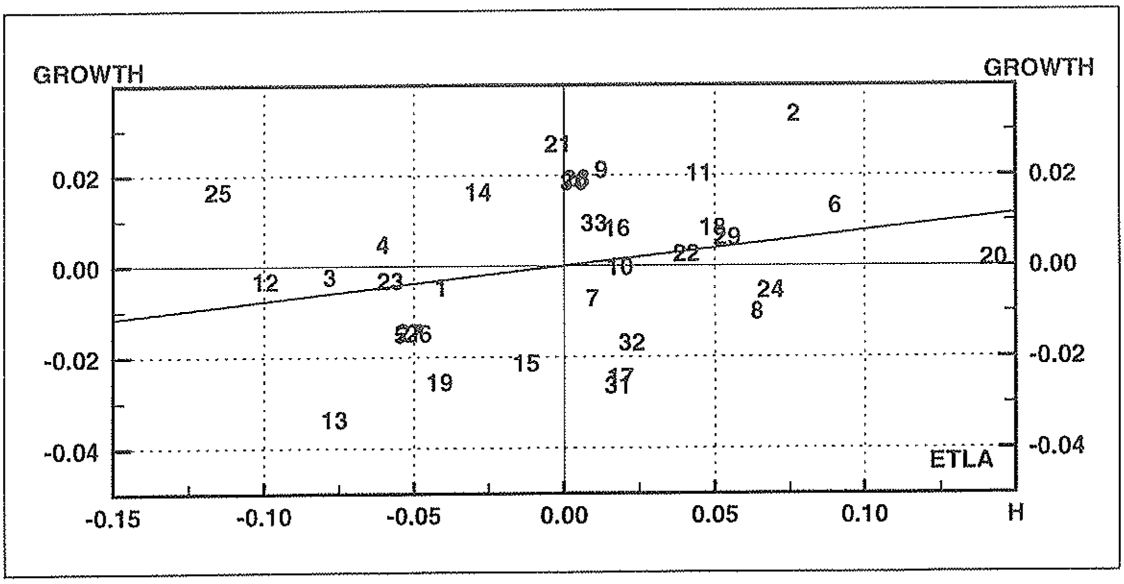
The companies that have chosen a research intensive strategy have not grown very fast in Finland. This is somewhat surprising, since according to some studies, research intensive industries generally grow faster, because they stay in the rapid growth phase of the innovation "s-curve" thanks to continuous innovation (e.g. OECD 1986: 65-66). The unprofitability of research cannot in this data set be completely explained by lags, because even the level in the year 1980 (DOC80) has a statistically significant negative coefficient, and also the R&D investments show up negatively, although the coefficient does not differ from zero. However, the number of employees with post-graduate degrees still remains at a very low level in Finnish industry, despite its rapid growth in the 1980s, which may make the results fragile and not very reliable.

The negative relationship of researchers and growth may also be partly explained by the singularity of the data set. In the Finnish industry, quite many of the firms that have chosen the research intensive strategy are (or were in the 1980s) state enterprises, that seem to have other goals in addition to maximizing profit and/or growth, for instance objectives related to employment and regional policies. Also, many of them operate in relatively slowly growing industries like food, base metals, energy and pulp production. Thus, in a slowly growing industry even a research intensive strategy may not be sufficient to accelerate growth much faster than the industry average.

The contribution of human capital to firm growth is demonstrated by including the equation 9, where only "traditional" growth factors, investment in fixed/physical capital and labor inputs, are used along with industry dummies. As compared with equations 6-8, it explains 6-8% less of the variation in growth performance across firms. It also shows, that the investment in fixed assets (INV) has a negative influence on growth rate if no human capital variables are controlled for. This seems to support the complementarity of human and physical capital: if the human capital and competence requirements are not taken into account, investing in machines and equipment may be unprofitable.

The partial correlations between growth of turnover and different human capital variables are presented graphically in figures 2-5, which illustrate the relationships represented in table 4 above.

Figure 2. Partial correlation of growth of turnover and human capital index



The relationship between human capital level and growth of turnover is positive but rather weak (figure 2). The technical competences seem to be more important in terms of growth (figure 3). The negative association of researchers and growth is demonstrated in figure 4 below. Growth of human capital is negatively associated with turnover growth, as seen in figure 5. However, the slope is not very steep and dispersion is high.

