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INTELLECTUAL CAPITAL AND ANTICIPATED FUTURE SALES IN SMALL AND MEDIUM-SIZED BIOTECHNOLOGY COMPANIES***

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ABSTRACT: The objective of the study is to empirically verify impacts of intellectual capital to the anticipated future sales of small and medium-sized companies within biotechnology industry. Intellectual capital is divided into the following three categories: human, structural, and relational capital. Theoretically, a balanced interaction between the three categories implies value creation potential, and high anticipated sales of the company. In the empirical setting, survey data of small and medium-sized Finnish biotechnology companies is employed. The econometric procedure contains two stages. First, the interaction between three intellectual capital categories is estimated in factor analysis. Second, regression analysis is applied for explaining the anticipated future sales. The interactions within the three categories of intellectual capital explain two thirds of the variations in the anticipated future sales within 5 years. As a result, a well-balanced combination of human capital, structural capital, and relational capital seems to contribute to the highest anticipated sales levels.

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TIIVISTELMÄ: Tutkimuksen tarkoituksena on empiirisesti tuoda esille niitä vaikutuksia, joita osaamispääomalla on tulevaan ennakoituun liikevaihtoon pienissä ja keskisuurissa biotekniikan alan yrityksissä. Osaamispääoma jaetaan seuraaviin kolmeen osa-alueeseen: inhimillinen pääoma, rakenteellinen pääoma ja suhdepääoma. Teoreettisesti ajatellen näiden kolmen osa-alueen tasapainoinen vuorovaikutus mahdollistaa lisäarvon luomisen ja antaa yritykselle edellytyksiä saavuttaa korkea ennakoitu liikevaihto. Tutkimuksen empiirisessä osassa hyödynnetään suomalaisista pienistä ja keskisuurista biotekniikan alan yrityksistä kerättyä haastatteluaineistoa. Tutkimuksen ekonometrisessä tarkastelussa on kaksi vaihetta. Ensiksi, osaamispääoman eri osa-alueiden vuorovaikutusta pyritään arvioimaan faktorianalyysin avulla. Toiseksi regressioanalyysiä sovelletaan ennakoidun tulevan liikevaihdon selittämiseksi. Osaamispääoman kolmen osa-alueen vuorovaikutus selittää kaksi kolmannesta ennakoidun liikevaihdon vaihtelusta tulevien 5 vuoden aikana. Keskeisenä tuloksena on, että inhimillisen pääoman, rakenteellisen pääoman ja suhdepääoman tasapainoinen yhdistelmä näyttäisi mahdollistavan sen, että ennakoitu liikevaihto kasvaa kaikkien korkeimmaksi. .

1. INTRODUCTION

1.1 Background

In management literature, the value of companies is often explained by the impact of intellectual capital (e.g. Edvinsson and Malone 1997; Sveiby 1997; Hall 2001; Mayo 2001). Adequate intellectual capital enables the company to create new innovations and to exploit them commercially. This is a prime source for future sales especially in high technology industries.

The anticipated future sales are reflected in the market valuation of a company. High present value estimates are characteristic of industries that have high prospects for future sales. Biotechnology industry is an archetype of industries with extraordinary high prospects for future sales. Within such fields of industry, the anticipated future sales can dominate the market valuations of companies. Because of its high future prospects, the biotechnology industry has attracted large infusions of private venture capital. Government agencies enhancing promising industries have also heavily supported the development of biotechnology.

Despite the high impact of intellectual capital on the anticipated sales and the valuation of companies, there have been only a few empirical contributions in these matters in knowledge management literature. Attempts to empirically measure the impact of intellectual capital on value creation have been rare (e.g. Gu and Lev 2001). Even though the biotechnology industry offers tempting future prospects and setsdemanding challenges for venture capital industry and for public support agencies, there is a lack of research studies exploring the special characteristics of companies in this field of industry (Cumby and Conrod 2001).

The present study attempts to address the twofold gap in the research literature. Figure 1 depicts the positioning of the present study in relation to different research traditions and disciplines.

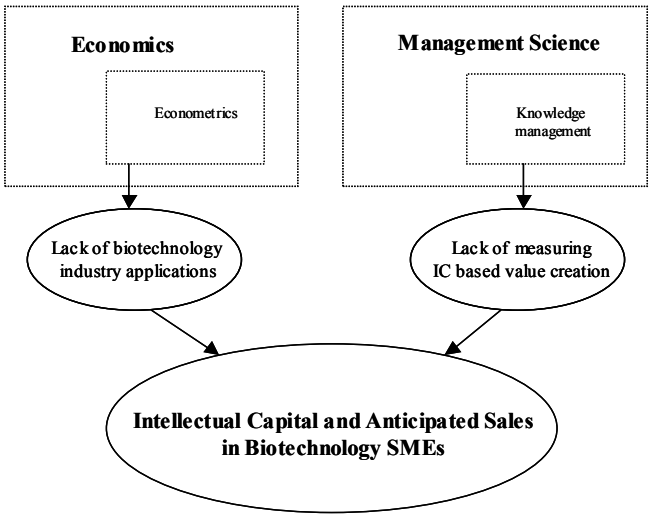

Figure 1. The positioning of the present study in relationship to different research traditions and disciplines (IC = Intellectual Capital).

In the present study, the empirical analyses are done using survey data from a sample of 72 small and medium-sized Finnish biotechnology companies interviewed at the beginning of 2002.[1] According to the survey more than 60 percent of the Finnish biotechnology companies are research-based spin-offs. At the time of the interviews many of the companies had few or no sales. The sample of companies constitutes a good case for studying companies, in which the book value in the balance sheet does not represent the value of the companies, but the anticipated sales determines the valuation. It is proposed that such anticipated future sales and corresponding valuations are heavily built on the intellectual capital of the companies. Accordingly, in the present study we empirically test the intellectual capital approach presented in knowledge management literature (e.g. Sveiby 1997; Edvinsson and Malone 1997; Stewart 1997; Ahonen 2000; Hussi and Ahonen 2002) by applying statistical tools.

1.2 The objective of the study

The objective of the present study is to empirically verify impacts of intellectual capital to the anticipated future sales of small and medium-sized companies within biotechnology industry.

[1] The paper draws on the ETLA and Etlatieto Ltd survey of Finnish biotechnology companies, conducted in March-May 2002. Descriptive survey findings have been reported in Hermans and Luukkonen (2002) and Hermans and Tahvanainen (2002).

1.3 The scope of the study

At the end of 2001 there were approximately 120 actively trading biotechnology companies in Finland (Kuusi 2001; Hermans and Luukkonen 2002). Of these, 84 companies replied to a survey conducted during the spring of 2002. Of the respondents, 72 were small and medium-sized, and formed the research sample of companies.

The survey data includes information about ownership, financial accounting, input-output networks, as well as research and development activities. The survey also presents the company managers' anticipations about the future development of the companies.

