Capabilities for innovation in small firms – a study of 131 high-tech firms and their relation to performance

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Abstract: Organisational capabilities have been widely discussed – most often at a conceptual level and from a large firm perspective. This paper examines the operationalisation and measurement of the capabilities for innovation in small firms and also how capabilities may be related to the firm's innovation performance. Based on a quantitative analysis of 131 small high-tech firms, this paper describes and analyses the dimensions critical for innovation with a special focus on very small high-tech firms. We propose a construct for investigation including five dimensions relating to small firm capabilities and their relation to innovation performance. We found 20 relationships between the capabilities dimensions and innovation performance, of which the performance dimension of 'patent' showed to be particularly correlated to capabilities. Our statistical analysis shows that two latent constructs have a positive effect on innovation performance: cooperation with universities and business planning and advice.

Keywords: capabilities for innovation; innovation performance; small high-tech firms; small firm capabilities.

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1 Introduction

The capability literature is based on the resource-based view of the firm (Barney, 1991; Grant, 1996; Penrose, 1959, 1960; Wernerfelt, 1984). The literature on organisational capabilities describes how firms deploy their resources to develop competitive advantage (e.g. Nonaka and Kenney, 1991; Prahalad and Hamel, 1990) and how the resource base must be reconfigured and developed strategically to adapt to change in the environment, according to the dynamic capabilities perspective (e.g. Danneels, 2011; Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Teece, 2007; Teece et al., 1997; Zollo and Winter, 1999, 2002). Typically, the notion of capabilities is described in terms of firm building blocks (Christensen, 1997) or core capabilities (Leonard-Barton, 1992). Christensen categorises an organisation's capabilities as consisting of resources, processes and values.

While Leonard-Barton describes the firm as the set of knowledge that provides competitive advantage. According to Leonard-Barton, a firm's capabilities have four dimensions: employee knowledge and skills, technical systems, the managerial systems that guide the knowledge creation and control processes and the values and norms associated with these processes.

Recently, research has focused on the capability to innovate for firms (or innovation capabilities), e.g. Francis and Bessant (2005), Olsson et al. (2010), Assink (2006), Danneels (2011), Börjesson and Elmquist (2011, in press), Burgelman et al. (1988), Colarelli O'Connor (2008), Colarelli O'Connor et al. (2008), Chiesa et al. (1996), research on this area is though limited and largely conceptual. There is a clear need for more empirically based studies (Helfat et al., 2007; Zollo and Winter, 2002). Also, the existing research and the knowledge and concepts developed are related mainly to large firms and the challenges they face to build and sustain capabilities. Very few studies focus on small firms. While a number of studies have looked at the impact of intellectual capital on small firm performance or the role of incubators, the other dimensions of capabilities and their relationship with firm performance for innovation have been overlooked. In this paper, we propose an approach to investigate key dimensions of capabilities for small firms, arguing that these are different and need to be expressed (and developed) differently.

Small high-tech firms are new firms established with the purpose of exploiting an invention or technological innovation associated with a high-technological risk (Little, 1979). These firms, therefore, are associated with high risk, but if they survive can make a huge contribution to the region and industry in the long term (Lindström and Olofsson, 2001). In this study, we study small high-tech firms, i.e. entrepreneurial firms. According to Borch et al. (1999), entrepreneurial firms exploit strategies related to innovation and growth characterised by risk-taking. Van der Auwera and Eysenbrandts (1989) propose a set of specific advantages related to small as opposed to medium/large new high-tech firms in Belgium. New high-tech firms enable greater job flexibility and are less hierarchical. The flow of information between management and production is faster, and they have a better overview of the innovation process. Small firms have direct relationships with suppliers and customers and can respond more rapidly to demand from abroad.

