

How Do Investments in Intellectual Capital Create Profits?

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Abstract

The objective of this paper is to determine how investments in intellectual capital (IC) are transformed through various stages into profits. First, a theoretical framework containing different aspects of IC (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 measures of different components are examined using correlation analysis. The data used in the empirical analysis comprises of information from financial statements of Finnish companies during the time between 2001 and 2003. It includes overall 60,304 cases which represent eleven largest industries in Finland. The study provides empirical evidence to support assumptions concerning the relationships between factors related to IC and productivity and profitability. Against expectations, the results showed no linear relationship between the investments in IC and profitability. However investments in IC seem to improve the value of IC, which seems to lead to higher productivity.

Keywords

CIV, intangible assets, intellectual capital, investments, productivity, profitability, VAICTM

Introduction

Intellectual capital (IC) of an organisation consist of the immaterial sources of value related to employees' capabilities, organisations' resources and way to operate and the relationships with its stakeholders (Lönnqvist 2004). Examples of IC include employee competencies and motivation, relationships with various stakeholders and management structures and processes as well as patent and other immaterial properties. An organisation's success is significantly affected by how well it can utilise the IC, e.g., in creating new innovations. Thus, the management of IC has emerged as an important practice and a research area.

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, also investing in IC is an important issue for any organisation. Examples of investing in IC include research and development, increasing customer loyalty, improving brand recognition and developing the competencies of employees. It is difficult to see that any organisation could be able to stay competitive in the long run without making investments into these kinds of factors.

Generally, it has been estimated that an investment in IC would create twice as much benefits to a company when compared to a similar investment in a physical asset (see e.g. Abernethy et al. 2003). However, it is currently unclear how investments in IC actually affect productivity and profitability. The relationships between IC and productivity and profitability have been studied quite a lot (Abernethy et al. 2003; Lönnqvist et al. 2004). For example, the relationships between R&D investments and profitability have been observed in several statistical studies. However, the relationships between the factors are complex and the empirical research results have so far been partly contradictory. Most of the research carried out so far consists of statistical testing on results of performance measures. In addition, questionnaires and case studies have been used. According to Lönnqvist et al. (2004), a key challenge in these studies has been the difficulty of getting comparable data. This is caused by two factors. First, the performance measures used by companies to measure IC are deficient or non-standard. Second, companies do not publish the measurement information related to IC. Therefore, the research has been difficult to carry out.

The objective of this study is to determine how investments in IC are transformed through various stages into profits. This research consists of two main phases. First, a theoretical framework containing different aspects of IC (e.g. 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 measures of different components are examined using correlation analysis.

The data used in the empirical part is gathered by the Central Statistical Office of Finland and it comprises of information from financial statements of Finnish companies during the time between 2001 and 2003. The data includes overall 60,304 cases which represent eleven largest industries in Finland. The design of this study (described later more thoroughly) overcomes most of the challenges faced previously in similar studies.

The study provides empirical evidence to support the assumptions concerning relationships between IC and productivity and profitability. The enhanced knowledge of the relationships can possibly be utilised when estimating the appropriate amount of investments in IC in companies. In addition, this may provide some indication when estimating the future impact of the investments in IC.

Theoretical framework

An underlying assumption in this study is that companies invest in IC in order to improve their business performance. For example, when a company invests in the competencies of its employees it may expect improved quality of work, better customer service, increased productivity and ultimately improved profitability. However, the links between IC and performance are highly complex in practice. For example, the following questions are not clear:

- Do all investments in IC create profits, and if not, which do and which do not?
- How do investments in IC (e.g. education) transform into increased IC (e.g. competence) and finally into profitability improvements?
- What is the time lag between IC investment and the business performance improvement?

- What rate of return on investment can be expected out of IC investments?