The study makes use of the definition of intellectual capital, in which intellectual capital is grouped into three categories: human capital, internal capital, and relational capital. These categories are used when conceptualizing the variables in the theoretical knowledge management framework. Theoretically, the interactions between human capital, internal capital, and relational capital are important in the value creation in companies. These categories of intellectual capital can be applied at the firm level (Mouritsen *et al*. 2000) and at the economy level representing groups of companies(Bontis 2002b).

A methodological contribution of the present study is the combining of econometric analyses with the knowledge management approach. On the one hand, the econometric procedures can be clarified from the viewpoint of the business management literature. On the other hand, the variables of knowledge management models can be linked to data on the biotechnology industry.

Econometric modeling is used as our main tool. Factor analyses are applied as an important analysis method. The factor scores resulting from the factor analyses are fed into regression analyses. The anticipated sales of the companies are explained by these regression models.

2. THEORETICAL BACKGROUND

Knowledge management literature has flourished since the mid 1990s. Nonaka and Takeuchi (1995) laid a foundation in the discussion on knowledge creation in companies. In the literature the intellectual capital of the companies was used as an explanation for the fact that the book values of companies are often lower than the market valuations of the companies. (Edvinsson and Malone 1997; Stewart 1997).

In the knowledge management literature, intellectual capital is usually grouped into three partly overlapping categories. For example, Sveiby (1997) defines the following three categories: individual competencies, internal structures, and external structures. Saint-Onge, Armstrong, Petrash, and Edvinsson (in Edvinsson and Malone 1997) list the following three categories: human capital, organizational capital, and customer capital, respectively. Hussi (2001, 2003) combines these definitions and puts forward the idea that intellectual capital contains the following three categories: human capital, internal structures, and external structures. Hussi argues that the category of individual competencies is too narrow a definition for human capital. According to Hussi, human capital contains other aspects besides individual competencies. Such additions can include, for example, the health of individuals. On the other hand, external structures can include a wider scope than only customer relations. For example, many companies are closely linked to their suppliers or academic research networks.

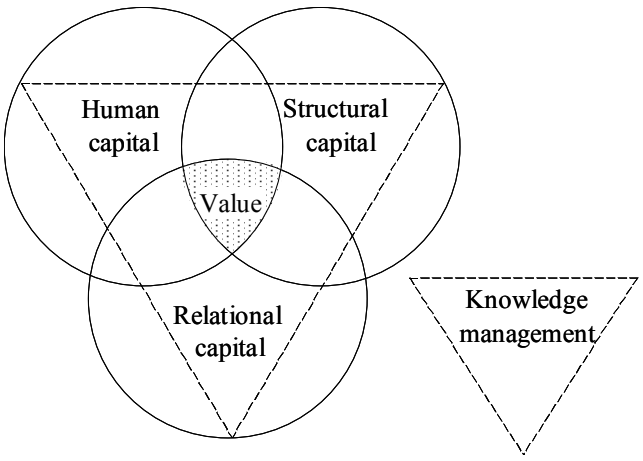

Figure 2. Intellectual capital and knowledge management, modified from Saint-Onge, Armstrong, Petrash, and Edvinsson in Edvisson and Malone (1997).

In the present study, we apply a recent consensual definition of intellectual capital (e.g. MERITUM project's 2002; Bontis 2002a), which also groups intellectual capital into three categories, Figure 2. The first category is human capital, which is composed of the skills and competencies of the company's labor. The second category is structural capital, which signifies the company's ability to organize its activities in a way that tacit knowledge can be converted into intellectual property rights owned by the company.[2] The third category is relational capital, which stresses the importance of external networks, for example, with customers and other partners. According to the knowledge management approach, when there is a close interaction between these three parts of intellectual capital, the firm is able to create value from its business activities and growth can be anticipated. A well-balanced combination of human capital, structural capital, and relational capital is needed and this requires proper knowledge management. For example, even if a company has ample human capital represented by labor with a high level of expertise, the value creation is not guaranteed if production or marketing processes are not well organized or customers are not reached.

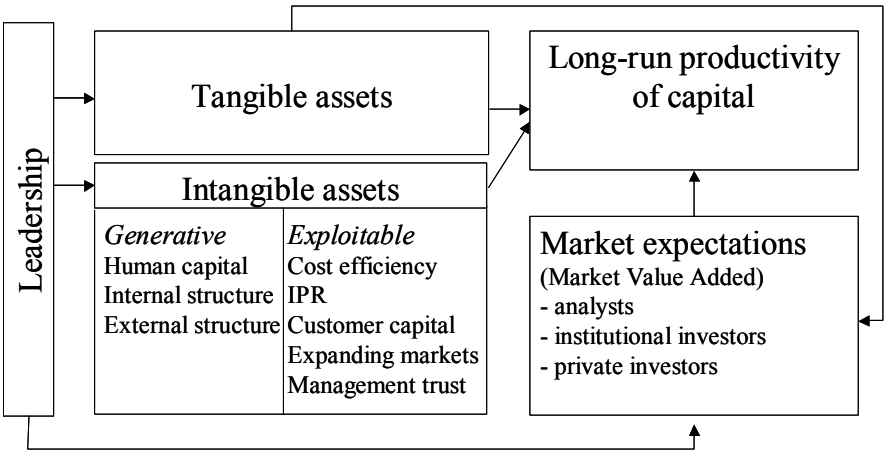

Figure 3. Intangible assets and long-run productivity of capital. Ahonen, Hussi, and Asplund in Hussi 2001.

Ahonen (2000) and Ahonen, Hussi, and Asplund (in Hussi 2001) deepen the description behind the value creation mechanism, Figure 3. They divide intangible assets into generative assets and commercially exploitable intangible assets. The scheme in Figure 3

[2] Nonaka and Takeuchi (1995) define their seminal model in which they interpret how the tacit knowledge is converted to explicit knowledge and back to the tacit knowledge of other individuals and groups. In the present study we do not focus on the so-called SECI model but instead we focus on measuring the interactions between different categories of intellectual capital and its impact to anticipated sales.

emphasizes the generative intangible assets as an enabler for the development of commercially exploitable intangible assets. The commercially exploitable intangible assets, in turn, enable the present value creation. The value creation is depicted as the interaction between human capital, internal structure (structural capital), and external structure (relational capital) in Figure 2. Generative intangible assets prepare the way for the commercially exploitable intangible assets in the future and affect a long-run productivity of capital in Figure 3.

3. RESEARCH MATERIALS AND RESEARCH METHODS

3.1 The survey companies

For the study, an attempt was made to identify as many as possible of the biotechnology companies in Finland. It is believed that the 120 companies found constitute an almost all-inclusive group of such companies. The companies were interviewed by telephone in the spring of 2002 and sufficient data was obtained from 84 companies. Of the companies interviewed, 12 companies were classified as large companies. A company was classified as a large company if two out of the following three conditions were fulfilled: the company has more than 250 employees, its sales is more than 40 million euros, or its total balance sheet exceeds 27 million euros. Thus, 72 of the interviewed biotechnology companies were small or medium-sized and formed the research sample of companies.