The small firms in our study are localised in incubators which aim to foster the development of small high-tech firms by mediating and facilitating the development of resources and capabilities. Many national and regional governments fund incubators to secure the survival and growth of new technology-based firms (NTBF). In Sweden, in 2010, there were more than 40 incubators and around 900 at the European level (CSES, 2002; SiSP, 2007). This implies large sums of public money, which in turn implies the need for an evaluation of these incubators. According to Bergek and Norrman (2008), the concept of 'incubator' is often used as an overall denomination for organisations that are conducive to the 'hatching' and development of new firms (Chan and Lau, 2005). Aerts et al. (2007) found that business incubators guide starting enterprises through their growth process and as such constitute a strong instrument to promote innovation and entrepreneurship.

We argue that there is a need to examine a broad set of capabilities and investigate the relationship to actual (innovation) performance for small high-tech firms, and especially very small high-tech firms firms (1–9 employees). In this paper, we propose a construct to explain capabilities for innovation in small firms. This paper discusses and analyses the dimensions critical to innovation performance. Our objective is to broaden the focus of both small firm capabilities for innovation and what these capabilities mean for firm innovation (innovation performance). This paper presents the findings from an exercise designed to measure the capabilities for innovation and innovation performance in 131 small high-tech (and innovative) firms localised in 16 incubators in Sweden. In this study, we see capability as consisting of five dimensions (36 variables) and innovation performance as consisting of one dimension (five variables). All the firms in the sample are research and knowledge-intensive and belong to sectors such as software/information technology, electronics/electrical, pharmacology and pharmaceutical preparations, mechanics, etc. This paper aims to contribute to the literature on organisational capabilities in that it addresses capabilities for small firms and the relation between capabilities and performance in general.

This paper is structured as follows: in Section 2, we present some notions pertaining to capabilities and innovation performance, and construct a research proposition in this study. Section 3 describes the methodology, the sample, means, frequencies and type of investigation. Section 4 presents the empirical findings and discusses the patterns of the linkages between innovation capabilities and firm innovation performance. Section 5 discusses the results and outlines directions for future research. Section 6 presents the main conclusions.

2 Framework and research proposition

2.1 Capabilities for innovation

Capability-based theories describe and explain how organisations change and develop. In general terms, organisational capabilities signify what an organisation is able to do.

Organisational capabilities correspond to the ability of the firm to deploy its available resources as its main assets (Prahalad and Hamel, 1990). Organisational capabilities are defined by Helfat and Peteraf (2003, p.999) as 'the ability of an organisation to perform a coordinated set of tasks, utilising organisational resources for the purpose of achieving a particular end result'. Firm resources include all the assets, capabilities, organisational processes, information, knowledge, firm attributes, etc. controlled by the firm (Daft, 1983). These firm-specific heterogeneous resources fall into three general categories:

1 physical capital resources (plant and equipment)
2 human capital resources (skills and know-how)
3 organisational capital resources (capabilities associated with formal and informal planning, controlling and coordinating) (Barney, 1991).

Organisational research suggests that firms in dynamic environments with high levels of information processing, communication and knowledge transfer are more likely to develop competencies which will result in successful technology innovation than firms in the same type of environments with lower levels of cooperative resources (Coff, 1997; Henderson and Cockburn, 1994).

Dynamic capability can be described as the ability to change existing capabilities. The need to revise and develop organisational capabilities – the perspective of dynamic capabilities – has been emphasised (Colarelli O'Connor et al., 2008; Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Helfat et al., 2007; Teece et al., 1997; Zollo and Winter, 1999, 2002). Dynamic capabilities thus refer to a firm's ability to renew its resources in an effort to address a changing environment (Danneels, 2011). Research that specifically addresses the capabilities for innoavtion is rather scarce with a few late exceptions (Assink, 2006; Börjesson and Elmquist, 2011, in press; Colarelli O'Connor, 2008; Colarelli O'Connor et al., 2008; Danneels, 2011; Francis and Bessant, 2005; Olsson et al., 2010). The research on capabilities for innovation – which should be noted has mainly a large firm perspective – shows that large, established firms face several different barriers to the development and commercialisation of innovations (Colarelli O'Connor, 2008), and change is the main obstacle to developing capabilities for innovation in large firms. Small firms, however, have other challenges. In the case of small firms, research on 'capabilities' has been confined most to the role of incubators and commercialisation and focuses much less on the notion of capabilities.