The relationships described above have been examined in several earlier studies. A brief summary of the previous findings is presented in the following:

- A review by Abernethy et al. (2003) that examined several studies concludes that there is a significant positive rate of return to R&D investments at corporate sector and national levels, and that corporate returns may be twice the rate of return to tangible investment.
- Bassi et al. (2002) identified a positive relationship between training and gross profit margin, return on assets income per employee and the ratio of price to book value.
- Bontis et al. (2000) discovered a positive relationship between human capital and customer capital. In addition, customer capital has a significant influence on structural capital. Finally, the development of structural capital has a positive relationship with business performance.
- Cazavan-Jeny (2002) found no correlation between the measures of intangible assets (e.g. training, research and development or advertising intensity) and market-to-book ratio.
- Chang and Chen (2002) discovered that training and development, teamwork and performance appraisal are positively related to employee productivity.
- A study by Chen et al. (2005) suggests that R&D investments have a positive effect on profitability and that IC has a positive effect on firm value and financial performance.
- Delaney and Huselid (1996) discovered that human resource management practices (e.g. selectivity in staffing, training and incentive compensation) are positively associated with organisational performance.
- A study by Huang and Liu (2005) suggests that investments in innovation capital and IT capital have a non-linear relationship with company performance implying that more investment is not always better.
- Riahi-Belkaoui (2003) discovered a relationship between intangible assets and net value added.
- Van der Wiele et al. (2002) found out that service quality is significantly correlated with sales and margin in the same time period and in the next year period.

Based on the previous research, a presentation of the assumed relationships between IC investments, profitability and some other related factors is provided in Figure 1. Investments in IC are expected to improve both the efficiency of utilising IC and also to increase the value of IC. These in turn may improve productivity and, eventually, profitability. However, it is more difficult to estimate the payback of investments in IC than those made in physical assets, e.g. a new production line. It is uncertain how, when and where the investments in IC will create profits. In addition, companies with good profitability may have better possibilities in making investments in IC than less profitable companies. Thus, the relationship may be bidirectional.

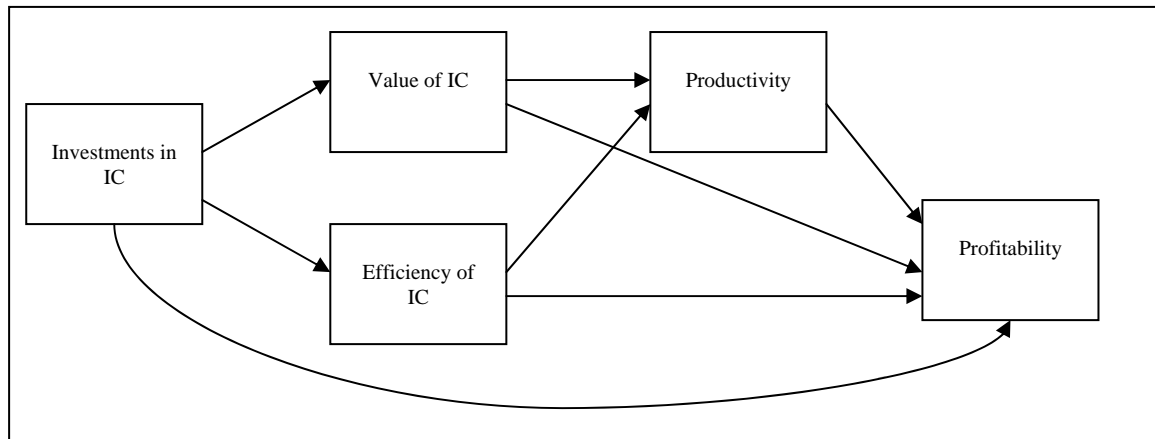


Figure 1. Some expected relationships between IC related factors, productivity and profitability

The uncertainties mentioned above are related to the nature of the IC investments. Investment in, e.g., employee competencies does not necessarily affect directly the profitability of a company. It may first improve customer satisfaction and loyalty and may later lead to improved profits. Thus, the relationship is indirect and time lag between the initial investment and the expected improvement in, e.g., profitability is uncertain. There is also a risk that the expected financial results are not realised. Further, the effects of improving employee competencies (or other types of IC) do not solely benefit the company making the investment. Also other stakeholders may benefit from these improved competencies. For example, another company may obtain these benefits if it is able to hire the employee. The effects of investments in IC may also benefit society in many ways, e.g. improve employment or create business opportunities for other companies.

Research method

Data

The study is based on the data gathered by the Central Statistical Office of Finland. It comprises of information from the financial statements of Finnish companies during the period 2001–2003. Companies employing less than five employees and those that operated less than six months during a year were excluded. Altogether around 60,000 cases were studied. The data contains the following sample sizes for each year: 20,677 for 2001; 19,013 for 2002 and 20,614 for 2003.

