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INTELLECTUAL CAPITAL AND PRODUCTIVITY: IDENTIFICATION AND MEASUREMENT OF THE RELATIONSHIP AT COMPANY-LEVEL

Antti Lönnqvist

Pellervon taloudellinen tutkimuslaitos PTT

Pellervo Ekonomiska Forskningsinstitut
Pellervo Economic Research Institute
Eerikinkatu 28 A, 00180 Helsinki
Puh. (09) 348 8844, fax (09) 3488 8500
Sähköposti: econ.res@ptt.fi
www.ptt.fi

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Antti Lönnqvist*

Helsinki, November 2007

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* Prodia Ltd and Tampere University of Technology, email: antti.lonnqvist@prodia.fi

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Tiivistelmä: Yrityksen aineeton pääoman koostuu erilaisista ei-fyysisistä arvonlähteistä, kuten henkilöstön osaamisesta, sidosryhmäsuhteista ja patenteista. Tämä työpaperi tarkastelee aineettoman pääoman suhdetta tuottavuuteen yritystasolla. Artikkeli perustuu käsitteelliseen tarkasteluun, jolla pyritään ymmärtämään mainittua suhdetta, ja kahteen tilastolliseen tutkimukseen, joilla pyritään kuvaamaan sitä empiirisesti. Empiirinen tarkastelu perustuu noin 20.000 suomalaisen yrityksen tilinpäätöstietojen analysointiin vuosina 2001–2003. Tutkimuksissa tarkastellaan aineettoman pääoman mittareiden ja tuottavuusmittareiden välisiä yhteyksiä. Käsitteellisen tarkastelun tuloksena aineettoman pääoman ja tuottavuuden välinen yhteys näyttää monimutkaiselta ja tapauskohtaiselta. Suurin ongelma ilmiön empiirisessä tarkastelussa on aineettoman pääoman mittareiden puuttuminen. Valideja ja vertailukelpoisia mittareita ei ole saatavilla, ja aineettoman pääoman tapauskohtaisesta luonteesta johtuen geneeristen ja samalla relevanttien mittareiden luominen näyttää jatkossakin hyvin haastavalta. Vaikka yrityksen aineettoman pääoman ja tuottavuuden välisen vahvan yhteyden olemassaolo näyttää hyvin todennäköiseltä, sitä on hankala todentaa empiirisesti. Myös tämän artikkelin tarkasteluissa yhteys jäi osin epäselväksi. Eräs havainto onkin, että voi olla järkevämpää tarkastella erikseen aineettoman pääoman osa-tekijöiden ja tuottavuuden suhteita sen sijaan että yritetään osoittaa koko aineettoman pääoman yleispätevää yhteyttä tuottavuuteen.
Avainsanat: *aineeton pääoma, johtaminen, kannattavuus, mittaaminen, tuottavuus*

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Abstract: A company's intellectual capital consists of a set of various non-physical sources of value, such as employee competencies, stakeholder relationships and patents. This paper examines the relationship between intellectual capital and productivity at company-level. It is based on a conceptual study aiming to understand the relationship as well as two statistical studies aiming to describe it empirically. The empirical examination is based on information gathered from the financial statements of Finnish companies between 2001 and 2003. Altogether around 20.000 companies are included in the analysis, in which the results of intellectual capital measures and productivity measures are examined. The conceptual study suggests that the company-level relationship between IC and productivity is a complex and case-specific phenomenon. The biggest problems in studying the relationship are related to IC measurement. Valid and comparable IC measures are missing, and due to the case-specific nature of IC, measures that would be generic and still relevant in different companies may be very difficult to create. Although it seems most probable that there is a strong relationship between IC and productivity it is difficult to ascertain the relationship empirically. Also in this paper, the empirical relationship was not clearly shown. However, instead of discussing about the generic relationship between IC and productivity it might be more useful to focus on various interrelated relationships between different IC-factors and productivity.
Keywords: *intellectual capital, management, measurement, productivity, profitability*

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1 IINTRODUCTION

This paper examines the relationship between intellectual capital and productivity at company-level. The relationship is analysed from a managerial point of view. Productivity improvement is the base of wealth creation in companies (Sink, 1983). It is also the most important factor driving long term profitability of a firm. Another important factor for companies regardless of industry (Kujansivu and Lönnqvist, 2007b) is intellectual capital (IC). Factually, the accumulation and utilisation of IC, such as technological innovations and employees’ competence, has a positive impact on productivity development. However, conceptually the linkage between productivity and IC is quite complex and not well understood.

The roots of productivity concept are in the traditional physical production process. In the case of intellectual (non-physical) capital, especially in knowledge work context, the traditional approach seems problematic. For example, intangible inputs such as information and knowledge are not actually consumed during the production process unlike physical resources such as energy and material. For the present, it is still unclear how the role of IC should be defined in the context of determining productivity. The unclear role of IC in this context is problematic because it affects the measurement and improvement efforts of productivity, especially in knowledge-intensive business where the role of IC (and especially knowledge) is emphasised.

According to the resource-based view of a firm, an organisation’s internal resources such as competencies determine the success of the organisation (Chamberlin, 1962; Penrose, 1995). The knowledge-based view focuses especially on knowledge assets in explaining the success of an organisation (Grant, 1997). It seems intuitively clear that certain factors related to IC should affect organisations’ productivity and profitability. For example, increasing employees’ competencies, improving management systems and developing knowledge management practices should lead to improved productivity. Thus, investing in IC is an important issue for any organisation. Examples of IC investments include research and development efforts, increasing customer loyalty, improving brand recognition and developing the competencies of employees. It is difficult to see that any organisation could be able to remain competitive in the long run without making these kinds of investments.

At the moment, the management research community needs to better understand how different intangible assets affect productivity. Also managers need information on how IC can contribute to concrete business benefits (e.g. productivity). For example, managers must make decisions on IC-related investments: which IC investments provide the biggest financial returns in a given organisational and competitive context?