In terms of small firms and their innovativeness, Amirahmadi and Saff (1993) point out six factors that were important in Silicon Valley's success:

1 availability of technical expertise
2 availability of pre-existing infrastructure
3 availability of venture capital
4 job mobility
5 information exchange networks
6 spin-offs from existing firms.

Whereas other authors point at the role of the manager (e.g. Löfsten and Lindelöf, 2001; Wiklund, 1998). The attitudes and motivation of the firm founders and managers are a key factor in the ability to raise funds and achieve high growth and profitability (Löfsten and Lindelöf, 2001). Furthermore, Löfsten and Lindelöf argue that typically, organisational capabilities in small high-tech firms with one or only a few employees are oriented around the capabilities of one person and his or her ability to attract capital (Löfsten and Lindelöf, 2001). Wiklund (1998) lists 11 empirical studies that have employed some variant of the measured entrepreneurial strategy and firm behaviour under different labels (entrepreneurship, entrepreneurial behaviour and strategic posture). Entrepreneurial orientation is often conceptualised as a latent construct comprising three dimensions: innovativeness, risk-taking and proactiveness. These three components of entrepreneurship are argued by Miller (1983) to comprise a basic, undimensional strategic orientation. Innovativeness involves seeking creative or unusual solutions to problems and needs. The risk-taking dimension refers to the willingness of management to commit significant resources to opportunities in the face of uncertainty, and this capability is a general attitude to strategy, i.e. 'a way of thinking business': those firms with dynamic and positive leadership that are seeking strong growth, are much more likely to be successful. This contrasts with those founders who are less aggressive and are unwilling to assume the risks associated with rapid growth (Monck et al., 1988).

In the broad research about incubators it is often argued that incubators provide a networking benefit. The ready availability of external advice and support can be of crucial importance to the small technology business in its formative years. Networks are especially important for small firms and can be seen as a resource that enables access to other resources and capabilities such as capital, innovation and advice (Uzzi, 1996, 1997; Zukin and DiMaggio, 1990). Entrepreneurial networks can be formal or informal (Birley, 1985). Informal networks include personal (friendship) relations, family contacts and business partners. Formal networks consist of suppliers of capital, such as venture capitalists and banks, creditors and professionals such as accountants, lawyers and trade associations (Das and Teng, 1997).

Proximity between incubator-based located small high-tech firms (as for the firms in this study) and a university promotes a natural exchange of ideas (Deeds et al., 2000) and, as Balconi et al. (2004) argue it is the proximity that supports the university-industry structure for networking and technology transfer. Also proximity to important customers, business advisers and competitors are considered being important factors (Löfsten, 2010). Proximity between firms and universities promotes the natural exchange of ideas through both formal and informal links. Formal methods include licensing and cooperative alliances (Lane and Lubatkin, 1998), while informal methods include mobility of scientists and engineers, social meetings and discussions (Pouder and St. John, 1996). Formal and informal exchanges provide information not only regarding formal projects, but also about ongoing research among other firms and organisations. The close proximity between the small high-tech firms and the nearby academy is assumed to create a setting for technology transfer processes and effects on technology innovation capability.

The proportion of qualified engineers employed in a firm is normally one indication of research and development (R&D) effort and intensity. Technological innovativeness has been linked to the percentage of scientists and engineers employed (Markusen et al., 1986). According to Lindelöf and Löfsten (2002), it is obvious that science park small high-tech firms have higher R&D intensity than off-park firms in terms of importance of R&D for starting a firm and post-graduate education, but they found no correlation between increasing levels of qualified levels of engineers/scientists employment and the number of patents. However, the lack of competence is seen as an obstacle against a continuous development of innovations, and in addition, the university is seen as the main source of recruitment, ideas and expertise for small high-tech firms. Some managers in the small high-tech firms have been appointed directly from industry or government institutions and universities, approximately evenly between marketing, management, finance, research and technology.