The data covers eleven largest industries in Finland. These are the food industry, the forest industry, the chemical industry, metal refining, the electronics industry, vehicle manufacturing, the construction industry, business services, electricity, gas and water supply, the wholesale and retail industry, and transportation, storage and telecommunications. In addition, companies are categorised by size as small and medium-sized enterprises (less than 250 employees) and large companies (at least 250 employees). Most of the companies involved are small and medium-sized (98 % in 2003).

Performance measures

Overview of the measures used

The measures used in this study are summarised in Table 1. They are discussed more in depth in the following sub-chapters. The main reason for choosing the measures that have been chosen is that they could be applied using the data provided by the Central Statistical Office of Finland. It is well-known 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 VAICTM 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.

Table 1. Performance measures used in the study

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)

In this study, the two problems related to the previous studies mentioned in the introduction chapter are avoided. First, the chosen IC measures are based on standard calculations. Because of that, different companies and industries are comparable. In addition, the results of different measures are based on the same data, and therefore, it is possible to examine relationships between different factors. Second, the data is composed of public financial information, and thus a large set of data was available. In conclusion, the approach chosen has both positive and negative aspects that must be taken into account when making conclusions.

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). However, the absolute monetary value can be related to the size of the company and, therefore, in this study the relative measure is used. Relative R&D expenses are simply calculated by dividing the R&D expenses with the net revenues. Moreover, the measure is presented as a percentage.

Since R&D expenses do not represent all investments in IC, also another measure is used. Besides relative R&D expenses, investments in IC are 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 and, finally, the measure is presented as a percentage.

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. That is to say, by utilising tangible assets, a company can reach only an average level of earnings – the premium is generated by 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*) (1):

$$c = a / b \quad (1)$$

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 (2):

$$\text{excess_return} = (a - d * b) * (1 - \text{average_income_taxes}) \quad (2)$$

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. (Antola et al. 2005)

There is not a lot of empirical evidence about utilizing CIV in practice. McClure (2003) has calculated the value of Intel's IC (\$ 35.3 billion) using the method. Also Stewart (1995) has calculated Merck's IC value (\$ 11.1 billion). In addition to these isolated applications of the method, little or no empirical research has been carried out related to CIV.

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 simplicity, the same percentage (10 %) was used in all industries in sixth step.

Efficiency of IC

The Value Added Intellectual Coefficient (VAICTM), developed by Ante Pulic, measures and monitors the total value creation efficiency in the company. The subordinate concept of VAICTM, Intellectual Capital Efficiency (ICE), describes the efficiency of IC within a company. Actually, VAICTM 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) In this study, both measures were used.

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 VAICTM). 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 (3):

$$VA = P + C + D + A \quad (3)$$

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 (4):

$$SC = VA - HC \quad (4)$$

Second, the capital employed efficiency (CEE) describes how much of the company's value added is generated with the capital employed. It is calculated by dividing the value added by capital employed (CE) (5):

$$CEE = VA/CE \quad (5)$$

Human capital efficiency (HCE) is calculated by dividing the value added by the human capital (6):

$$HCE = VA/HC \quad (6)$$

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 (7):

$$SCE = SC/VA \quad (7)$$

Third, the intellectual capital efficiency (ICE) is calculated by summing together the human capital efficiency and the structural capital efficiency (8):

$$ICE = HCE + SCE \quad (8)$$

Finally, the Value Added Intellectual Coefficient (VAICTM) is a composite sum of the intellectual capital efficiency and the capital employed efficiency (9):

$$VAIC^{TM} = ICE + CEE . \quad (9)$$

The basic proposition is that the higher the VAICTM and ICE are the better management has utilised the existing potential in the resources employed in creating value (Van der Zahn et al. 2004). VAICTM 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 VAICTM figure is comparable among companies and it can be reported to external stakeholders (Antola et al. 2005).

VAICTM method has been applied earlier in some other countries, e.g. in Singapore (see Van der Zahn et al. 2004) and Croatia (see e.g. International Business Efficiency Consulting L.L.C. 2002). Besides national analysis, VAICTM method has been used in comparing European Union countries (see e.g. International Business Efficiency Consulting L.L.C. 2003).