Using only small and medium-sized companies in the study increases the reliability of the study. Many of the large companies are multi-functional with only a (small) part of their sales coming from biotechnology products. Also some of the large sample companies are a part of a consolidated company and their reports are not given in a uniform manner.

The survey data includes information about ownership, financial accounting, input-output networks, as well as research and development activities. The survey also includes the company managers' anticipations on the future development of the companies. The survey contained 120 questions of which about one third are used in the present study.

Specific measures were taken in order to get undistorted answers from the company managers. For example, at the beginning of each interview, a confidentiality assurance was given to the respondents, by which no data that could identify a single company would be published. The psychological implications behind the sales anticipations would be an interesting research topic in itself, but in the present study these anticipations are taken as given.

3.2 Variable construction

In the present study, we follow the definition of intangible assets (IA) presented in Figure 3, in which intangible assets are divided into two categories: generative intangible assets and commercially exploitable intangible assets. The amount and quality of generative intangible

assets are measured in the empirical study by several variables describing intellectual capital. Commercially exploitable intangible assets are measured by the present sales of the companies. Accordingly, by studying separately the impact of generative intangible assets and the impact of present sales on the anticipated sales, we can separate the impact that the generative intangible assets and the commercially exploitable intangible assets have on the anticipated sales. In the present study, intangible assets are studied as stocks but intellectual capital through interaction (see e.g. Hussi 2003).

Many of the values of the variables in the present study have a very wide distribution and the distributions can be skewed. This can distort such analyses, which are based on linear correlations. Thus, as a common research procedure, variables are logarithmized before performing the analyses. This transformation is not needed for such variables, which are ratios or are dichotomous dummy variables.

3.2.1 Generative intangible assets

Variables to measure generative assets are constructed mainly based on Sveiby's (1997) notion that intellectual capital can be measured by using three categories of variables, namely

a) growth and renewal
b) efficiency
c) stability.

In biotechnology industry, large investments have been made in intensive research and development activities to commercialize innovations or sell intellectual property rights. Only few of the anticipated potential innovations have been successfully developed, and even less commercialized. Thus, the importance of efficiency and stability is not as remarkable as it is when there is something to sell. Accordingly, in the present study the focus is on the first category of variables, growth and renewal.

Human capital (HC)

Human capital is more central to the core of intellectual capital than the two other categories of intellectual capital (Edvinsson and Malone 1997). We modify Sveiby's (1997) classification in the construction of the three variables below which we will use to measure human capital in the companies:

a) the total personnel
b) the education level of the personnel (the number of doctors and licentiates)
c) the business experience of the CEO (in years).

The total personnel measures the quantity and the critical mass of human capital in the companies. Biotechnology is a knowledge intensive industry and, thus, the total personnel is a relevant variable measuring the critical mass of human capital. The number of personnel in the companies is connected to the age of the companies within the data. On the one hand, over half of the youngest companies in the sample employed less than 10 persons. On the other, almost half of the oldest companies had more than 250 employees.

The two other variables attempt to capture features describing the quality and the skills of the personnel. The education level of the personnel measures the general quality of the human capital and the specific quality of the human capital in the form of the research training of the personnel. This variable measures the formal knowledge stock and the ability to process the knowledge stock.

Table 1. Description of the human capital variables.

Statistics	N					
HC	Valid	Missing	Mean	Median	Std. Deviation	Sum
Personnel	72	0	29.4	8	104.4	2 119
Doctors and licentiates	72	0	3.0	2	3.8	215
CEO's business experience in years	71	1	10.6	10	7.6	756

The business experience of the company's CEO attempts to measure the skills related to the business performance. It is interesting to note that the youngest biotechnology companies have hired many employees with doctoral degrees but CEO's with doctoral degrees do not have long careers in business.

Structural capital (SC)

Structural capital includes the way of organizing the company's activities and also the intellectual property rights of the company. The present study operates with three variables describing structural capital:

a) research and development input (research and development costs in euros)
b) patent intensity (the number of patent applications and patents)
c) the age of the firm (in years)

In the present study, we deviate from the mainstream measures (Sveiby 1997), which focus on the information technology inputs. However, Deeds (2001) brings out research and development expenditure as a focal source of innovation potential. Within the data at hand, research and development intensity is strongly connected to the age of the companies. Over half of the young companies spend over 50 percent out of their total expenditure on research and development activities. This expresses clearly the nature of the biotechnology industry. Companies, which had a low research and development expenditure percent, were on average older than other companies in the sample. Such older companies were often owned by other non-financial companies.

Lev and Sougiannis (1998) discuss the impacts of different reporting methods on the relation of research and development expenditure and realized earnings. In the present study, we do not use figures taken from the official accounts of the companies, but rather figures given directly by the companies in the interviews. In Ahonen's (2000) terms, research and development expenditure can be held as generative intangible asset whereas the patent portfolio is a commercially exploitable intangible asset. A key question related to a company's structural capital and value creation is how its research and development expenditure can generate patent applications and patents that are commercially exploitable. Stewart (1997) also highlights the intellectual property rights as a way to create value with (internal) structural capital. The number of patents and patent applications is used to measure the future potential of the company. However, the interaction between the internal capability to produce patent applications and the external regulatory environment is essential. Because the variable measuring patenting intensity is the quantity of patent applications and the patents a company holds, it also reflects the future sales potential arising from the innovation portfolio of the company.

The age of the company is employed as a variable measuring structural capital. Some factors, for example, the stability of the organizational structures are often difficult to measure, and they can be quantified by using age as an estimator (Sveiby 1990, 1997). The age of the company can affect how the internal affairs have been organized in a company in many ways. Organizational cultures differ from each other in old companies, on the one hand, and in young companies, on the other.

Table 2. Description of the internal structure variables.

Statistics	N					
SC	Valid	Missing	Mean	Median	Std. Deviation	Sum
Research and development costs in million euros	72	0	1.39	0.17	3.40	100.34
Patents and patent applications	72	0	11.8	4	26.6	849
Age of company	72	0	7.2	6	4.9	521

Relational capital (RC)

Edvinsson and Malone (1997) and Stewart (1997) define the company's relational capital as customer capital. Sveiby (1997) also takes into account supplier networks in relational structures. Market potential and catering to customer needs are fundamental requirements for success in any business. Most of the future of the market potential in small open economies results from the anticipated sales in international markets. Foreign exports is, thus, essential to companies acting in a small open economy that does not have a large home market, and the anticipated future sales of companies can be related to their plans to internationalize their operations. The present level of foreign exports varies among different age groups of the sample companies. The younger sample companies, in particular, anticipate a relatively rapid increase in their exports in the future. Accordingly, the demand-pull of the global markets can be considered a key external driver for anticipated future sales of the Finnish biotechnology companies. However, the variable "anticipated change in exports" is not utilized in the present study due to a simultaneity and feasibility problem. Anticipated exports growth is deemed to occur simultaneously with anticipated sales srowth. Both are based on the companies' own articulations and this could raise a danger of explaining anticipations by anticipations from the same source.