The goal of this paper is to increase understanding of the relationship between IC and productivity at company-level. The research approach used is as follows. First, a conceptual study is carried out in order to understand how IC and productivity are linked as concepts. Second, two statistical studies are carried out in order to determine the relationship based on empirical measurements. These studies have separately been reported in the articles by Hannula and Lönnqvist (2007), Kujansivu and Lönnqvist (2007a, b) and Väisänen et al., (Forthcoming). The contribution of this summary paper is the assessment of the relationship between IC and productivity based on analysing the findings of these individual studies.

2 CONCEPTUAL LINKAGE

This section analyses the conceptual linkages of IC and productivity. It also brings together the previous findings of two distinct research discourses, i.e. IC and productivity research traditions. IC and productivity are very different topics when it comes to their position in management science. Productivity is a well known concept which has its steady position in economics and business research. However, the paradigm of IC is newer, starting roughly from the mid nineties. As a research field IC is still somewhat unestablished and it can also be regarded as a research theme rather than an independent discipline (Zambon, 2006). The conceptual section is organised as follows: First, the key concepts of this study – productivity and IC – are defined. Second, the current knowledge on the relationship between IC and productivity is summarised based on earlier literature.

2.1 Defining key concepts

Productivity is a key factor affecting the profitability of a firm. At the firm level, the improvement in productivity of each individual firm is necessary for it to gain its competitiveness and to maintain its profitability. Productivity is defined as output divided by the input used to produce the output. One should note that the output of productivity function refers to the quality and quantity of the products produced. Further, product refers in this paper to the combination of *physical product, service, information and intangible factors*, which together form the offering which is seen by customers (Hannula and Lönnqvist, 2007).

In this paper, the term intellectual capital is used to describe a company's non-physical sources of value, i.e. those assets that are not tangible. Nowadays, the term intellectual capital has become quite established due to academic conferences and journals, which have chosen the term (e.g., Journal of Intellectual Capital, International Journal of Learning and Intellectual Capital). However, terms intangibles, intangible assets and knowledge assets are often used to describe the same issue, although sometimes these terms are clearly defined as subsets of each other. The concept of social capital is sometimes used to describe issues that can be considered as important resources for companies. The terminological debate has been quite extensive in IC literature. One challenge is that IC is more a research topic than an individual research discipline. Therefore, researchers from different disciplines (e.g. accounting, economics and management research) have preferred different terms and definitions due to their differing needs.

Intellectual capital (IC) can be defined in many ways. In any given company there are a large number of different factors that can be regarded as a part of IC. A typical way to define IC is to split it into three main groups (cf. Lönnqvist et al., 2005; Seetharaman et al., 2004; Sveiby, 1997). There are also other ways for dividing IC into components (see e.g. Brooking, 1996; Edvinsson and Malone, 1997; Hussi and Ahonen, 2002; Lev, 2001; Marr and Schiuma, 2001; Mayo, 2001; Roos et al., 1997; Ståhle and Grönroos, 2000). According to Seetharaman et al. (2004), examples of IC components in each subcategory include the following:

- Human capital
    - Employee competence and knowledge
    - Innovativeness
- Relational capital
    - Brand
    - Customers (customer relationships)
- Structural capital
    - Company culture
    - Patents
    - Internal database

There has been discussion on the nature of IC in terms of being either a static resource (e.g. a stock of resources) or something more dynamic in nature (Meritum, 2001). Some assets may be considered important in the present situation (e.g. competence and business processes) while other may be more future-oriented (e.g. the renewalability of a company) (Pöyhönen, 2004). It is also possible to distinguish between resources (e.g. corporate image and patents) and activities related to those assets (e.g. customer relationship management and R&D) (Lönnqvist, 2004; Meritum, 2001).

IC differs from physical assets in several ways (see e.g. Abernethy et al., 2003). IC is immaterial while machines, facilities and financial capital are concrete. IC is not always owned by the company, e.g. in the case of employees' competencies. Similarly, buying certain intangible resources may be almost impossible (e.g. company culture) while physical assets are usually available. However, there are of course exceptions as patents and information, for example, which can be purchased.

Because of the nature of IC it is quite difficult to manage. Just like in the case of productivity measurement, there are many frameworks available for measuring and managing IC, e.g. the Calculated Intangible Value (CIV) (Stewart, 2001), the Intangible Assets Monitor by Sveiby (1997), the Meritum Guidelines (Meritum, 2001), the Danish Guidelines (Mouritsen et al., 2003), the Knowledge Asset Value Spiral by Carlucci and Schiuma (2006), the Value Chain Scoreboard by Lev (2001) and the Weightless Wealth

Tool Kit by Andriessen (2004). One rationale for applying these management frameworks is likely to be improving the productivity of a company.

2.2 Linking IC and productivity

The relationship between IC and productivity is intuitively quite clear. Improving IC (e.g. competence of personnel) is likely to have a positive effect on productivity. In the real world, the relationship between IC and productivity may be bidirectional. Companies with a high level of productivity compared to competitors in the same industry are likely to have good profitability and, thus, resources for investing in IC development.

Based on analysing existing literature, six different ways for approaching the relationships between IC and productivity can be identified. They are presented in Figure 1 and explained below.