In this study the application of the VAICTM method (i.e. ICE and VAICTM measures) proceeded according to the phases explained above. However, different components (e.g. total salaries and operating profits) needed more detailed definition. Determination of components was made in cooperation with the Central Statistical Office of Finland.

Productivity and profitability

In this study, 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).

Statistical methods

The empirical part of this study is exploratory by nature. The aim is to examine the different relationships between IC-related factors and productivity and profitability, instead of definition and clarification of these relationships in-depth. Pearson's correlation coefficient (r) was used to determinate the association between different measures (e.g. investments in IC and CIV). 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. Also, other methods (e.g. regression analysis) would have been applicable. However, correlation analysis provides sufficient information from this study's point of view. In further examination, regression analysis is worth considering.

In this study, certain choices were 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 other measure (investments in IC, ICE, VAICTM, productivity and profitability) was calculated to facilitate the comparison. Only those companies, for which data was available for three years, were 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, small and medium-sized companies are compared. Third, relationship is analysed separately in each industry. The significance level (p-value) used in this study was 0.05. Therefore, the correlation is considered statistically significant in that case the p-value is less than five percent. Correlation coefficients are calculated by the Central Statistical Office of Finland.

Results

Overall findings

The correlation coefficients (and p-values) related to the whole data between 2001 and 2003 are presented in Table 2. However, not all possible relationships are discussed in this study. They are referred as ‘not studied’ in the following table.

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

	Relative R&D expenses	Relative development expenses	CIV	ICE	VAIC TM	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)	-0.00003 (0.9971)
ICE	–	–	–	–	Not studied	0.84839** (<0.0001)	0.00996 (0.1261)
VAIC TM	–	–	–	–	–	0.14756** (<0.0001)	0.41310** (<0.0001)
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.

According to the results, CIV is positively correlated with both investment measures, i.e. relative R&D expenses and relative development expenses ($r=0.016236$ and $r=0.02938$). Accordingly, the correlations are statistically significant at the level 0.01 ($p<0.0001$ and $p=0.0003$). The relationship between ICE and investment measures is not as clear. There exists no correlation between ICE and relative R&D expenses ($p=0.2593$). However, the correlation between ICE and relative development expenses is negative ($r=-0.02598$) and clearly statistically significant ($p<0.0001$). Instead VAICTM does not correlate with either of the investment measures ($p=0.02593$ and $p=0.0559$). The results show that investment measures are not correlated with either productivity ($p=5362$) or profitability ($p=1306$) in the whole sample.

As presented in Table 2, CIV, ICE and VAICTM are correlated with the productivity measure (i.e. value added per number of employees). The correlations are all positive ($r=0.11917$, $r=0.84839$, $r=0.14756$) and statistically significant (all p-values less than 0.0001). According to the correlation coefficients, the linear relationship between ICE and productivity measure is very strong.

The results show no linear relationship between ROI and the following measures: relative R&D expenses ($p=0.5362$), relative development expenses ($p=0.1306$), CIV ($p=0.9971$), ICE ($p=0.1261$) and value added per number of employees ($p=0.2106$). Instead, one exception occurs, since there is clearly a positive correlation between VAICTM and ROI ($r=0.41310$, $p<0.0001$).

More detailed results related to each relationship are discussed in the following subsections. In practice, first, correlation analysis is conducted in small and medium-sized enterprises and large companies, and second, correlation coefficients related to different industries are discussed. The two tables in Appendices 1 and 2 summarise the results of correlation analysis.

Relationship between investments in IC and value of IC

Further analysis shows that relative R&D expenses and CIV are correlated regardless of the size of the company. However, the relationship between relative development expenses and CIV varies according to the size: In small and medium-sized enterprises the correlation is positive and statistically significant, but in large companies there exists no correlation.

The relationship between measures of investments in IC and CIV varies in different industries. In construction industry, wholesale and retail industry and transportation, storage and telecommunications industry there is a positive correlation between relative R&D expenses and CIV. In the eight other industries, these two measures are not related. Similarly, the correlation between relative development expenses and CIV is positive and significant in four out of eleven industries. Those are forest industry, construction industry, business services and transportation, storage and telecommunications industry. In seven other industries the correlation analysis shows no linear relationship.