Many of the early-stage biotechnology companies have no customers. Thus, their success rests on future anticipations. Potentials in research and development increase a company's anticipated sales that, in turn, draw financial investments necessary to continue research and development activities aiming at commercialization. When speaking of the early-stage biotechnology companies, a most important aspect of relational capital is research and development collaboration and investor networks. A strong science base is necessary in order to attract large investments. (Darby and Zucker 2002.)

Relational capital is measured in the present study by seven variables, which are divided into the following three groups

a) university collaboration intensity (university research and development paid from governmental research and development support in euros)
b) sources of equity finance
c) sources of capital loan finance

The equity shares of both private venture capitalists and public venture capitalists measure ownership structures. Hermans and Tahvanainen (2002) showed that the ownership related variables are loaded with value creation. Public research and development support intensity can be viewed from two perspectives. Firstly, in accordance with the name of the variable, it indicates the public sector's willingness to support companies. Secondly, it also reflects the external research collaboration with academic institutions. This is because Finnish authorities have typically set a condition of such collaboration for granting their own research and development support. In Stage 2 of regression analysis, we choose academic collaboration and governmental equity finance and capital loan finance separately as variables measuring relational capital.

Table 3. Description of the external structure variables (in millions of euros).

Statistics	N					
	Valid	Missing	Mean	Median	Std. Deviation	Sum
University research and development in collaborating projects	68	4	0.11	0.001	0.36	7.66
Equity finance from individuals active in business	71	1	0.42	0.03	1.37	29.96
Equity finance from other non-financial companies	72	0	0.56	0.00	2.28	40.04
Equity finance from private venture capital companies	72	0	0.41	0.00	2.12	29.23
Equity finance from governmental venture capital institutions	72	0	0.35	0.00	1.44	25.46
Capital loan finance from private venture capital companies	71	1	0.28	0.00	1.00	19.69
Capital loan finance from governmental venture capital institutions	70	2	0.56	0.02	1.70	39.54

In order to avoid circular argumentation, we exploit the present sales as a measure of the company's present ability to exploit its internal and external intellectual capital. This decision is made following the argumentation of Ahonen (2000) and Hussi and Ahonen (2002). The above thinking predicts that value creation occurs in the interaction between

external and internal factors (including human capital) and, therefore, present sales cannot be taken as a predictor for relational capital only. The present sales are taken as a present measure of how effectively commercially exploitable assets have previously been utilized.

3.2.2 Commercially exploitable intangible assets

To a great extent, the anticipated sales seem to rely on the market potential of the future, and not on the present sales and present market share. Almost one third of the sample companies had annual sales of less than 100 thousand euros (see Table 4). The oldest companies had relatively high sales volumes. Present sales are an estimator to measure the part of the intangible assets that are already exploited commercially. Among the sample companies, the anticipated sales in years 2001 - 2006 were on average expected to grow at about 45 percent annual rate. The anticipated sales are a prime determinant in the valuation of the company. In the next section, anticipated sales will be the dependent variable in the regression analysis and will be explained by the indicators of intellectual capital.

Table 4. Description of the present and anticipated sales (in millions of euros).

Statistics	N					
Millions of euros	Valid	Missing	Mean	Median	Std. Deviation	Sum
Sales in 2001	72	0	1.80	.20	4.96	129.85
Anticipated sales in 2006	70	2	11.73	1.40	31.78	821.12

3.3 Statistical procedure

We operate in two stages when we conduct the statistical procedure. First, we try to find the forms of interactions between the three categories of intellectual capital (IC). According to the knowledge management theory, this is important for two reasons. First, the value creation in business activities is connected to the interactions between the three categories of intellectual capital. Second, there can be interactions, which are not strictly connected to the value creation. It is important to separate the latter kind of interactions from those that create value. Despite the fact that we employ cross-sectional data, the analysis is dynamic in a similar sense as Bonfour (2002). We are interested in the valuation of assets and the input-output relations of intellectual capital.

Our statistical procedure consists of two stages

Stage 1: Factor analysis is used to identify the three intellectual capital factors and produce factor scores for each company.
Stage 2: Regression analysis is used to explain the companies' anticipated sales in 2006. The intellectual capital factors are formed by factor scores produced in Stage 1. The factor scores are used as variables in the regression model. In other words, the output of the factor analysis is used as predictors that explain the anticipated sales of the sample of biotechnology companies.

The idea in the first stage is to find the common variation between the variables and form the intellectual capital factors discussed above. Because an orthogonal factor analysis method is applied, the factors are uncorrelated with each other, which is an advantage in regression analysis. This lowers the risk of multicollinearity. Factor scores are constructed from the factors and they are used as new variables in Stage 2.

Our attempt is to explain the anticipated sales of the companies based on the knowledge management approach. Regression analysis is used to produce three alternative models. Firstly, we use original variables without the results of the factor analysis. Secondly, we construct a regression model with all the factors received from Stage 1. Thirdly, we regress only statistically significant factors and add some significant dummy variables found in the data.

4 RESULTS

4.1 Factor analysis

Factor analysis produced four factors in Stage 1. Applying generalized least squares (GLS) method the factors interconnected the variables within three intellectual capital components mentioned above (see e.g. Sharma 1996). We took natural logarithms from other than ratio variables or dummy variables. Appendix 1 presents the communalities for each variable. It shows that the factor model explains 28 - 78 % of the variance of a single variable. The model can explain 73 % of the total variance of all the variables (see eigenvalues in Appendix 1).

Table 5. Factor matrix.