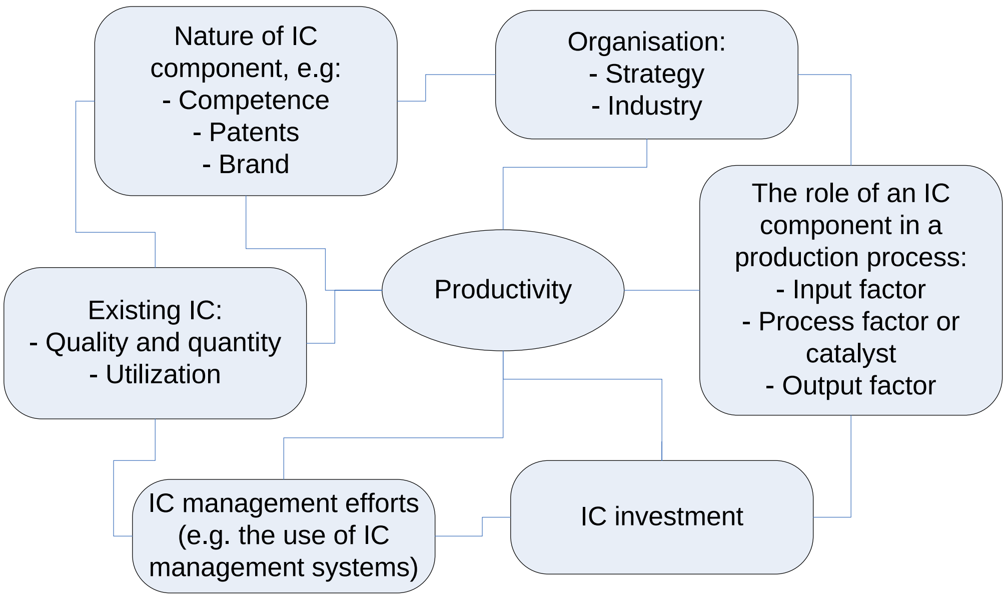

Figure 1 Six ways of approaching the relationships between IC and productivity.

First, different IC components (e.g. competence, patents and image) seem to have different effects on productivity. It is not reasonable to discuss about the relationship between IC and productivity so that IC is handled as a bundle of different assets – each IC component has its own kind of relationship with productivity. Actually, the situation is no different to physical assets: financial capital, machines, labour and energy have different relationships with productivity.

Second, these relationships are likely to be situation specific since IC is related to the industry and the strategy of a company in question. For example, not all companies possess patents or product brands (subcontractors). It is clear that these IC components have little or no significance for those companies. This issue is quite obvious since different things are important for each company also more generally speaking, not just in the case of IC. However, this is an important point to notice especially if the IC components and IC as a whole are considered the key drivers (which are company-specific) of productivity. This issue should be kept in mind when studying the relationship between certain IC components and productivity and also, e.g., in searching for best practices in IC development (i.e. a good IC development practice in one company may not work in another).

Third, it seems that both the quantity and quality (i.e. how much and what) of IC are important from productivity point of view. More IC is likely to be better than less. For example, competent employees do better work than those who are incompetent. In addition, the utilisation of the asset is also important; e.g., information systems and databases are useless if employees do not use them.

Fourth, it is important to make a distinction between IC investments[1] (e.g. R&D projects, competence development or buying of information) and IC, which can be the result of such investments.

A) There are time lags between making an IC investment (e.g. R&D project), the improvement in IC (e.g. a new patent) and, finally, the productivity improvement.
B) It is likely that the productivity impact of investments in different assets (e.g. brand, competence, image, immaterial property rights or stakeholder relationships) will differ: the development of certain assets will likely result in bigger productivity impacts than some other assets, and the benefits may come sooner or later. For example, an R&D project may take a long time to carry out and the benefits may only be felt after several years if ever.
C) IC investments take resources and it is not self-evident that their impact on productivity will be positive. When a company's employees participate in training in order to improve their competencies or in a customer event in order to improve customer relationships, their labour input cannot be utilised in creating the output that they would otherwise create. Thus, productivity may, at least for a short period, be decreased due to an IC investment.
D) In the case of IC investments a spillover effect often takes place (Abernethy et al., 2003). For example, new innovations benefit also other companies than just the one that has developed it. Similarly, competence development efforts may

[1] The term 'investment' is used loosely here. It covers also issues that are not considered investments in the strict accounting sense.

benefit a competitor company in case an employee changes jobs. In this case the productivity impact is also shared.

Fifth, systematic IC management efforts may lead to improved productivity, although there is still not much empirical experience. There are many models for managing IC (e.g. the Meritum model and the Danish model). These models provide means for linking IC components to business objectives. This work can be supported by designing strategy maps which visualise these relationships (Kaplan and Norton, 2004). However, they do not specifically explain how IC can be linked to productivity. Nevertheless, although companies do not yet seem to be very actively applying these frameworks in practice, current evidence shows that when they are applied it often leads to improved productivity (Lönnqvist et al., 2006). On the other hand, any effort on improving productivity is likely to have an effect on some aspect of IC.

Sixth, IC components may be considered in different roles in the production process (1. input factors, 2. process factors or catalysts, 3. output factors; or all of these at the same time). Thus, in order to understand how IC affects productivity its role in the production process should be understood in a more detailed way than just as a capital or an asset. These three roles are described below.

In addition to physical input factors such as materials and energy, important inputs of a production process can consist of competencies, information, patents etc. The result of a production process is usually a product, service or information. However, also intangible outputs are produced. The product itself may include intangible aspects, such as the manufacturer’s brand. On the other hand, the output can also be intangible as such. Information and knowledge are good examples. In addition, as a result of the primary output the production process creates also other by-products such as increased employee competence, company image, customer relationships etc.

IC can also be considered a catalyst that improves the production process, the utilisation of input factors as well as sometimes enhances the customer value. For example, company culture and work atmosphere are likely to have an effect on knowledge sharing and cooperation, which may lead to improved (or decreased) productivity. Similarly, a respected product brand may make it possible to sell products with a higher price than a competitor with a less-known but technically similar product. In addition, a well-known brand may also decrease the need for selling efforts. When this is the case, the brand substitutes the need for labour input.