2.2 Innovation performance

Innovation resources are required to produce technological innovation, but are rarely sufficient on their own to assure commercial benefit. Intellectual property rights, patents and the launch of new products are major considerations in university-industry collaborative ventures. Patenting and patents can be used as a measure of firm output, but for the majority of small firms undertaking R&D, the ultimate goal is the launch of new products. The typical development pattern for new firms is an initial heavy dependence on contract R&D activities. Innovation for most firms – small and large – is a top strategic priority. However, from a practical point of view, there are difficulties related to measuring the actual impact of innovation on performance. For example, in a survey of senior managers performed by the Boston Consulting Group (BCG, 2007), it was found that very few companies track their innovation efforts and despite being aware of the importance of metrics and mesurement it was hard to find measures (BCG, 2007). The BCG study found that the majority of companies used a small number of metrics to measure their innovation activities and the most widely tracked components were profitability (82% of respondents), time to market (62%) and ideas generation (61%). Surprisingly, patents were not mentioned. Chiesa et al. (1996) in a conceptual piece of work propose a useful although very complex framework for measuring innovation performance and suggest some qualitative measures such as concept generation, product development effectiveness (typically time to market, product performance, design performance), technology aquistion, resourcing, etc. (Chiesa et al., 1996, p.115).

It could be argued, therefore, that innovation is related to the firm's overall results and business performance and can be measured using means such as profitability and market share, or for small firms, simply growth. One the other hand, innovation and innovation performance could be linked to dimensions related to the ability to introduce new products and services to the market, involving complex qualitative measures. It could also be argued that the problem is not what to measure, but how to organise measurement in an efficient and value creating manner, from both a practical and an academic point of view. There is a dearth of studies focusing on firm performance related to innovation. Also, very few studies deal with the role of capabilities for firm innovativeness or ability to innovate, and especially among very small firms.

2.3 Research proposition

The empirical evidence provided in this study is restricted to industries where

1. the technological environment is dynamic or hostile
2. perceived uncertainty is high
3. as a result there is a need for new information.

In such industries, technological innovations can be expected to range from dynamically continuous to discontinuous (Lin and Zaltman, 1973). The research proposition in this study relates specifically to the prerequisites for innovation for small firms – the capabilities for innovation. In our study, we use five dimensions to determine the capability for innovation for small high-tech firms:

- *skills* (work experience and education)
- *motivation drivers* (attitudes and motivation of the firm's founders and managers)
- *behaviour* (strategic posture and attitudes)
- *business* (basic dimensions of a firm's business planning and perspective on the environment)
- *external networks* (R&D and business networks).

It is recognised generally that in technologically intensive industries, competitive firms need a set of core resources and core capabilities aside from the actual technology. Being innovative is not the same as being successful at commercialisation, which implies the long-term ability to deliver new knowledge, concepts and products to the market. In our study, we are interested in investigating the relationship between capabilities for innovation and actual performance. Small high-tech firms, both in incubators and outside of them, are perceived as 'very innovative' and their good innovation performance we suggest is explained by the capabilities to innovate. Our research proposition is that:

> The proposed dimensions of innovation capabilities in small high-tech firms have an influence on their innovation performance.