Relationship between investments in IC and efficiency of IC

The relationship between investments in IC and efficiency of IC is vague. As in whole sample, there is no correlation between relative R&D expenses and ICE in small and medium-sized enterprises. On the contrary, in large companies the correlation is negative. The analysis regarding different industries shows that there exists no correlation between relative R&D expenses and ICE in most industries. Instead, in three industries (i.e. food industry, metal refining and electricity, gas and water supply) there is negative linear relationship and in transportation, storage and telecommunications the correlation is positive.

When measuring the investments in IC with relative development expenses, the size of the company does not affect the relationship with ICE. Accordingly, in all sizes of companies the correlation is negative. However, between different industries, there are variations. In five industries (food industry, forest industry, metal refining, electricity, gas and water supply and storage and telecommunications) the relationship between relative development expenses and ICE is negative. Instead, in all other industries the correlation does not exist.

In case efficiency of IC is measured by VAICTM, the size of the company does not affect the relationship between investments of IC (measured with two different measures) and efficiency of IC. Additionally, in most industries there is no correlation. In contrast, in business services, the correlation between relative R&D expenses and VAICTM is positive and in wholesale and retail industry the correlation is negative. Similarly, correlation between relative development expenses and VAICTM is positive in one, electricity, gas and water supply, and negative in one, wholesale and retail, industry.

Relationship between investments in IC and profitability

As mentioned above investments in IC (measured with relative R&D expenses and development expenses) does not correlate with profitability in the whole sample. The same occurs when analysing different size of companies. In addition, in most industries there is no linear relationship between these measures. Only in the vehicle manufacturing industry the correlation between relative R&D expenses and ROI is negative and significant. Correspondingly, in two industries (metal refining and electronics industry) there is negative correlation between relative development expenses and ROI.

Relationship between value of IC and productivity

Based on the results, CIV and value added per employees are positively correlated in general. Accordingly, the same situation can be seen in both small and medium-sized enterprises and in large companies. Also in all eleven industries the correlation is clearly positive.

Relationship between efficiency of IC and productivity

The relationship between the efficiency of IC and productivity is not as obvious as the previous relationship. When measuring the efficiency of IC by ICE, the relationship is similar in both small and medium-sized enterprises and large companies: the correlation is significantly positive. Also, in different industries the analysis reveals statistically significant linear dependency between these two measures.

However, the association between VAICTM and productivity measure varies based on the size. In small and medium-sized companies the correlation is positive, but in large companies there exists no linear relationship. The variation can be seen in different industries as well. In seven industries the correlation is positive. Instead, in four industries (forest, metal refining, vehicle manufacturing and transportation, storage and telecommunications) the measures do not correlate.

Relationship between value of IC and profitability

Based on the correlation analysis, there is no statistically significant correlation between the value of IC (CIV) and profitability (ROI). The size of the company does not affect the relationship. Moreover, in most industries correlation does not exist. However, in vehicle manufacturing industry the situation is opposite: there is a positive correlation between CIV and ROI.

Relationship between efficiency of IC and profitability

As Table 2 shows, the relationship between the efficiency of IC and profitability varies according to the efficiency measures. The analysis related to the correlation coefficients calculated in two groups (based on the size) shows no exceptions. ICE and ROI are not correlated. Vice versa there is a positive (clear) correlation between VAICTM and ROI.

The analysis in different industries is not as straightforward. Contrary to the previous, in most (eight out of eleven) industries there is a significant positive association between ICE and ROI. Those are the following: forest, chemical, metal refining, vehicle manufacturing, construction, electricity, gas and water supply, wholesale and retail, and transportation, storage and telecommunications industries. On the other hand, in most industries there is a clear linear relationship between VAICTM and ROI. The only exception is the electronics industry, in which there is no correlation between these two measures.

Relationship between productivity and profitability

According to the correlation coefficients calculated in small and medium-sized enterprises and large companies, there is no difference in relationship between productivity and profitability measures (i.e. no correlation). However, in many industries correlation exists. Only in four industries (food, forest, electronics and construction industries), the results correspond to the results based on the whole sample.