According to the traditional productivity thinking, it is possible to improve productivity by using less input. However, in the case of information there is no need to try to minimise input usage. Information is not usually consumed in the production process unlike raw material or machines. In addition, information can also be shared in the organisation's information systems with low cost and thus it can be used for many purposes simultaneously. Similar characteristic can be identified in brands and patents when they are considered as inputs. The situation is different when knowledge is considered: knowledge is tied to humans which can stand overload for limited time only. Thus, the nature of knowledge as an IC component differs significantly from information. This is paradoxical since the dividing line between these two is not always so clear. Obviously the human presence in knowledge (or knowing) is the key factor in this phenomenon.

In summary, the theoretical linkage between IC and productivity is challenging and far from simple. It has not been studied a lot and it is not yet well understood. There is an implicit understanding of the relationship between IC and productivity (IC improves productivity). However, there seems to be many different kinds of relationships between various IC components and productivity. The effects between these are also time-dependent. Thus, a more detailed way of analysing these associations would be needed.

3 EMPIRICAL RELATIONSHIP

3.1 Approach and data

The data examined here was gathered by the Central Statistical Office of Finland. It comprises of information from the financial statements of Finnish companies between 2001 and 2003. Companies employing fewer than five employees or operating for less than six months a year were excluded from the data set. The sample sizes per year were as follows: 20,677 for 2001, 19,013 for 2002 and 20,614 for 2003.

The data was divided into the eleven largest industries in Finland, namely food, forest, chemical, metal refining, electronics, vehicle manufacturing, construction, business services, electricity, gas and water supply, wholesale and retail, and transportation, storage and telecommunications. The data was also divided into large companies and SMEs. According to the EU definition guideline (European Commission, 2005), to qualify as an SME, a company must have no more than 249 employees. There are other factors included in the EU definition as well, including annual turnover and annual balance sheet, but in this study takes only the staff headcount into account. This classification is important, as 99.7 per cent of all Finnish companies in 2003 were SMEs. An equally important observation is that 92.9 per cent of all Finnish companies were reported to have fewer than nine employees (Statistics Finland, 2003). Since companies employing fewer than five employees were excluded from this study the results do not apply to Finnish micro-enterprises.

3.2 Performance measures

3.2.1 Overview of the measures used

The measures used in this study are summarised in Table 1. They are discussed more thoroughly in the following sub-sections. The main reasons for choosing the measures that have been chosen were that they measure the factors discussed in this paper and that they could be applied using the data provided by the Central Statistical Office of Finland (most existing IC measures are not comparable between companies and the data is not available). It is acknowledged that the IC measures chosen are not the most valid IC measures available. They are based on financial information and their validity has been criticised since financial statements capture only a part of IC. Andriessen (2004), for example, has criticised the validity of the VAIC^{TM} method. He states that the basic assumptions of the method are problematic and thus it produces dissatisfying results.

However, the choice of measures has also positive implications such as comparability of results.

Table 1 *Performance measures used.*

Factors	Performance measures
Investments in IC	- Relative R&D expenses - Relative development expenses
Value of IC	- Calculated Intangible Value (CIV)
Efficiency of IC	- Value Added Intellectual Coefficient (VAIC^{TM}) - Intellectual Capital Efficiency (ICE)
Productivity	- Value added / number of employees
Profitability	- Return on investments (ROI)

3.2.2 Investments in IC

Investments in IC are evaluated using two different measures: relative research and development (R&D) expenses and relative development expenses. R&D expenses are commonly used in evaluating the investments in IC (see e.g. Abernethy et al., 2003). Relative R&D expenses are calculated by dividing the R&D expenses with the net revenues. In this study, using relative figures was considered to provide better grounds for comparing different sized companies.

Since R&D expenses do not represent all investments in IC, also another measure is used. Investments in IC are also measured by the relative development expenses. In this study, the development expenses are calculated by summing up four components: R&D expenses, investments in advertising and marketing, investments in IT and programming and immaterial property expenses. Correspondingly to the first measure, the absolute value is divided by the net revenues. Neither of these measures captures all IC investments because not all of them are reported in the financial statement. However, they provide and indication of the level of IC investments using the data that is available.

3.2.3 Value of IC

The value of IC is measured using Calculated Intangible Value (CIV). The method is based on the assumption that a company’s premium earnings, i.e. the earnings greater than an average company’s ones within industry, result from the company’s IC. The data for method is found from the financial statement of a company except the data for the average return on tangible assets in an industry. The execution of CIV can be divided into six steps as follows (Stewart, 1997):

1. Calculate the company's average pre-tax earnings *(a)* for the latest three years.
2. Calculate average year-end tangible assets of the company *(b)* for the latest three years (i.e. all of the 'Assets' from the financial statement except 'Intangible Assets').
3. Divide the earnings by the tangible assets and you get the company's return on tangible assets (ROA) *(c)*:
$$c = a / b \quad (1)$$
4. Calculate the average ROA *(d)* for industry (alike the ROA for the company) for the latest three years. *If and only if the return on tangible assets of the company is greater than the return on tangible assets of the industry (i.e. c>d) executing the method can be continued.*
5. Calculate the "excess return" by multiplying the industry ROA by the average year-end tangible assets of the company. Subtract the result from the pre-tax earnings of the company. Multiply this by the following clause: 1 less the three-year-average income tax rate of the company:
$$excess\_return = (a - d * b) * (1 - average\_income\_taxes) \quad (2)$$
6. Finally, divide the after-tax number by an appropriate percentage, e.g. the company's cost of capital.

The result of executing the six phases above is CIV. It measures a company's ability to use its IC to succeed better than the other companies within the industry. CIV can be used in company-to-company or business unit-to-business unit comparisons. (Stewart, 1997) The fact that majority of the data needed for executing the method is found from the financial statement of a company is a double-edged sword: On the one hand, the data is relatively easy to access and the results of different organisations are comparable with each other at least within the same industry. On the other hand, the data from the financial statement is not necessarily the best source of information regarding the valuation of IC due to the fact that only a minor part of IC is included in the financial statement. Also, the data for calculating the average return on tangible assets within industry might be difficult to find. However, CIV is a quantitative method, which gives some kind of estimate of the monetary value of IC. (Lönnqvist et al., 2006)

In this study, the calculation of the value of IC (CIV) was based on 15,252 Finnish companies. The sample included the companies which had operated the whole period, 2001–2003. The application of the measure was based on the six steps presented above. For the sake of simplicity, the same percentage (10 %) was used in all industries in sixth step.