Figure 3. Partial correlation of growth of turnover and technical competence capital (share of white-collar workers with a degree in engineering or natural sciences)

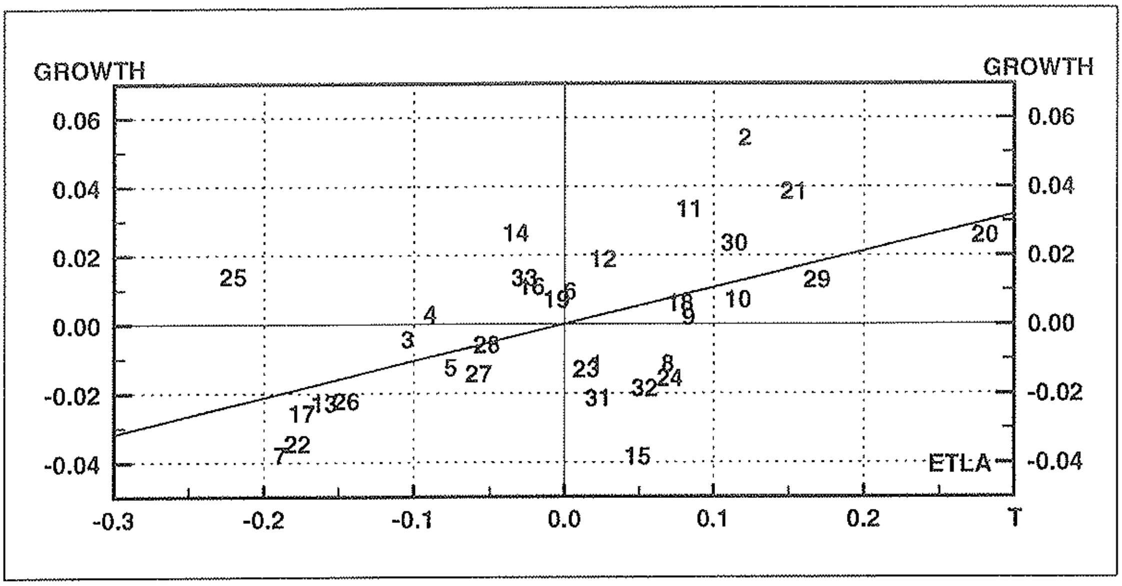


Figure 4. Partial correlation of growth of turnover and white-collar workers with a post-graduate degree