3 Method

3.1 Methodological design

This paper is based on a sample of 131 (NTBF) in Sweden and the data collection was undertaken in spring 2005. The firms in the sample were localised in 16 incubators and include small, new and recently established firms. Incubators and related organisations are a relative novelty in Sweden. The first incubators were established in 1980s. There is some evidence that incubators can promote industry renewal and growth. This has generated interest from the Swedish government in supporting this initiative. The Swedish National Incubator Programme includes 18 incubators which we used to make our selection of small high-tech firms. We made our selection from only 16 of the 18 incubators because we judged to be more in the nature of firm 'hotels', i.e. with no business support to the located firms. The study covered the following incubators: Inova, Science Park Jönköping, ProNova Science Park, Ideon Innovation, Gothia Business Incubator, Företagsinkubator Teknikdalen, Uppsala Innovation Centre, GU Holding, Karolinska Science Park, Mjärdevi, Uminova Innovation, Stockholm Innovation and Growth, Blekinge Business Incubator, SSE Business Lab, Chalmers Innovation and Malmö Incubator, which hosted a total of 189 – mostly technology – firms. Defining what is and what is not high technology is problematic. We chose a definition based on Monck et al. (1988), i.e. firms that are new knowledge-based, leading edge and R&D-intensive. The incubators host only independent, entrepreneurially managed firms.

3.2 Data collection and the sample

To identify the population and avoid defects of frame, we constructed the following control parameters: no longer in operation, wrong business (no R&D), bankrupt business, mergers and businesses with more than 50 employees. Questionnaires were administered to the small firms in the 16 incubators (respondent: manager/director) during the spring of 2005. After two written and one telephone reminder, we received responses from 133. We rejected two of these as invalid due to incomplete responses to the questionnaire. All measures in the questionnaire were on a five-point Likert-type scale, yes = 1, no = 0, and percentage.

The branches used to classify the firms located in the incubator are software/ information technology, technology consultants, electronics/electrical, pharmacology and pharmaceutical preparation, mechanics and industrial chemistry/plastics. Table 1 presents the broad characteristics of the firms involved. A total of 189 small high-tech firms were surveyed from which we recieved 131 valid responses, a response rate of 69%. Table 1 shows that most of the surveyed firms are new (mean 2.76 years). The tracking of firms inside Swedish incubators was successfully achieved due to the supplementary information regarding organisation name changes and/or organisation changes provided by incubator managers. Growth in this study is not analysed as a separate employment element (<3 years). However, expanding sales are central to a successful innovation process.

Table 1 Means and frequencies of surveyed firms located in 16 incubators

1 Response rate						
N (population)	189					
n (response)	133					
No. of valid firms	2					
Response rate (%)	69.3					
2 Firm size – means and SDs (total population)						
	N		*Mean*		*SD*	
Sales[a] 2004	105		1,679,226		7,533,985	
Employment[b] 2004	108		2.07		4.10	
3 Firm age – means and frequencies						
	Total population			*Response*		
	Mean	*SD*	*Median*	*Mean*	*SD*	*Median*
Age	3.59	2.40	3.0	2.76	1.93	2.0
4 Branch – frequencies (%)	*Total population*			*Response*		
Software/information technology	35.10			41.90		
Technology consultants	18.30			14.00		
Electronics/electrical	6.90			5.60		
Pharmacology and pharmaceutical preparation	16.80			17.70		
Mechanics	9.90			10.50		
Other	13.00			10.30		
Sum	100.00			100.00		

[a]SEK (Swedish crowns).

[b]Number of employees.

Questionnaires tend to be weak on validity and strong on reliability. The artificiality of the survey format reduces validity, which is related to the strength of the conclusions or propositions. Cook and Campbell (1979) define validity as the best available approximation to the truth or falsity of a given inference, proposition or conclusion. Since managers' perceptions are difficult to capture in terms of dichotomies such as 'agree/disagree', 'support/oppose', 'like/dislike', Likert scales (1–5), etc. The measures are only approximate indicators.