Discussion

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 hypothesis model presented in Figure 1. Three different routes from IC investments to profitability were examined, and they are discussed below:

I: Investments in IC → Profitability

The results showed no linear relationship between the investments in IC and profitability. There may be several reasons for this. There may be problems with the measures used or with the research (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 & Liu 2005).

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

The results suggested 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 seven out of eleven industries; also previous theoretical knowledge supports this).

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

Investments in IC did not correlate clearly with the efficiency of IC. However, the efficiency of IC was associated with high productivity (both measures) and profitability (only VAICTM measure). These results seem reasonable when the composition of the measures used, i.e. ICE and VAICTM, 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. VAICTM 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. For these reasons, the measures of the efficiency of IC used in this study (i.e. ICE and VAICTM) could be categorised more as (financial) performance measures of a company rather than IC measures. Thus, the reason for the lack of correlation between the investments in IC and the efficiency of IC might be similar to those between the investments in IC and profitability.

Many of the relationships between IC related factors and other business phenomena varied in different industries. It was not the objective of this study to provide explanations to these differences. It seems that industry specific factors must be studied further in order to explain the variations.

The validity of the study is open to criticism. 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 is 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). In addition, the information was provided and calculations made by a reliable actor (the Central Statistical Office of Finland).

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Appendix 1. Correlations between different measures in small and medium-sized enterprises and large companies

	SMEs	Large companies
Relative R&D expenses and CIV		
Correlation, r	0.40560**	0.30154**
p-value	<0.0001	<0.0001
Relative development expenses and CIV		
Correlation, r	0.10103**	0.09300
p-value	<0.0001	0.1370
Relative R&D expenses and ICE		
Correlation, r	-0.01180	-0.09457*
p-value	0.0728	0.0349
Relative development expenses and ICE		
Correlation, r	-0.02375**	-0.09797*
p-value	0.0003	0.0288
Relative R&D expenses and VAICTM		
Correlation, r	-0.00723	-0.04127
p-value	0.2722	0.3581
Relative development expenses and VAICTM		
Correlation, r	-0.00896	-0.05141
p-value	0.1736	0.2522
Relative R&D expenses and ROI		
Correlation, r	-0.00396	-0.02147
p-value	0.5475	0.6327
Relative development expenses and ROI		
Correlation, r	-0.01004	-0.03475
p-value	0.1271	0.4390
CIV and Value added per number of employees		
Correlation, r	0.15032**	0.41064**
p-value	<0.0001	<0.0001
ICE and Value added per number of employees		
Correlation, r	0.84895**	0.81988**
p-value	<0.0001	<0.0001
VAICTM and Value added per number of employees		
Correlation, r	0.15402**	0.04934
p-value	<0.0001	0.2718
CIV and ROI		
Correlation, r	0.00727	0.02101
p-value	0.3705	0.7375
ICE and ROI		
Correlation, r	0.01002	0.06885
p-value	0.1278	0.1250
VAICTM and ROI		
Correlation, r	0.42027**	0.17418**
p-value	<0.0001	<0.0001
Value added per number of employees and ROI		
Correlation, r	0.00840	0.05949
p-value	0.2014	0.1850