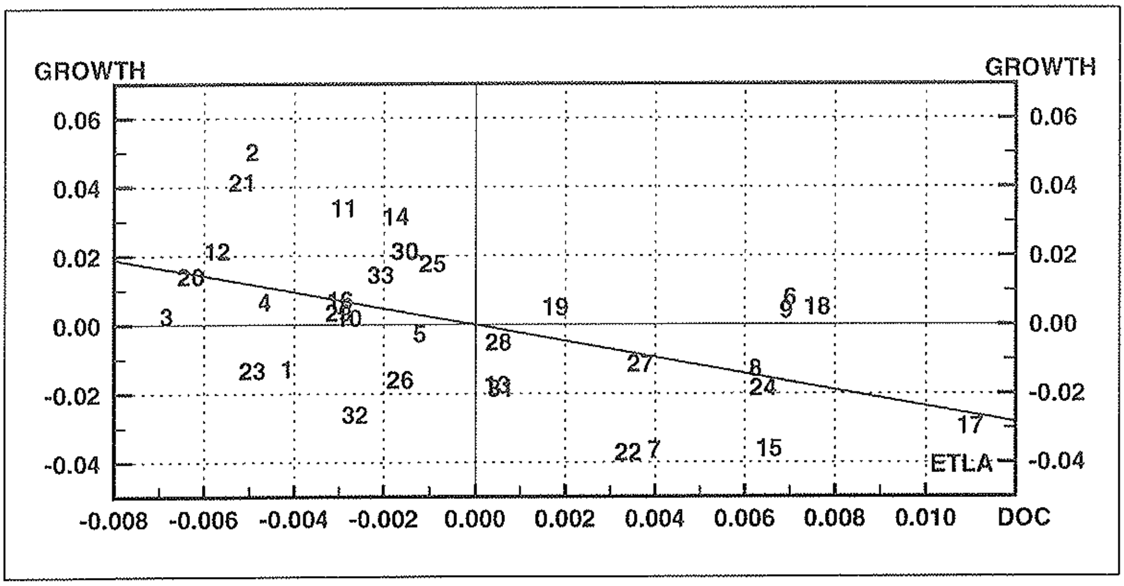
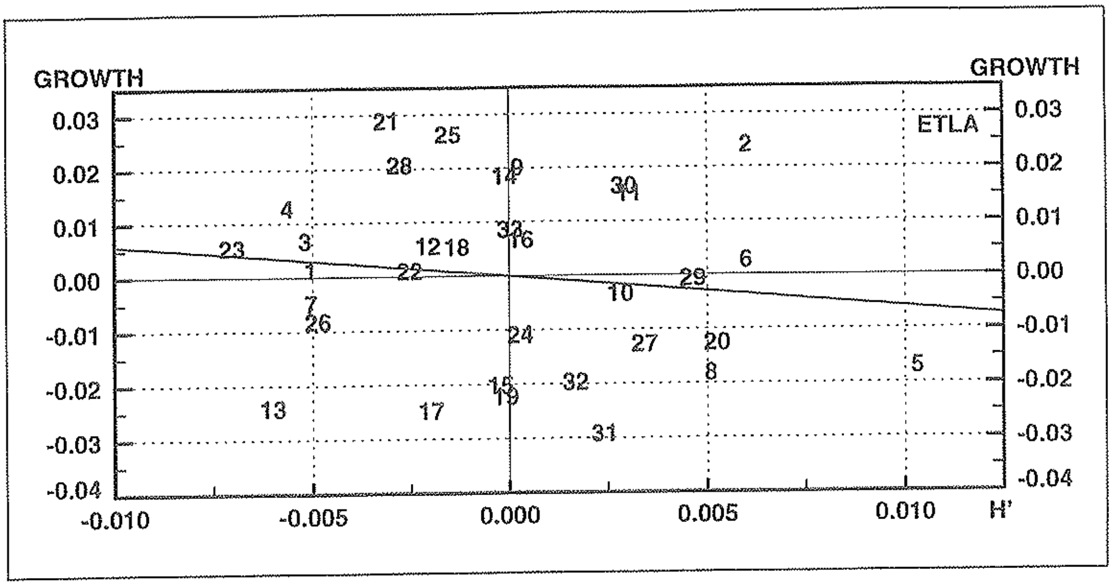


Figure 5. Partial correlation of growth of turnover and growth rate of human capital stock as measured by the human capital index



5.1.2 Competence Rent Cross-sectionally

In this section the competence rent, approximated by period average return on investment (ROI), is explained by knowledge capital indicators. The regression results are reported in table 5.

The human capital indicators alone are not significantly correlated with the rate of return, but when industry specific factors are controlled for, the human capital variables are positively related to the return on investment. The only exception is the share of technically/scientifically educated (T), which is strongly and significantly negatively related to profitability. It seems that firms which increased their technical orientation grew quite fast due to material and intellectual efforts, but this happened at the expense of profits. The technically oriented firms appear to be more willing to take risks. This result also supports including both T and other human capital indicators in the regressions. Despite the multicollinearity they unveil different aspects of the implications of human capital for industrial change.

Now also the growth of the human capital index (H') and the share of employees with post-graduate degree (DOC) appear with a positive coefficient, although the coefficient of DOC is not significant in any of the specifications. Instead, coefficients of the original human capital level (H80) and its growth H' are positive and statistically significant (at the 5% level).

Growth of turnover and profitability seem to be positively correlated in the data set, contrary to the classical Marris framework (Hay and Morris 1979: 278-289). The negative coefficient of L' might come from the fact that the international mergers and take-overs undertaken by Finnish corporations were not always very successful during the period. Also, the negative coefficient on investment refers to a low rate of return on investment in those firms that have invested a lot. This is of course natural in the sense that the most lucrative investment opportunities are seized first.