	Factor								
	1	2	3	4	5	6	7	8	9
Turku (=1)	**0.845**	-0.021	-0.026	-0.161	-0.145	**0.486**	-0.002	-0.001	0.000
Helsinki (=1)	**-0.786**	0.115	-0.147	-0.166	**0.369**	**0.427**	-0.002	0.001	-0.001
Diagnostics	**0.329**	**-0.554**	**-0.512**	0.192	**0.530**	-0.067	0.000	0.000	0.000
Doctors and licentiates (log)	**0.345**	**0.529**	**0.419**	**0.387**	**0.524**	-0.005	-0.008	-0.002	0.001
Anticipated change in exports per turnover	0.259	**0.456**	0.043	**-0.381**	0.075	0.070	0.220	0.104	-0.167
Pharma (=1)	0.085	**0.323**	0.168	0.127	0.215	-0.114	0.188	0.013	-0.132
Capital loan finance from private VC (log)	0.071	**-0.394**	**0.592**	**-0.634**	0.284	-0.078	-0.001	0.000	0.000
Present sales (log)	-0.243	**-0.551**	**0.466**	**0.602**	-0.147	0.189	-0.004	0.002	-0.001
Personnel (log)	-0.001	0.041	**0.446**	**0.526**	0.170	0.101	**0.487**	-0.041	-0.184
Capital loan finance from government VC (log)	0.072	0.098	0.281	**-0.331**	0.048	0.032	0.189	0.048	0.182
Agriculture (=1)	-0.170	-0.073	0.063	0.104	-0.243	-0.037	0.194	-0.120	-0.074
Patents and patent applications (log)	0.021	0.053	0.094	0.118	0.227	0.192	**0.772**	-0.130	-0.093
Expenditures on university collaboration (log)	0.265	0.277	0.259	0.071	0.179	0.108	**0.659**	-0.195	0.038
R&D expenditures (log)	0.166	0.175	**0.446**	0.279	0.275	0.198	**0.553**	-0.162	-0.162
Services (=1)	0.072	0.058	**0.308**	-0.068	-0.124	0.073	**-0.427**	0.111	0.103
Equity finance from other companies (log)	-0.157	-0.222	**0.298**	0.270	-0.217	-0.056	**0.330**	-0.196	-0.156
Biomaterials (=1)	0.004	-0.124	0.219	-0.099	-0.151	0.044	0.232	-0.155	0.202
Industrial enzymes (=1)	-0.095	-0.005	-0.067	0.022	-0.093	0.080	-0.166	-0.074	-0.124
Equity finance from government VC (log)	**0.441**	0.215	0.240	-0.031	0.169	0.115	0.244	**0.629**	-0.090
Equity finance from private VC (log)	0.274	0.150	0.081	0.165	0.267	-0.097	**0.448**	**0.544**	0.089
Equity finance from persons active in business (log)	0.090	0.249	-0.026	0.056	0.136	0.064	0.164	**0.497**	0.271
CEO experience (log)	-0.145	-0.068	0.237	0.151	0.133	**0.301**	**0.379**	-0.213	**0.601**
Age of company (log)	-0.219	**-0.365**	-0.067	**0.351**	-0.053	0.045	0.279	0.066	**0.425**
Problems in skilled labor supply (=1)	-0.173	0.194	0.112	0.091	0.210	0.116	-0.087	-0.107	-0.270

Factor loadings ≥ 0.30 bolded.
Extraction Method: Generalized Least Squares.

A 9 factors extracted. 18 iterations required.

B Only cases for which SME biotech firm = 1 are used in the analysis phase.

Then, using the factor solutions presented in Table 5, we produced factor scores for each case company and factor by multiplying the factor loadings by the values of the initial variables.

4.2 Regression analysis

The outcome generated by the intangible assets is the anticipated future sales in Figure 4 instead of long-run productivity of capital in Figure 3. The anticipated sales approximate the productivity of capital due to the following reasoning. The biotechnology industry resembles pharmaceutical industry in the sense that both have extremely long product development processes. Consequently, as many as one third of the companies in the sample are involved in the development of pharmaceutical products. Furthermore, when Scherer and Ross (1990) and Linnosmaa, Hermans, and Karhunen (2002) analyzed price-cost margins in the pharmaceutical industries in the USA and Finland, they found relatively high price-cost margins in both countries. This implies that physical capital does not play a focal role in the value creation process of the pharmaceutical industry. If this is also typical for the biotechnology industry, it seems reasonable to assume that the anticipated future sales imply growth in productivity of capital. Hence, the original theoretical framework by Hussi and Ahonen (2002) holds for the framework in Figure 4.

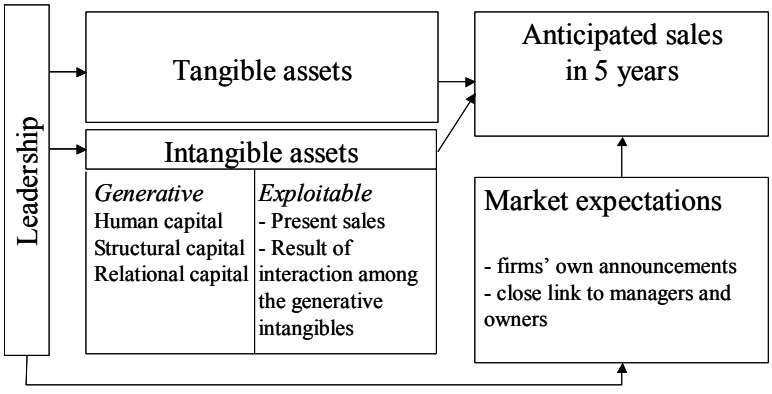

Figure 4. Intellectual assets and anticipated future sales of the company. Modified from Ahonen, Hussi, and Asplund in Hussi 2001.

The regression analysis exploits the theoretical models presented above. First, we utilize the initial variables without factor scores in the regression analysis. The results of the initial variable models are shown in Table 6. Generally speaking, the initial R^2 ratios show

that model 3 explains most of the variance of the variables in the model. However, when the adjusted R^2 is observed, model 2 holds the best fit.[3] In this setting, the anticipated sales are almost entirely explained by the present sales. This describes a size effect (or scale economies) of the companies. Simplifying, if you are big now, you will be expected to be big in the future.

Table 6. Regression model: Explaining anticipated future sales of small and medium-sized biotechnology companies by initial variables.

Dependent variable: Anticipated sales in 2006.

Variable Logarithmized variable (log) Dummy variable (d)	Model 1: without dummies	Model 2: extended model	Model 3: extended model with tangible assets
R^2	.744	.817	.837
Adjusted R^2	.672	.705	.691
F-test	10.384***	7.267***	5.732***
Constant	**1.880** (.909)**	1.666 (1.070)	1.112 (1.644)
Present commercially exploitable assets			
Present sales (log)	**.914*** (.126)**	**.956*** (.144)**	**.912*** (.183)**
Human capital			
Personnel (log)	-.131 (.291)	-.477 (.313)	**-.684* (.385)**
Doctors and licentiates (log)	-.174 (.343)	-.529 (.391)	-.367 (.546)
CEO experience (log)	-.019 (.330)	.070 (.401)	-.697 (.566)
Structural capital			
R&D expenditures (log)	.156 (.154)	.230 (.160)	.284 (.193)
Patents and patent applications (log)	-.037 (.215)	-.121 (.256)	.160 (.331)
Age of company (log)	-.368 (.371)	-.397 (.396)	.152 (.672)
Relational capital			
Equity finance from other companies (log)	.066 (.081)	-.089 (.088)	.122 (.104)
Equity finance from persons active in business (log)	.123 (.087)	-132 (.091)	**.222* (.114)**
Equity finance from private VC (log)	-.130 (.105)	**-.200* (.118)**	-.202 (.135)
Equity finance from government VC (log)	.092 (.098)	**.282** (.118)**	.185 (.168)
Capital loan finance from private VC (log)	.151 (.108)	.029 (.090)	.058 (.162)
Capital loan finance from government VC (log)	.004 (.087)	.055 (.114)	.123 (.119)
Expenditures on university collaboration (log)	.047 (.132)	.136 (.143)	-.039 (.184)
Anticipated change in exports intensity (% units)		.002 (.812)	-.419 (1.063)
Problems in employing skilled labor (d)		**1.136** (.519)**	.797 (.613)
Pharmaceuticals (d)		.217 (.471)	-.153 (.550)
Diagnostics (d)		.566 (.544)	.287 (.721)
Biomaterials (d)		.667 (.553)	.884 (.646)
Industrial enzymes (d)		-.592 (.843)	.203 (1.260)
Agriculture (d)		.152 (.959)	-.171 (1.122)
Services (d)		.569 (.595)	-.129 (.755)
Helsinki (d)		-.064 (.570)	.058 (.657)
Turku (d)		**-1.211* (.632)**	-.746 (.872)
Tangible assets (log)			.108 (.177)