3.2.4 *Efficiency of IC*

The Value Added Intellectual Coefficient (VAIC^{TM}), developed by Ante Pulic, measures and monitors the total value creation efficiency in the company. The subordinate concept of VAIC^{TM}, Intellectual Capital Efficiency (ICE), describes the efficiency of IC within a company. Actually, VAIC^{TM} indicates the total efficiency of value creation from all resources employed and ICE reflects the efficiency of value created by the IC employed. The better a company's resources have been utilised the higher the company's value creation efficiency will be. (See e.g. Pulic, 2000; Van der Zahn et al., 2004)

The execution of the method is quite simple. The data needed for the calculation can be found in the financial statement. The method is based on two resources: capital employed (CE) and intellectual capital (IC). Both resources play a significant role in the value adding of a company and are considered as investments. Capital employed consists of equity, the accumulation of profit-adjusting entries and liabilities with interest. IC consists of human and structural capital (defined this way in the context of VAIC^{TM}). The phases of executing the method are described below (based on International Business Efficiency Consulting L.L.C, 2002; 2003; Pulic, 2002; 2004).

First, the value added (VA) of a company is calculated as outputs less inputs, e.g.,:

$$VA = P + C + D + A \tag{3}$$

P describes operating profits, C employee costs (the salaries and the social expenses of staff) and $D + A$ depreciation and amortisation of assets. Then, the human capital (HC) of the company is calculated as the sum of the total salaries for the company, and the structural capital (SC) of the company is calculated by subtracting the human capital from the value added:

$$SC = VA - HC \tag{4}$$

Capital employed efficiency (CEE) describes how much of the company’s value added is generated with the tangible capital employed. It is calculated by dividing the value added by capital employed (CE):

$$CEE = VA/CE \tag{5}$$

Human capital efficiency (HCE) is calculated by dividing the value added by the human capital:

$$HCE = VA/HC\,. \tag{6}$$

HCE is an indicator of the efficiency of value added by human capital resources employed. The third efficiency component, the structural capital efficiency (SCE), shows how much of the company's added value is generated with the structural capital and is calculated by dividing the structural capital by the value added:

$$SCE = SC/VA \,. \tag{7}$$

Intellectual capital efficiency (ICE) is calculated by summing together the human capital efficiency and the structural capital efficiency:

$$ICE = HCE + SCE \,. \tag{8}$$

Finally, the Value Added Intellectual Coefficient (VAIC™) is a composite sum of the intellectual capital efficiency and the capital employed efficiency:

$$VAIC^{TM} = ICE + CEE \,. \tag{9}$$

The basic proposition is that the higher the VAIC™ and ICE are the better management has utilised the existing potential in the resources employed in creating value (Van der Zahn et al., 2004). VAIC™ considers different efficiency factors related to IC, and in doing so, evaluates how effectively organisation's IC adds value to the organisation. Like CIV, the VAIC™ figure is comparable among companies.

3.2.5 Productivity and profitability

There are numerous different productivity measurement methods presented in the literature (Hannula, 1999; Hawaleshka and Mohamed, 1987; Mammone, 1980; Sink, 1983; Sumanth and Einspruch, 1980). In this study, the productivity of a company is measured by value added per number of employees (see e.g. Uusi-Rauva, 1986). It is not a valid measure of total productivity, i.e. total output per total input, because output is measured by value added (which is not the same as total output) and input is measured by the number of employees (and there are many other inputs also). However, the measure is comparable between different companies and is thus well suited to this study. Profitability of a company is measured by return on investments (i.e. ROI). It is a typical and widely used profitability measure (see e.g. Uusi-Rauva, 1986).

3.3 Study 1

3.3.1 Objectives

The objective of this study is to determine how investments in IC are transformed through various stages into profits. First, a theoretical framework containing different aspects of IC (i.e. investments in IC, value of IC and efficiency of IC) and productivity and profitability, as well as their relationships is constructed based on a literature review. Second, relationships between the measures of different components are examined using correlation analysis. When interpreting the results of previous research using the concepts defined above, three different routes from IC investments to profitability can be identified:

I: Investments in IC → Profitability
Investments in IC are directly linked to profitability. This route is supported by the findings of Abernethy et al. (2003), Bassi et al. (2002), Chen et al. (2005), Delaney and Huselid (1996) and Huang and Liu (2005).

II: Investments in IC → Value of IC → Productivity → Profitability
Investments in IC are connected to profitability via the value of IC and productivity. This route is supported by the findings of Bassi et al. (2002), Bontis et al. (2000), Chang and Chen (2002), Delaney and Huselid (1996), Riahi-Belkaoui (2003) and Van der Wiele et al. (2002).

III: Investments in IC → Efficiency of IC → Productivity → Profitability
Investments in IC are connected to profitability via the efficiency of IC and productivity. This route is supported by the findings of Chang and Chen (2002) and Delaney and Huselid (1996).

The relationships between IC investments and profitability are likely more complex than those presented above. However, this simplistic presentation makes it possible to study the relationships described above using empirical data.

In this first study, the goal was to study how investments in IC are transformed into profits. This understanding could enable the calculation of return on IC investments. Due to the focus on profitability effects, the direct relationship between IC investments and productivity was not studied. However, this examination is carried out in the second empirical study presented later in this paper.

3.3.2 Statistical methods

Pearson’s correlation coefficient *(r)* is used to determinate the association between different measures. Pearson's correlation coefficient summarises the linear relationship between two studied variables having ranked categories (e.g. ratio scaled). Since all measures examined are ratio scaled correlation analysis was a suitable method.