Table 5. Competence rent regressions

Dependent variable: Average (1980-1990) return on investment (ROI), N=33

Variable	1	2	3	4	5
CONST	1.99 (0.13)	-1.13 (-0.13)	0.03 (0.003)	-4.21 (-0.44)	-5.14 (-0.58)
GROWTH		58.61* (1.93)	62.71* (2.07)	66.29** (2.23)	65.17** (2.21)
INV		-12.61 (-1.27)	-10.64 (-1.13)	-11.42 (-1.17)	-11.37 (-1.17)
L'		-50.95* (-1.76)	-55.90* (-1.94)	-61.36** (-2.16)	-60.31** (-2.12)
H		18.80* (1.77)	16.49 (1.65)		
T	-5.03 (-0.76)	-23.50*** (-3.23)	-21.67*** (-2.98)	-24.20*** (-3.40)	-24.99*** (-3.50)
H80	9.80 (0.57)			21.47* (1.86)	23.10** (2.25)
DOC80	25.86 (0.21)			32.98 (0.38)	
H'	135.4 (0.71)	204.80 (1.56)	175.89 (1.41)	295.81* (1.84)	298.07* (1.87)
FOR		0.21 (0.21)			
ELECT		-4.01 (-1.28)	-4.08 (-1.34)	-3.68 (-1.30)	-3.66 (-1.31)
MACH		2.52* (2.01)	2.60* (2.04)	2.76** (2.11)	2.74** (2.14)
CHEM		4.63*** (3.07)	4.76** (2.77)	4.79** (2.79)	4.87*** (2.80)
FOOD		-1.20 (-0.77)			
CONSTR		3.64*** (3.25)	3.50*** (3.38)	3.75*** (3.72)	3.79*** (3.78)
$\overline{R}^2$	-0.08	0.14	0.21	0.22	0.25

***=99%, **=95%, *=90% confidence interval, two-tailed test

The human capital indicators contribute positively to the rate of return on investment, but by using physical and human capital variables we are able to explain only about 25% of the variation at most. However, the human capital indicators H, H80 and H' show up with rather significant coefficients in specifications 2-5 (all confidence intervals are more than 90%, most are more than 95%). The positive relation might of course also be interpreted the other way round: profitability enables companies to hire more educated people and researchers. This possibility will be tested for in the next section. So far we content ourselves with having obtained some support for Eliasson's proposition of a competence rent.

5.1.3 Human Capital Accumulation

This section studies the usual claim that human capital is itself accumulated as a result of economic success, i.e. it is not a growth factor but more like a consumption good. The firms can afford to employ more educated employees if they are more profitable. The regression results are shown in table 6. However, this is a very rough way of assessing the possible problems of simultaneity.

Profitability (ROI) is in most cases negatively related with the human capital index (H), but if the technical competence variable is included, the relationship turns positive. In that case also the growth rate of turnover becomes negatively associated with human capital index, otherwise its coefficient is positive, as shown in the table below. This may result from multicollinearity. The technical/scientific competence capital stock is a very important regressor, it increases the coefficient of determination up to 69%.

The relationship between the human capital index and firm performance measured by profitability is not robust, since the signs of the coefficients vary and so does their significance. The growth rate of human capital level (H') is not explained by either profitability or turnover growth, on the contrary, turnover growth is negatively associated with human capital growth and ROI is not significant. Thus the data do not support the proposition that human capital is accumulated as a result of economic success.

Investment in fixed assets seems to be positively related with both the human capital level and its rate of change, or in other words, investment requires more specific competences. Human and physical capital are probably accumulated simultaneously as firms expand their operations. However, there is a strong negative connection between human capital level and its growth rate. The firms that had a high level already in the beginning of the period of study have not been increasing it as fast as those with originally low human capital level. So there seems to be some kind of human capital convergence in effect. There are limits to the pay-off from increasing the level of education, or in other words, decreasing returns to general human capital.

The regression results of the industry dummies are mostly according to prior expectations. The forest (pulp and paper) industry has both a lower level and a lower growth rate of human capital than the other groups. Machine and (surprisingly) food industries have high levels and have been increasing them fast. The growth of the human capital stock has been slow in the chemical industry.