Standard errors are in parentheses. The asterisk labels (*) stand for the level of the statistical risk of denying incorrectly the null hypothesis: the regression coefficient is zero.
* 10 per cent risk level.
** 5 per cent risk level.
*** 1 per cent risk level.

[3] Conventional R^2 increases with the variables included in the model and decreases with the number of cases included in the analysis. The adjusted R^2 takes those matters into account .

When we regress the anticipated sales, explaining the sales in 2006 by the initial variables, only few of the variables are statistically significant. The model loses the interrelation effects of intellectual capital trying to relate intellectual capital measures directly to the value creation (anticipated sales).

Next we conduct the second phase by employing the factor scores formed above in the factor analysis. These factors describe how the three forms of intellectual capital are interlinked to each other. The results of the factor-based models 4, 5, and 6 are presented in Table 7.

In model 4, we employ all the factors received from the generalized least square (GLS) method factor analysis in Stage 1. It implies that factors 2, 4, 5, 6, 8, and 9 do not significantly explain the anticipated sales. Therefore, we drop these factors from model 5. Then we add intangible assets to the analysis in model 6.

Table 7. Regression model: Explaining anticipated future sales of small and medium-sized biotechnology companies by interacting factor scores.

Dependent variable: Anticipated sales in 2006.

Variable	Model 4: all the factors	Model 5: focal factors	Model 6: focal factors and tangible assets
R^2	.724	.703	.722
Adjusted R^2	.678	.688	.700
F-test	**15.736*** **	**47.273*** **	**31.869*** **
Constant	**7.001*** (.180)**	**7.009*** (.177)**	**5.800*** (1.313)**
Factor 1: RC + HC	**.461 (.192)****	**.468** (.188)**	.297 (.270)
Factor 2: HC + RC + SC + non commercial exploitability	-.100 (.195)		
Factor 3: RC + HC + SC + commercial exploitability	**2.137*** (.193)**	**2.125*** (.188)**	**2.029*** (.260)**
Factor 4: HC + SC + commercial exploitability	.010 (.185)		
Factor 5: RC + HC	.194 (.183)		
Factor 6: RC + HC	.135 (.214)		
Factor 7: HC + SC + RC	**.461** (.178)**	**.458** (.175)**	**.371* (.198)**
Factor 8: RC + HC	-.217 (.181)		
Factor 9: HC + SC	.155 (182)		
Tangible assets			.100 (.118)

Standard errors are in parentheses. The asterisk labels (*) stand for the level of the statistical risk of denying incorrectly the null hypothesis: the regression coefficient is zero.
* 10 per cent risk level.
** 5 per cent risk level.
*** 1 per cent risk level.

Model 6 is able to explain 70 percent of the regressors' variance according to the adjusted R^2. That is, the independent variables in model 6 are able to predict systematically 70 percent of the variation of anticipated sales. The successful predictors are the chosen intellectual capital factors. As a result, the company anticipates high sales if the company's intellectual capital is well balanced according to factors 3 and 7 in models 4, 5, and 6. Factor 1 deviates also significantly from zero in models 4 and 5, but remains insignificant in model 6 (see also the sensitivity analysis in Section 4.3). Tangible assets do not deviate significantly from zero in both models.

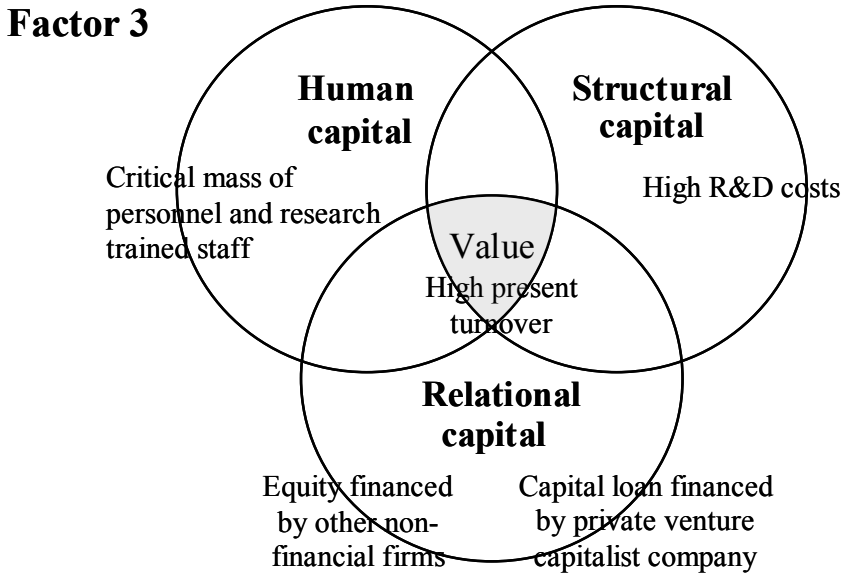

Figure 5. Intellectual capital (IC) driven value creation within the small and medium-sized biotechnology companies (factor 3).

The intellectual capital (IC) driven value creation of factor 3 is depicted in Figure 5. There is the following interaction within the three intellectual capital categories explaining high anticipated sales. A critical mass of personnel and doctors are directed to research and development activities, which are financed by capital loans from private venture capital companies. These biotechnology companies are often partly owned by other companies. The sample companies have already been able to generate some sales.