Certain choices are made in order to be able to examine the empirical relationships between different measures. Since CIV method provides only one value for the average company during the period 2001–2003, also a single figure (average value) for each of the other measures (i.e. investments in IC, ICE, VAIC™, productivity and profitability) is calculated to facilitate the comparison. Only those companies, for which data is available for three years, are included in the calculations when examining the relationship between different measures.

The relationship between different measures is analysed from three perspectives. First, the association is analysed in all companies in the sample. Second, SMEs and large companies are compared. Third, relationship is analysed separately in each industry. The significance level (p-value) used in this study is 0.05. Therefore, the correlation is considered statistically significant in case the p-value is less than five percent. In this study, for absolute values of correlation coefficient,0–0.19 is regarded as very weak, 0.20–0.39 as weak, 0.40–0.59 as moderate, 0.60–0.79 as strong and 0.80–1 as very strong correlation.

3.3.3 Results

The correlation coefficients (and p-values) of the relevant relationships in the whole data between 2001 and 2003 are presented in Table 2. Relationships that are not included in this study are 'not studied' in Table 2. In addition, correlation coefficients and p-values for different industries and different sized companies are not presented. However, some observations are pointed out. The three different routes from IC investments to profitability that were examined are discussed below.

Table 2 *Correlation coefficients and p-values related to relationships between different measures.*

	Relative R&D expenses	Relative development expenses	CIV	ICE	VAIC™	Value added / number of employees	ROI
Relative R&D expenses	–	Not studied	0.16326** (<0.0001)	-0.01198 (0.0657)	-0.00735 (0.2593)	Not studied	-0.00403 (0.5362)
Relative development expenses	–	–	0.02938** (0.0003)	-0.02598** (<0.0001)	-0.01246 (0.0559)	Not studied	-0.00984 (0.1306)
CIV	–	–	–	Not studied	Not studied	0.11917** (<0.0001)	Not studied
ICE	–	–	–	–	Not studied	0.84839** (<0.0001)	Not studied
VAIC™	–	–	–	–	–	0.14756** (<0.0001)	Not studied
Value added / number of employees	–	–	–	–	–	–	0.00814 (0.2106)
ROI	–	–	–	–	–	–	–

** The result is statistically significant at the level 0.01; * The result is statistically significant at the level 0.05.

I: Investments in IC → Profitability

The results show no linear relationship between the investments in IC and profitability, since neither of the investment measures correlate with profitability (p=0.5362, p=0.1306) in the whole sample. The result is the same in SMEs and in large companies. In addition, in most industries there is no linear relationship between these measures. Only in the metal refining and vehicle manufacturing industries the correlation between relative R&D expenses and ROI is negative and very weak. Correspondingly, in two industries (metal refining and electronics industry) there is a very weak negative correlation between relative development expenses and ROI.

There may be several reasons for not showing any positive relationship between investments in IC and profitability. There may be problems with the measures used or with the research method (e.g. the possible time lags were not taken into account). In addition, it is possible that investments in IC do not have a relationship with profitability because many of the investments in IC fail. It is also possible that the relationship between the investments in IC and profitability is non-linear (Huang and Liu, 2005).

II: Investments in IC → Value of IC → Productivity → Profitability

According to the results, there is a very weak positive correlation between both investment measures, i.e. relative R&D expenses and relative development expenses, and CIV (r=0.16326, p<0.0001; r=0.02938, p=0.0003). Further analysis shows that there exists a weak or moderate positive correlation between CIV and relative R&D expenses regardless of the size of the company. However, the relationship between CIV and relative development expenses varies according to the size: In SMEs the correlation is positive but very weak. Instead, in large companies there exists no correlation. The relationship between the measures of IC investments and CIV varies in different industries. Both investment measures have a positive (weak or very weak) correlation with CIV in four industries (metal refining, construction industry, wholesale and retail industry and transportation, storage and telecommunications industry). In seven remaining industries the analysis shows no linear relationship.

In the whole data CIV is positively correlated with the productivity measure (i.e. value added per number of employees) (r=0.11917, p<0.0001). Accordingly, positive correlation can be seen in both SMEs and in large companies. However, in large companies the correlation is moderate and in SMEs it is weak. Also in all eleven industries the correlation is clearly positive.

There is a well-known theoretical relationship between productivity and profitability (see e.g. Hannula, 1999). However, the results show no linear relationship between value added per number of employees and ROI ($p=0.2106$) in the whole data set. In addition, either in SMEs or large companies, there was no correlation observed between the productivity and profitability measures. On the other hand, in seven out of eleven industries a positive correlation between productivity and profitability measures exists.

The results suggest that this route works quite well as expected:

- Investments in IC seem to improve the value of IC.
- The increased value of IC seems to lead to higher productivity.
- Productivity increase has a positive effect on profitability (in most industries; also previous theoretical knowledge supports this).

However, in many cases the observed associations were weak. In addition, the analysis carried out does not verify the direction of the relationships.

III: Investments in IC → Efficiency of IC → Productivity → Profitability

The relationship between investments in IC and efficiency of IC is vague. In the whole sample investments in IC do not correlate clearly with the efficiency of IC. There exists no correlation between relative R&D expenses and ICE ($p=0.0657$). In addition, the correlation between relative development expenses and ICE is very weak and negative ($r=-0.02598$, $p<0.0001$). Either of the investment measures do not correlate with VAIC^{TM} ($p=0.2593$ and $p=0.0559$). Analysis in different industries and different sized companies was also quite confusing. Depending on which investment measure and which efficiency measure is examined, no correlation, very weak or weak negative correlation or very weak positive correlation exists.