Table 6. Explaining the investment in human capital

Dependent variable: Human capital index (1-4) and its growth rate (5-7), N=33

Dependent variable →	**Human Capital index**				**Rate of Change of Human Capital index**		
	H 1	**H 2**	**H 3**	**H4**	**H' 5**	**H' 6**	**H' 7**
CONST	1.00*** (11.07)	0.97*** (10.43)	1.03*** (10.06)	0.73*** (14.75)	0.009 (1.66)	0.03** (2.36)	0.04*** (4.40)
GROWTH	0.34 (0.99)	1.68** (2.70)	0.58 (1.11)	-1.01** (-2.21)	-0.09 (-1.62)	-0.06 (-1.62)	-0.11*** (-3.25)
INV		-0.26 (-0.92)	0.07 (0.21)	0.40*** (2.87)	0.02 (1.61)	0.02 (1.29)	0.04*** (2.80)
L'		-1.30** (-2.06)	-0.67 (-1.17)	0.87 (1.59)	0.05 (0.97)	0.03 (0.67)	0.09* (2.00)
H						-0.02** (-2.14)	-0.06*** (-4.00)
T				0.62*** (11.65)			0.04*** (4.08)
ROI	-0.004 (-0.51)	-0.005 (-0.68)	-0.001 (-0.11)	0.003 (1.12)	0.0002 (0.65)	0.0002 (0.59)	0.0003 (1.41)
H'			-6.08** (-2.70)	-7.82*** (-5.09)			
FOR	0.004 (0.11)	-0.01 (-0.24)	-0.05 (-1.49)	-0.02 (-1.41)	-0.003 (-1.48)	-0.005** (-2.06)	-0.003* (-1.91)
ELECT	-0.02 (-0.37)	-0.07 (-1.38)			0.001 (0.12)		
MACH	0.07 (1.64)	0.07* (1.80)			0.001 (0.50)		
CHEM	0.07 (1.69)	0.10** (2.09)	0.05 (1.60)	-0.03 (-1.19)	-0.005* (-2.01)	-0.004* (-2.01)	-0.006*** (-2.80)
FOOD	-0.07 (-1.14)	0.003 (0.06)	0.001 (0.03)	0.07* (2.05)	0.005 (1.33)	0.004 (1.26)	0.007*** (2.80)
CONSTR	-0.002 (-0.03)	-0.03 (-0.59)			0.002 (0.87)		
$\bar{R}^2$	0.01	0.08	0.12	0.69	0.23	0.39	0.59

*****=99%, **=95%, *=90% confidence interval, two-tailed test**

In short, the level and rate of change of human capital in the Finnish industry is not explained by economic performance, but rather by increasing technical orientation and convergence in educational levels across firms. The educational distribution among firms seems to be narrowing.

5.2 Panel Data Approach

Using longitudinal data enables the analysis of both time-series and cross-sectional aspects of the data simultaneously. Thus the panel data methods should increase the reliability of estimations. Two methods are used in this section. Both are fixed effects methods, the first makes use of partitioned regression and the second is based on the Least Squares Dummy Variable (LSDV) method.

In the first case the fixed effects are calculated by subtracting the period means for each firm from the data, and then estimating using OLS. The assumption is that there exist firm-specific time invariant differences, such as managerial skills, that have to be accounted for, and for example according to Greene (1993: 467) subtracting the means is an equivalent method. Using industry dummies is equivalent to the LSDV method, but with industry dummies instead of firm dummies. We assume that there are important industry specific differences, but that firms in an industry are similar enough to be treated as one object of research.

In this section we have the turnover (in 1000 Finnish marks) as the dependent variable, not its growth rate. The regressors include total workforce (number of people), fixed assets (1000 Finnish marks), internationalization (share of total personnel abroad), R&D investment (in proportion to turnover). Human capital indicators are defined as in previous section, now calculated for each year. Since the original data are only for the years 1980, 1985 and 1990, the average of 1980 and 1985 is used for the years 1981-84, and similarly the average of 1985 and 1990 for the years 1986-89. The coefficients for human capital variables and industry dummies in tables 7 and 8 appear to be huge in magnitude, but this results from having the turnover in Finnmarks as the dependent variable.