Appendix 2. Correlations between different measures in eleven industries

	Food industry	Forest industry	Chemical industry	Metal refining	Electronics industry	Vehicle manufacturing	Construction industry	Business services	Electricity, gas and water supply	Wholesale and retail industry	Transportation, storage and telecommunications
Relative R&D expenses and CIV											
r	0.01604	0.04708	0.08967	0.07115*	0.14895	0.16484	0.18779**	-0.00550	-0.00636	0.12492**	0.23794**
p-value	0.8056	0.4587	0.1575	0.0318	0.0824	0.0640	<0.0001	0.8036	0.9562	<0.0001	<0.0001
Relative development expenses and CIV											
r	0.08332	0.17955**	0.00638	0.05737	0.15800	-0.08771	0.13496**	0.05246*	0.01151	0.01553	0.24310**
p-value	0.2002	0.0044	0.9200	0.0835	0.0652	0.3268	<0.0001	0.0176	0.9209	0.3500	<0.0001
Relative R&D expenses and ICE											
r	-0.12182**	0.00085	0.00451	-0.09358**	-0.01778	-0.8907**	-0.02454	-0.04580*	-0.02571	0.00245	0.04387*
p-value	0.0077	0.9842	0.9304	0.0010	0.6991	0.1912	0.3194	0.0136	0.7206	0.8534	0.0425
Relative development expenses and ICE											
r	-0.12302**	-0.23926**	-0.03331	-0.17694**	-0.01138	-0.09210	-0.04318	0.00324	-0.20004*	-0.02377	-0.07775**
p-value	0.0071	<0.0001	0.5191	<0.0001	0.8046	0.1764	0.0796	0.8616	0.0049	0.0778	0.0003
Relative R&D expenses and VAIC											
r	-0.03803	-0.00319	-0.03354	-0.01993	-0.03295	-0.12760	-0.02156	-0.04246*	-0.04331	0.04893**	-0.01372
p-value	0.4073	0.9404	0.5162	0.4828	0.4926	0.0606	0.3821	0.0225	0.5467	0.0002	0.5267
Relative development expenses and VAIC											
r	-0.02556	-0.06770	-0.07403	-0.02993	-0.03156	-0.10794	-0.01380	-0.03536	-0.21528*	0.06773**	-0.03536
p-value	0.5776	0.1118	0.1514	0.2917	0.4926	0.1129	0.5759	0.0575	0.0024	<0.0001	0.1026
Relative R&D expenses and ROI											
r	-0.00362	-0.00725	-0.06377	-0.06238*	-0.08566	-0.15178*	-0.02501	-0.02299	-0.07690	-0.00231	-0.02338
p-value	0.9371	0.8648	0.2167	0.0279	0.0621	0.0254	0.3101	0.2161	0.2841	0.8615	0.2804
Relative development expenses and ROI											
r	0.02569	-0.02532	-0.04618	-0.06851*	-0.09022*	-0.07233	-0.01562	-0.02620	0.04510	-0.01086	-0.01147
p-value	0.5757	0.5523	0.3712	0.0157	0.0494	0.2888	0.5262	0.1586	0.5302	0.4126	0.5964
CIV and Value added per number of employees											
r	0.28597**	0.31564**	0.12468*	0.65636**	0.49938**	0.47248**	0.18065**	0.12437**	0.42533**	0.36110**	0.15822**
p-value	<0.0001	<0.0001	0.0485	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
ICE and Value added per number of employees											
r	0.92327**	0.78447**	0.65474**	0.85344**	0.99138**	0.82145**	0.68410**	0.23915**	0.88588**	0.48062**	0.88239**
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
VAIC and Value added per number of employees											
r	0.10116*	0.03986	0.57409**	0.01731	0.75956**	0.00707	-0.07565**	-0.05083**	0.78787**	0.07177**	0.03620
p-value	0.0270	0.3495	<0.0001	0.5420	<0.0001	0.9175	0.0021	0.0063	<0.0001	<0.0001	0.0946
CIV and ROI											
r	0.04202	-0.01463	-0.02013	-0.00181	-0.02167	0.18648*	-0.00062	0.00078	0.12413	0.02473	0.00187
p-value	0.5189	0.8180	0.7509	0.9565	0.8016	0.0358	0.9836	0.9719	0.2821	0.1365	0.9448
ICE and ROI											
r	0.03455	0.78447**	0.17341**	0.19685**	-0.00022	0.25005**	0.07408**	0.03454	0.24300**	0.05277**	0.05823**
p-value	0.4511	<0.0001	0.0007	<0.0001	0.9962	0.0002	0.0026	0.0630	0.0006	<0.0001	0.0071
VAIC and ROI											
r	0.59007**	0.70552**	0.17341**	0.09247**	0.8657	0.53769**	0.45907**	0.38198**	0.23783**	0.51131**	0.21398**
p-value	<0.0001	<0.0001	<0.0001	<0.0001	0.0586	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	<0.0001
Value added per number of employees and ROI											
r	0.01736	-0.00218	0.10655*	0.11554**	-0.01490	0.22495**	0.04322	0.07281**	0.18752**	0.05962**	0.07345**
p-value	0.7049	0.9591	0.0381	<0.0001	0.7452	0.0008	0.0793	<0.0001	0.0085	<0.0001	0.0007