In general, the efficiency of IC (measured with both measures) is associated with high productivity. ICE has a very strong and positive correlation ($r=0.84839$, $p<0.0001$) with the productivity measure (i.e. value added per number of employees), whereas the correlation between VAIC^{TM} and the productivity measure is positive but very weak ($r=0.14756$, $p<0.0001$). When measuring the efficiency of IC by ICE, in both SMEs and in large companies as well as in most industries (nine out of eleven) the correlation with the productivity measure is significantly positive and very strong. However, the association between VAIC^{TM} and productivity measure varies slightly based on company's size. In SMEs the correlation is very weak and positive, whereas in large companies there exists no linear relationship. More significant variation can be seen in different industries. In five industries the correlation is positive (i.e. electronics and electricity, gas and water supply, chemical, food and wholesale and retail); in two industries (i.e. construction and business services) the correlation is negative and, finally, in four industries (forest, metal refining, vehicle manufacturing and transportation, storage and telecommunications) the measures do not correlate.

These results seem reasonable when the composition of the measures used, i.e. ICE and VAIC^{TM}, are examined in detail. ICE is composed of two components, HCE and SCE. HCE is defined as value added per total salaries, which is similar to the productivity measure used (i.e. value added per number employees). In addition, the SCE component of ICE can only have the value of less than one while the contribution of HCE component is usually higher (e.g. average HCE values varied between two to five in different industries in this study). Therefore, ICE is in fact a kind of a productivity measure, and for this reason the very strong correlation between ICE and the productivity measure discovered seems understandable. VAIC^{TM} is calculated as a sum of efficiency of capital employed (CEE) and ICE. This makes it a combination of a productivity measure and a financial performance measure. In fact, there was a strong correlation between VAIC^{TM} and ROI ($r=0.41310$, $p<0.0001$). For these reasons, the measures of the efficiency of IC used in this study (i.e. ICE and VAIC^{TM}) could be categorised more as (financial) performance measures of a company rather than IC measures.

In conclusion, the results of this study failed to provide a clear answer to the research question: how investments in IC are transformed through various stages into profits? This is not surprising since the issue is complex. However, the results support partially the assumed relationships.

Based on the experience of applying the new IC measures, CIV and VAIC (which have not been used a lot in previous research), there seems to some problems with the validity of the measures, especially in the case of VAIC. Thus, in the following study it was decided not to use them but to focus on the IC investment measures. Also the time lag between investment and the productivity and profitability impact was decided to be taken into account in the next study.

3.4 Study 2

3.4.1 Objectives

The objective of Study 2 is to answer to the following research questions:

I How and at what rate do R&D investments affect a company’s productivity?
II How and at what rate do overall IC investments affect a company’s productivity?
III How and at what rate do R&D investments affect a company’s profitability?
IV How and at what rate do overall IC investments affect a company’s profitability?

Research questions I–IV are studied in the whole sample. In addition, settings where companies are classified by industry and size are briefly discussed. It is acknowledged that the relationships are complex. For example, good profitability may result from investing in IC and, respectively, good profitability affords good opportunities for investments in IC. However, in this study, these relationships are examined in one direction only.

3.4.2 Statistical methods

First, the data is examined by correlation analysis. Both Pearson's and Spearman's correlation coefficients are computed between IC investments (R&D expenditures and overall IC expenditures) and their outcomes (productivity and profitability). Spearman's correlation is included in case the data are not normally distributed or if the outliers caused bias. Correlation analysis gives us the first insight into which variables might be worth investigating. The correlations are calculated using time-lagged observations. That is to say, correlation of IC investments at the time t will be computed with the IC investment results (i.e. productivity and profitability) at time t, t+1 and t+2.

To ascertain more precisely how different IC investments influence the productivity and profitability of the company, regression analysis is also applied to the data. The aim of the regression analysis is to provide as simple a model as possible to show how and when IC investments benefit the company. Hence, a simple regression model is constructed as follows:

$$y_{j,t} = \beta_0 + \beta_1 x_{k,t-i} + \varepsilon_t, \quad j = 1,2,\ k = 1,2,\ i = 0,1,2 \qquad (10)$$

where $y_{1,t}$=company's productivity at time t, $y_{2,t}$=company's profitability at time t, $x_{1,t}$=R&D investments at time t and $x_{2,t}$=overall IC investments at time t. The β_0 coefficient in the regression equation is the intercept, the β_1 coefficient measures the direct benefits from the IC investments, while ε_t is the error term.

In order to counter any possible bias from any outliers or other influential observations, the *dffits* statistic is used, measuring the influence of i^{th} case on the fitted value from the model (Neter et al., 1996). The absolute value for the cut-off point for influential observations is set at 2. If the absolute value of the *dffits* statistic turns out to be any larger, a weight of 0.1 is used to counter the bias from these influential observations.

3.4.3 Results

The results of the correlation analysis for lagged observations for the whole sample are presented in Table 3. When a 5 % risk level is assumed, it is seen that the Spearman's correlation coefficient provides the most satisfactory results, so only these are presented here. This is most likely due to non-normal distribution of the data.

Table 3 *Lagged Spearman correlations (0.05 risk level).*

	R&D investments 2001	Overall IC investments 2001
Productivity 2001	0.175	-0.182
Productivity 2002	0.181	-0.130
Productivity 2003	0.194	-0.111
Profitability 2001	-0.084	-0.163
Profitability 2002	-0.101	-0.117
Profitability 2003	-0.094	-0.086

The only significant positive correlations are between R&D investments and productivity. Nevertheless, the numerical values of the correlations seem to increase as the time lag increases with the exception of profitability and R&D costs. This implies that with time, it becomes more and more unlikely that IC investments yield negative results in companies, even though the correlation observed here is quite weak. This provides evidence that it will take some time before the results of the investments actually show. The two-year lag used in this study, however, is not enough to verify this.

The correlation analyses reveal the existence of a possible linear dependency between investments in IC and a company's productivity and profitability. In order to study the relationships more, a simple regression model with correction weights (10) was constructed. Table 4 presents the estimates of the regression coefficients for the R&D investments and the overall investments when they are used to explain companies' productivity and profitability. The investments were measured in 2001 and their outcomes in 2001, 2002 and 2003 according to the table. The research questions are discussed based on regression analysis in the following paragraphs.