5.2.1 Fixed Effects By Subtracting The Means

With the panel data the explanatory power of human capital indicators is not as obvious as cross-sectionally, but in most cases they enter with the expected positive sign. The human capital index (H) is positive and significant except when DOC (share of people with post-graduate degree) is included. DOC is neither positively nor negatively significant in any of the specifications. Both H, HIGH and T show up positively and significantly. R&D investments enter negatively again, and because of numerous missing observations, the adjusted coefficient of determination is low.

Employment has a quite stable coefficient again, as in cross-sectional estimations, and so has physical capital. In the panel data regressions the degree of internationalization (measured by the share of workforce abroad) is an important explanatory variable. In the cross-sectional regressions it was so insignificant, that it was left out of the specifications. Internationalization seems also to be related to the scale of operations to a notable extent.

Table 7. Fixed Effects I

Dependent variable: Turnover

	1	2	3	4	5	6	7	8
L	0.42*** (9.22)	0.49*** (9.93)	0.42*** (9.35)	0.50*** (10.45)	0.42*** (9.20)	0.51*** (8.70)	0.42*** (9.19)	0.42*** (9.15)
K	0.27** (2.56)	0.36*** (2.95)	0.27** (2.57)	0.37*** (3.07)	0.26** (2.49)	0.13 (1.31)	0.26** (2.43)	0.27** (2.55)
H		5727** (2.36)	-1267 (-0.40)			14985*** (4.09)		
T				5014** (2.51)				1985 (1.34)
HIGH					6476* (1.77)		5458* (1.82)	
DOC			12305 (0.30)		-25423 (-0.70)			7140 (0.24)
RD						-24623 (-1.46)		
INT	5424*** (5.69)		5488*** (5.31)		4906*** (4.57)		4851*** (4.43)	5248*** (5.33)
$\bar{R}^2$	0.63	0.57	0.63	0.57	0.63	0.48	0.63	0.63

***=99%, **=95%, *=90% confidence interval, two-tailed test

5.2.2 Fixed Effects By Industry Dummies

In the industry dummy approach the coefficients of employment and physical capital are stable and significant, but this time capital is more important in magnitude. The effect of internationalization is probably included to some extent in the dummies, because it does not enter significantly, whereas the profitability (ROI) is positively related to turnover, with a confidence interval of over 90%.

The human capital index (H), technical competence capital (T) and higher education capital (HIGH) have positive and significant coefficients. The sign of DOC is positive, when the effects of technical competences are accounted for, and negative when higher education is controlled for. Thus the role of post-graduate education remains blurred. R&D effort is again negatively correlated with turnover. This might also reflect the increasing returns in R&D: Once a critical level of R&D activities is reached, there is no need to continue expanding them, because the results can be replicated in all business units of the company.