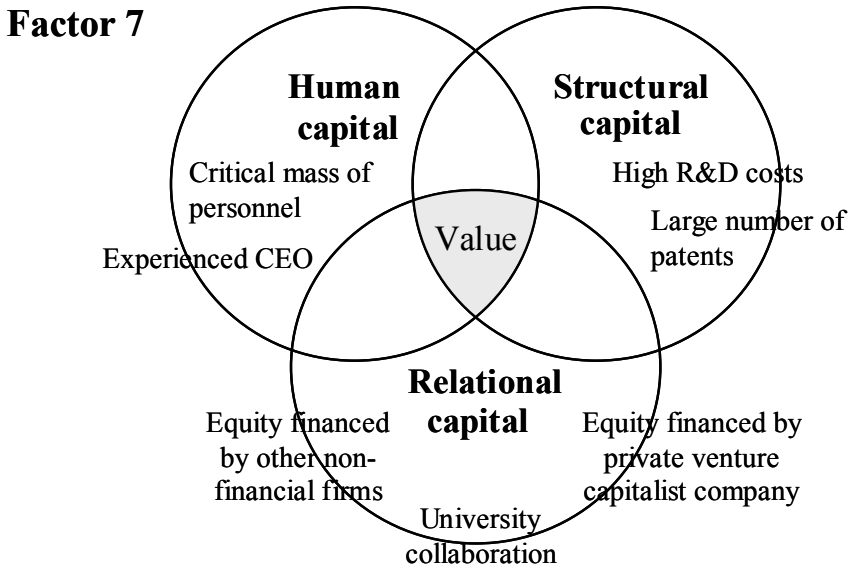

Figure 6. Intellectual capital (IC) driven value creation within the small and medium-sized biotechnology companies in (factor 7).

Factor 7 presents how Saint-Onge's *et al*. value platform is concretized within the Finnish biotechnology industry (Figure 6). The company still does not have an above normal present sales level as was the case in factor 3. The company's personnel are directed to research and development activities and the company collaborates with academic research institutions. In addition, the company owns a large portfolio of patents or patent applications, and the company is managed by an experienced CEO. A high proportion of these companies are partly owned by private venture capital companies or other companies.

Factor analysis seemed to be able to divide the size effect more effectively than the first regression model with the initial variables. For example, factor 4 is closely related to the present sales and the critical mass of personnel with a high number of doctors as factor 3 is, too. In contrast, factor 4 is not loaded with research and development activities, number of patents, or university collaboration. Most interestingly without a link to these research-oriented assets, factor 4 does not explain significantly the anticipated sales of the companies.

4.3 Sensitivity analyses

In order to test how sensitive the results presented above are in relation to the compressing method we employ the principal component analysis (PCA) instead of the generalized least

square (GLS) method factors. Then we apply the principal component scores in regressing the intellectual capital interactions towards the anticipated sales of the biotechnology companies. The results remain mainly parallel in the principal component analysis. The R^2 of the regression model applying the principal component analysis is 61.4 %, which is somewhat lower than in the analysis applying the factor analysis. Four significant principal components were found instead of the three (or two) factors explaining the anticipated sales.

The principal component analysis comprises qualitatively similar basic features as the factor analysis. However, the role of governmental funding and the pharmaceutical branch are linked to the same component as factor 7. In the principle component analysis, a component related to factor 3 could be identified, however, it had added features such as long CEO experience, high age of the company, and some agriculture related activities. The variables related to the region of the companies do not seem to be robust in this benchmark model. The Helsinki region with business experienced leaders and capital loans from government institutions explain part of the anticipated sales in the benchmark model. Part of the anticipated future sales is explained by service companies that are already generating some sales and are owned by individuals active in business.

Another sensitivity analysis was made by performing the same research analyses using relative measures instead of the absolute measures. The relative measures were attained from the absolute measures by dividing each of the values of the original variables by an appropriate figure representing the size of the corresponding company. Obviously, this transformation was not needed for dummy variables or variables which already are rational variables. Appropriate figures for dividing the values of original variables were, for example, total costs or personnel of the company.

In the generalized least square (GLS) factor analysis done with the relative measures, three factors significantly explained the anticipated sales. The R^2 of the regression model utilizing relative measures is 29.8 %. The first factor had positive loadings with the variable describing other companies' relative equity share and with the company's innovation intensity, which was measured by the ratio of patents and patent applications to research and development labor. The first factor had a negative loading with the relative equity share of individuals active in business. The second factor had a positive loading

with the ratio of present sales to labor, with the logarithmized age of the company and with government venture capitalists' relative equity share. The third factor had a high loading with the ratio of present sales to labor. The factors 1, 2, and 3 were related to the branches of agriculture, service, and diagnostics, respectively.

The factor analysis applying the relative measures was not able to reveal the detailed structures behind the anticipated sales. This analysis stressed the importance of the present sales per labor and of branch specific features. These results, together with the results of the principal component analysis above, raise a need for a closer look at branch specific phenomena within the biotechnology industry.

5. CONCLUSIONS

The present study relates the knowledge management theory and the measurement of intellectual capital (IC) to the anticipated sales that small and medium-sized biotechnology companies have articulated. According to the literature, the interaction of the three categories of intellectual capital, namely human capital, structural capital, and relational capital, create value.

We tested the theoretical framework among small and medium-sized Finnish biotechnology companies. In the first stage of empirical analyses, we identified factors that present interaction between the variables measuring the different categories of intellectual capital.

In Stage 2 of the empirical analysis, we constructed two kinds of regression models that explained the anticipated sales of the companies. Firstly, we utilized the initial variables. Secondly, we exploited factor scores from Stage 1. The regression models implied that the strict effects of single initial variables without interaction explained the anticipated sales at a general level as much as the factor-based variables that take into consideration the interaction between the categories of intellectual capital. The initial variable model stressed the present ability of commercialization as an explanation for anticipated future sales.

The factor-based model seemed to be able to separate some size-effect features. Particularly, two factors were found that systematically explain the anticipated future sales. Both of these factors link to some degree human capital, structural capital, and relational capital. Firstly, the critical mass of highly educated personnel is directed to research and development activities. These companies are partially owned by other companies and they have already generated some sales. Secondly, the educated human capital is involved in research and development activities as above. Furthermore, the company has a large patent portfolio and is managed by an experienced CEO who favors external academic collaboration. The ownership that other companies and or private venture capital companies have in the biotechnology companies was connected to the three components of intellectual capital.

Three paths for further research are evoked by the present study. Firstly, in the present study some preliminary results concerning explanations for the anticipated future sales of Finnish biotechnology companies were obtained. Deeper analyses could help to build various economic forecast models. These could be, for example, industry specific or region-based. Secondly, a follow-up study of the same sample of companies would be very attractive. In it the real sales of 2006 could be compared to the anticipated sales, which was articulated by the company managers in 2002. What kind of companies were the most successful in realizing their anticipated sales? Thirdly, it would be interesting to investigate to what degree various kinds of investors have been able to select the companies, which have turned out to be the most successful in terms of economic profitability and in terms of continuous intellectual capital development.

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Appendix 1. Communalities and total variance explained by factor analysis.