Table 4 *Regression coefficients on productivity and profitability (0.05 risk level).*

Productivity			
		β_1	
	2001–2001	2001–2002	2001–2003
R&D investments	-0.24	-0.21	-0.11
Overall IC investments	-0.06	-0.04	-0.02
Profitability			
		β_1	
	2001–2001	2001–2002	2001–2003
R&D investments	[1]	[1]	[1]
Overall IC investments	[1]	[1]	[1]

[1] Not statistically significant

The first research question addressed the issue of R&D expenditures and their effects on a company's productivity. The regression analysis shows that the direct impact of R&D investments on productivity is negative. This is consistent with Sougainnis' (1994) results, where investments in R&D actually had a negative direct effect on a company's market price, which in turn is affected by productivity (McGee and Peters, 2005), among other things. However, the negative effect diminishes over time and reduces by half within two years (from -0.24 to -0.11). This implies that in general some time must elapse before the positive changes in productivity made possible by R&D investments can be seen.

The wholesale and retail, electricity, gas and water supply, construction and forest industries yielded the biggest regression coefficients in an industry-specific setting in general. In most of the industries, the impact of R&D investments grew stronger in two years, providing further evidence that it takes time to fully utilise them. Additionally, the results from SMEs alone correlate better with the industry-specific results than results from large enterprises only.

The second research question addresses the overall IC investments, and their impact on productivity. The regression coefficients from the whole sample are negative, and that negative impact also seems to diminish. The regression model stays the same for R&D investments, the only difference being that advertising, IT and programming and immaterial property expenses are added to the equation. This addition clearly diminishes the negative impact caused by pure R&D investments. The result indicates that R&D investments are expected to increase productivity much later than other types of IC investments.

The same effect can be seen in an industry-specific setting. The overall IC investment model did not provide as many significant coefficients as the R&D investment model, but for those industries where the coefficients are significant for both models, the addition of other types of IC investments seemed to improve the effect on productivity. Since the number of statistically significant results throughout the time span of this study was so few (only metal refining and business services provided consistent results), it was not possible to determine whether overall IC investments need the same amount of time as R&D investments to be fully utilised. The correlation between overall IC investments and productivity is again clearly shown in SMEs, unlike in large companies.

The third and fourth research questions examined IC investments and profitability. A linear relationship was found between both types of IC investments and profitability. However, in a setting where IC investments are used to predict a company's profitability (using regression analysis), no statistically significant results are found regardless of the industry or the company's size. This is also true of both R&D investments and overall IC investments. There is no obvious explanation why profitability does not seem to be affected by IC investments.

The results of this study provide evidence that investments in IC do yield benefits, but these benefits may come with a delay. These benefits, however, are dependent on the types of investments made.

4 CONCLUSIONS

This paper is based on a conceptual study and two empirical studies. The conceptual study identified six different ways for examining the relationship between IC and productivity. Depending on the point of view chosen, different studies can be carried out and different views of the relationship obtained. The first empirical study examined different routes from IC investments to profitability impacts. The results suggested that investments in IC seem to improve the value of IC, which seems to lead to higher productivity, which then seems have a positive effect on profitability. However, only weak statistical relationship could be observed. The second empirical study examined the time-lagged relationships between IC investments and productivity and profitability. It was discovered that the relationships between IC investments and productivity are negative on the short run but they seem to be turning positive later on. However, the data set available was not fully able to confirm this assumption.

The validity of the empirical studies can be criticized. It is debatable whether the methods that were chosen are sound for measuring IC. However, at this point in time, there are no perfect solutions available for measuring IC. On the other hand, the reliability of the study can be considered fairly good. The measurement results are based on a large sample, since they cover all companies from the eleven largest industries in Finland (excluding micro companies).

The company-level relationship between IC and productivity is complex and it seems to be case-specific. The biggest problems in studying the relationship are related to IC measurement. Valid and comparable IC measures are missing, and due to the case-specific nature of IC, measures that would be generic and still relevant in different companies may be difficult if not impossible to create. As a result, the findings presented in this paper are difficult to compare against earlier studies. Some studies have shown positive associations between IC and productivity while in other studies the relationship seems negative. (For a summary of previous studies see, e.g., Abernethy et al., 2003; or Kujansivu and Lönnqvist, 2007.) Findings obtained in different studies seem to depend on the choices made regarding how IC is defined, which measures are used, which the statistical methods are applied, how time-lags are taken into account as well as other case-specific and contextual issues.

In conclusion, based on the theoretical literature and the empirical studies carried out so far it seems most probable that there is a strong relationship between IC and productivity at company-level. It is clear that it is impossible to create a productive business operation without IC (e.g. information, competence, customers and processes). However, due to the nature of the relationship and the problems associated with measuring IC it is difficult to ascertain the relationship in practice. Furthermore, it is actually not reasonable to discuss about *the relationship* between IC and productivity, but perhaps it is a question of *a set of interrelated relationships between IC-factors and productivity*.

Another way to learn about the relationships between the components of IC and productivity would be to examine the development of IC within individual organisations. Qualitative research methods (e.g. using action research or case studies) seem well-suited for examining these complex relationships in-depth and holistically. Longitudinal case studies especially might provide new insights about the effects of different types of IC initiatives. It is also important to understand how IC development projects can be carried out in practice. For example, information on applying different IC management frameworks in practice is necessary in order to learn about their impact on productivity.

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PELLERVON TALOUDELLINEN TUTKIMUSLAITOS PTT
Pellervo Ekonomiska Forskningsinstitut
Eerikinkatu 28 A, 00180 Helsinki, Finland
puh. (09) 348 8844, telefax (09) 3488 8500
sähköposti: econ.res@ptt.fi, kotisivut: www.ptt.fi

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