Table 8. Fixed Effects II

Dependent variable: Turnover

	1	2	3	4	5	6	7	8
L	0.32*** (6.34)	0.31*** (6.38)	0.30*** (6.66)	0.30*** (6.06)	0.29*** (5.85)	0.29*** (5.72)	0.35*** (5.66)	0.29*** (4.20)
K	0.63*** (4.21)	0.61*** (4.07)	0.61*** (4.43)	0.63*** (4.35)	0.64*** (4.32)	0.64*** (4.29)	0.50** (2.25)	0.47** (2.39)
H		6113*** (6.34)					19019*** (3.75)	
HIGH			15639*** (6.36)					44661*** (3.34)
DOC			-68065** (-2.09)	35840 (1.46)	36524 (1.49)	30559 (1.29)		-99515 (-1.24)
T				7382*** (6.75)	7995*** (7.09)	7933*** (6.95)		
RD							-94016*** (-2.28)	- 137620*** (-2.89)
ROI	16.26 (0.71)	31.59 (1.36)			40.86* (1.87)	36.40 (1.54)		
INT	969 (1.14)	187.7 (0.21)				397 (0.48)		
MACH	-331 (-0.70)	-731 (-1.62)	-1817*** (-3.40)	-1944*** (-3.25)	-1985*** (-3.30)	-2045*** (-3.32)	-1688** (-1.99)	-4743*** (-2.75)
FOR	-1439*** (-2.66)	-1734*** (-3.37)	-1250** (-2.46)	-2621*** (-4.07)	-2569*** (-4.01)	-2557*** (-4.00)	-3125*** (-2.60)	-1842* (-1.87)
ELECT	544 (1.48)	-487 (-1.16)	-2707*** (-3.94)	-2810*** (-3.71)	-3156*** (-4.42)	-2288*** (-3.49)	-1448* (-1.91)	-1769 (-1.24)
CONSTR	316 (0.97)	-14.52 (-0.05)	-460 (-1.18)	-1425*** (-2.64)	-1498*** (-2.79)	-1524*** (-2.84)	62.78 (0.10)	-1011 (-1.48)
CHEM	13682*** (4.23)	13203*** (4.08)	14203*** (4.52)	11729*** (3.60)	11585*** (3.54)	11593*** (3.54)	12826*** (3.24)	14629*** (4.04)
FOOD	260 (0.71)	415* (1.27)	411 (1.41)	432 (1.34)	555* (1.72)	516 (1.53)	339 (0.39)	224 (0.29)
MET	-20.40 (-0.05)	-427 (-1.18)	-485 (-1.43)	-1970*** (-3.99)	-1855*** (-3.75)	-1838*** (-3.76)	-1752* (-1.90)	-410 (-0.46)
CONST.	77.94 (0.17)	-5669*** (-5.17)	-2268*** (-4.50)	-2125*** (-4.76)	-2846*** (-4.91)	-2697*** (-4.27)	-16210*** (-3.72)	-5507*** (-3.57
$\overline{R^2}$	0.74	0.75	0.76	0.76	0.76	0.77	0.70	0.73

***=99%, **=95%, *=90% confidence interval, two-tailed test

In conclusion, the panel data approach does not bring much new aspects into the analysis of the effects of human capital on firm performance. The importance of the role of internationalization is one difference, and the ambiguity of the effects of post-graduate education is another. However, with this approach the increase in the coefficient of determination associated with adding human capital proxies to the regression is clearly smaller. At any rate, the positive effects of general human capital level (H) and technical competences (T) are significant, and the negative impact from R&D intensive strategies is also present.

6. Conclusions

This empirical study has assessed the importance of education in creating technical and other white-collar competences that have economic relevance. Education facilitates the creation of specific business competences.

The skills of white-collar workers are mainly used in the creation of value into products outside the physical production process. This includes research and product development, organization and supervision of production, marketing etc. These functions may in fact be the source of most of the labor costs in the value chain of the product in modern corporations.

The main outcome of the regression analyses performed in this study was that the human capital stock, measured by educational levels of the white-collar workers, contributes significantly to corporate growth. Thus human capital is an essential component in theories of growth either as a factor of production or as a non-rival organizational knowledge input (tacit knowledge).

The lags with the effects of human capital, that seem to be considerable although they cannot be properly investigated with the data set at hand, lend support to the tacit knowledge aspect. The level of knowledge and education has an important impact on growth, not necessarily its rate of increase. This means that human capital should not be treated exactly as other production factors.

Due to the aforementioned lags and other characteristics of human capital, the rate of increase of educational level had a negative impact on the growth of the firm. This contradictory result suggests, that the characteristics and, in particular, the dynamic properties of human capital need to be more thoroughly examined.

In totality, with the production function estimated in cross-sectional regressions, taking the industry specific differences into account by using dummies, we were able to explain almost 90% of the growth differences among firms.

The proposition that the competence rent is created by human capital received some support from the data. The general human capital created in education seemed to increase the profitability of firms. Also the rate of change of human capital received a positive coefficient. Instead, the share of people with technical or natural scientific education had a strong negative relationship with the average rate of return on investment. This might reflect different aims and aspirations of technically oriented employees, compared to employees with business or administrative schooling background.

The strong growth impact from technical/scientific competences may also be caused by the special characteristics of Finnish industry. Engineering orientation is a very strong tradition in Finnish industrial firms, and it dates back to the rapid industrialization of the country during the first half of this century.