A common problem with self-reported data is the possible occurrence of common method bias. One solution to resolve this is to send out the questionnaire to two or more respondents in each firm and then extract the average, if the differences between the observation are not significant one might say that common method variance is not present. In our case, we deal with very small firms and since there is usually only one person in a manager position, which makes this method unworkable. Our response rate is 69% and is in line with guidelines on sample size, or minimum number of respondents necessary for a good result. We find different patterns regarding response rates from different incubators. Another solution to control for common method bias is to apply statistical remedies (Podsakoff et al., 2003). One of the most widely used techniques is to apply the Harman's single-factor test (Podsakoff et al., 2003). Using this test, all variables in the study are loaded into an explorative factor analysis. If

1 a single factor emerges from the factor analysis

2 one major factor accounts for the covariance among the measures, then common method bias is apparent.

3.3 Construct for investigation

The tool for measuring *innovation capabilities* in this study was developed based on part the light of the knowledge about capabilities for large firms, but, mainly derived from areas of research relating to innovatioveness in small firms. The five dimensions and their related variables are here argued to represent the most important dimensions of the capabilities for innovation in small high-tech firms (for an overview of all 41 variables, see Table 2).

Table 2 Means and SDs for the variables

Variable	*Mean*	*SD*	*Scale*
Skills			
Education level – PhD	0.692	1.646	Number
Education level – master/bachelor	2.412	2.887	Number
Other education – business and management	0.546	0.500	1/0 (yes/no)
Work experience – business	0.741	0.440	1/0 (yes/no)
Importance of work experience – selling	3.055	1.662	1–5
Firm start – importance of R&D-results, university	2.702	1.753	1–5
Firm start – importance of R&D-results, business	2.706	1.434	1–5
Motivation drivers			
Importance of sales growth	4.661	0.688	1–5
Importance of growth of profits	3.931	0.974	1–5
Importance of growth of employment	2.908	1.060	1–5
Importance of R&D, technology and innovation	3.862	1.340	1–5

Table 2 Means and SDs for the variables (continued)

Variable	*Mean*	*SD*	*Scale*
Behaviour			
The firm is conservative – focus on growth/R&D	4.390	1.012	1–5
The firm follows competitors – market leaders	3.817	1.122	1–5
Relation to competitors – cooperation or elimination	2.670	1.177	1–5
Business			
Use of business plans	3.171	1.364	1–5
Long-term prognoses of selling	2.504	1.306	1–5
Long-term prognoses of market devel	2.411	1.272	1–5
Studies of competitors	3.023	1.320	1–5
Marketing studies	2.302	1.196	1–5
Investment planning	2.382	1.249	1–5
Long-term analyses of technology devel	2.389	1.368	1–5
Studies of customers	3.542	1.360	1–5
Product prices – low – high	2.603	1.155	1–5
External networks			
Common R&D-projects with university	1.687	1.447	1–5
Communication with university Personnel	2.214	1.622	1–5
Transfer of R&D-documents – university	1.489	1.297	1–5
External networks			
Use of R&D-equipment – university	1.931	1.642	1–5
Basic research – university	1.520	1.318	1–5
Applied research – university	1.725	1.420	1–5
General development – university	1.800	1.416	1–5
Advice from banking institutions	1.550	1.068	1–5
Advice from chamber of commerce	0.657	0.892	1–5
Advice from consultants	2.160	1.640	1–5
Advice from lawyers	1.741	1.582	1–5
Advice from regional devlopmen funds	1.137	1.352	1–5
Advice from patenting bureau	2.038	1.666	1–5
Innovation performance			
Patents	0.414	0.494	1/0 (yes/no)
Copyrights	0.236	0.426	1/0 (yes/no)
Licenses	0.111	0.316	1/0 (yes/no)
Change in product portfolio in previous three months	0.711	0.455	1/0 (yes/no)
New products before competitors	0.438	0.498	1/0 (yes/no)

Skills: Skills in small high-tech firms generally refer to the work experience and education of the few employees (or sometimes the owner) and the extent to which these are or are not broad and multi-disciplinary. It includes the skills gained through work experience (seven variables).

Motivations: The attitudes and motivation of the firm founders and managers are a key factor in the ability to raise funds and achieve high performance. Firm drivers are the underlying factors that motivate the firm and include such aspects as employment growth and profits (four variables).