Table A1.1 Communalities of the factor analysis

Communalities(a,b)		
	Initial	Extraction
Sales	0.751	0.999
RDcost	0.779	0.841
Person	0.778	0.833
Ceoexp	0.570	0.788
Patent	0.692	0.811
Age	0.568	0.669
Docs	0.691	0.999
Firminv	0.552	0.661
Activinv	0.456	0.611
PrVCinv	0.652	0.789
GovVCinv	0.683	0.855
GovVCL	0.420	0.526
PrVCL	0.415	0.999
UnivRD	0.717	0.802
Dexport	0.622	0.730
ProbPers	0.335	0.447
Pharma	0.378	0.480
Diagnost	0.498	0.999
Biomater	0.305	0.410
IndEnz	0.287	0.457
Agricult	0.276	0.356
Service	0.449	0.552
Helsinki	0.546	0.999
Turku	0.631	0.999

Extraction Method: Generalized Least Squares.

a Only cases for which SME biotech firm = 1 are used in the analysis phase.

b One or more communality estimates greater than 1 were encountered during iterations. The resulting solution should be interpreted with caution.

Appendix 1, continues.

Table A1.2 Total variance explained by generalized least square (GLS) method factors.

Total Variance Explained(a)

Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.546	18.943	18.943	2.246	9.360	9.360	3.332	13.885	13.885
2	3.238	13.493	32.435	1.872	7.802	17.162	1.951	8.128	22.013
3	1.889	7.869	40.305	1.988	8.284	25.446	1.932	8.049	30.062
4	1.745	7.270	47.575	1.932	8.049	33.495	1.382	5.760	35.822
5	1.523	6.345	53.920	1.393	5.804	39.299	1.319	5.496	41.319
6	1.400	5.834	59.754	0.733	3.053	42.352	1.298	5.407	46.726
7	1.242	5.175	64.929	2.618	10.907	53.259	1.288	5.367	52.092
8	1.083	4.514	69.443	1.191	4.963	58.221	1.222	5.091	57.184
9	1.023	4.261	73.704	0.949	3.956	62.177	1.198	4.994	62.177
10	0.849	3.537	77.241						
11	0.829	3.455	80.697						
12	0.754	3.144	83.840						
13	0.673	2.803	86.643						
14	0.518	2.158	88.802						
15	0.475	1.980	90.781						
16	0.450	1.875	92.656						
17	0.345	1.436	94.092						
18	0.318	1.326	95.418						
19	0.278	1.158	96.576						
20	0.228	0.950	97.526						
21	0.194	0.809	98.335						
22	0.177	0.736	99.072						
23	0.113	0.471	99.543						
24	0.110	0.457	100						

Extraction Method: Generalized Least Squares.

Only cases for which SME biotech firm = 1 are used in the analysis phase.

Appendix 2. Finance structure (Equity and capital loan finance from different sources)

Table A2.1. Estimated distribution of aggregate equity, capital loans, and debt by firm size and age (Hermans and Tahvanainen 2002).

	Equity	Capital loans	Debt	Total
A: All (N=72)				
%	43.6 %	31.5 %	24.9 %	100.0 %
(amount, mill.€)				305.3
B: Breakdown by size of SME				
Small	-6.9%	70.9 %	36.0%	100.0 %
(amount, mill.€)				32.7
Large	49.3 %	27.1 %	23.6 %	100.0 %
(amount, mill.€)				274.7
C: Breakdown by age of SME				
Infant	39.5 %	46.2 %	14.3 %	100.0 %
(amount, mill.€)				162.7
Adolescent	41.0 %	27.0 %	32.0 %	100.0 %
(amount, mill.€)				64.1
Middle-aged	54.4 %	4.6 %	41.0 %	100.0 %
(amount, mill.€)				78.4
Old	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)				n.a.

Table A2.2. Estimated distribution of equity by firm size and age (Hermans and Tahvanainen 2002).

	Individuals		Institutions					
	Active in business	Other individ.	Public VC	Private VC	Financial instit.	Other companies	Other equity	Total sources of equity
A: All (N=72)								
%	22.8 %	5.2 %	19.4 %	24.3 %	2.2 %	22.0 %	4.2 %	100.0 %
(amount, mill.€)								215.0
B: Breakdown by size of SME								
Small	32.1 %	2.8 %	27.1 %	7.3 %	1.8 %	24.9 %	4.0 %	100.0 %
(amount, mill.€)								14.4
Large	22.1 %	5.3 %	18.8 %	25.5 %	2.2 %	21.8 %	4.2 %	100.0 %
(amount, mill.€)								200.7
C: Breakdown by age of SME								
Infant	28.9 %	6.1 %	24.0 %	37.8 %	0.5 %	2.4 %	0.3 %	100.0 %
(amount, mill.€)								116.1
Adolescent	22.7 %	7.7 %	25.8 %	14.2 %	7.6 %	18.1 %	3.7 %	100.0 %
(amount, mill.€)								50.8
Middle-aged	8.2 %	0.2 %	1.3 %	2.3 %	0.5 %	73.3 %	14.2 %	100.0 %
(amount, mill.€)								48.2
Old	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)								n.a.

Appendix 2, continues.

Table A2.3. Distribution of capital loans by firm size and age (Hermans and Tahvanainen 2002).

Table 2.7

	Private Dom. fin. instit.	Foreign fin. instit.	Foreign VC	Private VC	Public Public VC	Sitra	Finnvera	Tekes	Other govt. & public	Other	Total
A: All (N=72)											
%	0.6 %	0.0 %	4.0 %	18.1 %	0.4 %	13.7 %	0.3 %	53.4 %	0.0 %	9.6 %	100.0 %
(amount, mill.€)											96.2
B: Breakdown by size of SME											
Small	2.5 %	0.0 %	16.9 %	18.4 %	0.0 %	37.7 %	1.4 %	19.2 %	0.0 %	4.0 %	100.0 %
(amount, mill.€)											21.7
Large	0.0 %	0.0 %	0.3 %	18.0 %	0.6 %	6.7 %	0.0 %	63.3 %	0.0 %	11.2 %	100.0 %
(amount, mill.€)											74.5
C: Breakdown by age of SME											
Infant	0.7 %	0.0 %	5.1 %	22.5 %	0.6 %	11.4 %	0.2 %	48.0 %	0.0 %	11.4 %	100.0 %
(amount, mill.€)											75.2
Adolescent	0.0 %	0.0 %	0.0 %	1.4 %	0.0 %	20.1 %	0.7 %	76.1 %	0.0 %	1.7 %	100.0 %
(amount, mill.€)											17.3
Middle-aged	0.0 %	0.0 %	0.0 %	5.4 %	0.0 %	29.9 %	0.0 %	55.4 %	0.0 %	9.3 %	100.0 %
(amount, mill.€)											3.6
Old	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
(amount, mill.€)											n.a.

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