The Finnish tradition also emphasized capital investment as a fundamental factor of economic growth. However, during the 1980s investment in physical capital had only modest growth effects according to the regression results, and furthermore, it had a negative impact on profitability. This could mean, that the benefits from physical expansion and Finland's economic convergence to the rest of the Western world are fading, and the factors leading to economic success have to be found elsewhere in the future.

The accumulation of human capital, which was investigated as well, is not explained by economic performance, but by convergence in educational levels across firms, and it appears to happen simultaneously with accumulating technical competences. Technical competence capital explains most of the accumulation of general human capital. Apparently the technical and engineering orientation of Finnish industry is continuously deepening.

The panel data estimations confirm the cross-sectional results for the most part. The role of physical capital in economic growth is strengthened. Multicollinearity among the human capital indicators causes contradictory results in different combinations in the specifications. The effects of R&D still seem negative, which is somewhat puzzling. The role of researchers (share of employees with post-graduate degree) remains ambiguous, since when general human capital level is controlled for, it is negative, but in case technical competences are controlled for, it is positive. A possible interpretation is that in technically oriented businesses, such as machine and electronics industries, the investment in high level researchers has higher returns.

According to the regression results the level of human capital stock was more important than its rate of change in determining the growth rate of firms. This could be due to the positive effect human capital may have on innovativeness and also on the ability to adopt knowledge created by others. Since adding the educational level into the firm growth models clearly improved the empirical results, we may conclude, that education is an important part in the creation of general human capital.

References

Arrow, Kenneth (1962): "The Economic Implications of Learning by Doing", Review of Economic Studies 29, 155-173.

Asplund, Rita (1993): "Essays on Human Capital and Earnings in Finland", ETLA A18, Helsinki 1993.

Asplund, Rita (ed.) (1994): "Human Capital in an Economic Perspective", Physica Verlag and ETLA, Heidelberg/Helsinki.

Ballot, Gérard (1994): "Continuing Education and Schumpeterian Competition: Elements for a Theoretical Framework" in Asplund, Rita (1994), (ed.): "Human Capital in an Economic Perspective", Physica Verlag and ETLA, 160-171.

Barro, Robert (1991): "Economic Growth in a Cross-Section of Countries", The Quarterly Journal of Economics 106, 407-444.

Benhabib, J.; Spiegel, M. (1994): The role of human capital in economic development - Evidence from aggregate cross-country data, Journal of Monetary Economics 34, 143-173.

Eliasson, Gunnar (1990): "The Firm as a Competent Team", Journal of Economic Behaviour and Organization 13, 275-298.

Eliasson, Gunnar (1994): "Education, Competence Development and Economic Growth - A Microeconomic Explanation to Macroeconomic Growth" in Asplund, Rita (ed.): "Human Capital in an Economic Perspective", Physica Verlag and ETLA, 172-195.

Greene, William H. (1993): "Econometric Analysis", 2nd ed., Macmillan Publishing Co., New York.

Hay, D. A.; Morris, D. J. (1979): "Industrial Economics - Theory and Evidence", Oxford University Press.

Leiponen, Aija (1993): "Henkinen pääoma ja talouskasvu - Suomi ja muut OECD-maat empiirisissä vertailuissa", ETLA Discussion Papers No. 451

Lucas, Robert E. (1988): "On the Mechanics of Economic Development", Journal of Monetary Economics 22, 3-42.

Lynch, Lisa (1992), "Private-Sector Training and the Earnings of Young Workers", American Economic Review, Vol. 82, 299-312.

Mankiw, N.G.; Romer, D.; Weil, D.N. (1992): "A Contribution to the Empirics of Economic Growth", The Quarterly Journal of Economics 107, 407-37.

Marris, R. (1963): "A Model of the Managerial Enterprise", The Quarterly Journal of Economics 77, 185-209.

OECD (1986): Science & Technology Indicators 2.

Romer, Paul M. (1990): "Endogenous Technological Change", Journal of Political Economy 98, S71-S103.

Scott, Maurice (1992): "A New Theory of Endogenous Economic Growth", Oxford Review of Economic Policy, Vol. 8, No. 4, 29-42.

Uzawa, Hirofumi (1965): "Optimum Technical Change in an Aggregative Model of Economic Growth", International Economic Review 6, 18-31.

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