Behaviour: A firm's strategic position can be established by a variable ranging from conservative to entrepreneurial. Conservative firms tend to be risk averse, non-innovative and reactive. Entrepreneurial firms tend to be risk-takers, innovative and proactive. The dimension also includes attitude to competitors (three variables).

Business: The variables in our study relate to several basic dimensions of the firm's business planning and perspectives. These dimensions include business plans, investment planning, etc. and whether or not the firm uses business and investment plans (nine variables).

External networks: A network can be seen as a separate resource and through the network the firm acquires access to resources and capabilities like advice. Two different types of networks are measured (13 variables).

The construct to measure *innovation performance* was designed to correspond to easily accessed measures for small high-tech firms in particular. The range of questions in the overall survey was intended to provide an indication of the technological capability of firms. In this paper, we use five variables to capture innovation performance more specifically: patents, copyright, licences, change in product portfolio in previous three months and new product introduction before competitors.

Table 2 presents the 41 variables used in this study including five dimensions for innovation capability and one dimension for innovation performance. All innovation performance measures are yes/no (1/0) choices, and the innovation capability measures in most cases are based on 1–5 Likert scales or yes/no answers.

3.4 Statistical analysis

For the analysis, we used the Pearson correlation to predict initial factorability using visual examination to identify the variables (items) that are statistically significant (correlation is significant at the 0.05 level). The correlation analyses present the simple relationships among items (Pearson correlation, −1−1). Among the correlations that are significant at the 0.01 or 0.05 levels, several of the higher values stem from correlations between variables within the same group. The fact that many of the variables within the groups are highly correlated with each other indicates that the variables have been grouped appropriately. Our focus is on the relations between the five groupings for innovation capability: skills, motivation drivers, behaviour, business, external networks and innovation performance. We computed regression analyses computed for the innovation capability variables with significant correlation to the innovation performance variables.

The next step will be a factor analysis. According to Kim and Mueller (1978), factor analysis has been used in economics to derive a set of uncorrelated variables for further analysis when the use of highly inter-correlated variables may yield misleading results in regression analysis. Factor analysis tests whether or not the variables selected to measure each construct exhibit sufficient convergent and discriminating validity. Factor analysis uses a principal component method and a varimax rotation. The varimax rotation is orthogonal and is uncorrelated throughout the rotation process and produces theoretically meaningful factors. Factor loadings are considered significant for different sample sizes (Hair et al., 1995). In our case a sample size of 131 firms need a factor loading exceeding 0.50–0.45 to be considered significant at the 0.05 level (Hair et al., 1995), which is sufficient for exploratory studies. The analysis involves estimation of the innovation capability measures and innovation performance variables using factor analysis, and tests whether or not the variables selected to measure each construct exhibit sufficient convergent and discriminatory validity. Factor analysis specifies the relations between the observed measures and their posited underlying constructs, where the constructs are allowed to inter-correlate freely. In general, most departures from previous factor analytical findings appear to be attributable to small firms and the inclusion of additional variables (Child, 1972; Pugh et al., 1968; Reimann, 1973). To test the reliability of the latent constructs, we computed Cronbach's alpha using the more conservative value of 0.50 as the threshold value (Cohen, 1977). This is considered sufficient for exploratory studies (Hair et al., 1995).

4 Empirical findings

This section reports the responses of the firms to questions about the variables, correlations and regression analysis (Tables A1–A5 in Appendix) and presents the results of the factor analyses. The results of the factor analyses and Cronbach's alpha are reported in Tables 5 and 6. Each variable is named and linked to a factor, i.e. has a factor loading. Of the 36 variables, 26 have connections with one or several of the innovation performance dimensions and 17 of the innovation capability variables split into two factors.

We find that the capabilities for innovation variables embedded in the five dimensions explain firm innovation performance (five variables). Several interesting features emerge from the correlation analyses, regression analyses and factor analyses. Tables 3 and 4 report the Pearson correlations (r) between the significant variables and show some strong correlations between the five innovation capability dimensions in the firm and performance measures. Tables 3 and 4 present the correlations and the variables to which they relate under the headings of the variables: skills, motivation drivers, behaviour, business networks, external networks and innovation performance.

It should be noted that the innovation performance measure ‘patent’ correlates with up to 20 of the innovation capability variables. All five innovation capability dimensions are correlated to patent and some of the variables have a negative effect on patent. The firm variables that affect patent negatively are use of business plans, long-term analyses of technology development, common R&D projects with university, basic research-university, applied research-university and advice from consultants (6 out of 20 variables, see Table A1). All these variables are located in the dimension external networks. The notion that networks are important in innovation, and that small high-tech firms will build networks if they located in close proximity, which seems to be partly contradicted by our study.

There are few connections between copyright and licenses and the other variables. Copyright is affected by long-term prognoses of selling, general development-university and advice from banking institutions, all positively affected (see Table A2). The performance measure licences is affected by only two innovation capability variables – importance of work experience-selling (negative association) and relation to competitors cooperation or elimination (positive) (see Table A3). The two ‘product innovation’ variables – change in product portfolio in previous three months and new products before competitors – have correlations with 14 of the innovation capability variables.

‘Change in product portfolio in previous three months’ is positively affected by education level: masters/bachelors, other education-business and management; firm start: importance of R&D-results (business); relation to competitors: cooperation or elimination, and product prices: low, high (see Table A4). New products before competitors are correlated to other education-business and management, firm start: importance of R&D-results (business), importance of R&D, technology and innovation, common R&D-projects with university, advice from lawyers, basic research-university and communication with university personnel, with only the last having a negative effect of the performance variable *N* (see Table A5).

Table 5 reports the factor analysis for cooperation with universities and business planning and advice, and 17 out of 26 variables are correlated (significant at 0.05 level) with one or several of the performance measures. Nine variables had factor loadings below 0.300 and are not included in Table 5. The variables can be split into two different factors – factor 1 (latent construction), cooperation with universities nine variables, and factor 2 (latent construction), business planning and advice eight variables.

Table 3 Correlation matrix for skills, motivation drivers, behaviour and innovation performance

		1	*2*	*3*	*4*	*5*	*6*	*7*
Skills								
1	Education level – PhD							
2	Education level – master/bachelor	0.082						
3	Other education – business and management	0.059	0.016					
4	Work experience – business	0.091	0.139	0.020				
5	Importance of work experience – selling	0.100	0.041	0.012	0.255**			
6	Firm start – importance of R&D-results, university	0.460**	0.002	0.190*	0.079	0.043		
7	Firm start – importance of R&D-results, business	0.018	0.019	0.135	0.056	0.195*	0.040	
Motivation drivers								
8	Importance of sales growth	0.076	0.052	0.048	0.047	0.015	0.177*	0.002
9	Importance of growth of profits	0.087	0.019	0.102	0.023	0.040	0.138	0.082
10	Importance of growth of employment	0.105	0.015	0.140	0.016	0.067	0.224*	0.102
11	Importance of R&D, technology and innovation	0.178*	0.025	0.143	0.138	0.055	0.445**	0.228**
Behaviour								
12	The firm is conservative – focus on growth/R&D	0.081	0.026	0.087	0.090	0.006	0.144	0.005
13	The firm follows competitors – market leaders	0.032	0.031	0.063	0.012	0.002	0.136	0.052
14	Relation to competitors – cooperation or elimination	0.076	0.058	0.046	0.056	0.006	0.062	0.048
Innovation performance								
15	Patents	0.292**	0.008	0.027	0.169	0.097	0.333**	0.018
16	Copyrights	0.040	0.070	0.060	0.093	0.135	0.131	0.048
17	Licenses	-0.060	0.072	0.031	0.026	0.179*	0.083	0.055
18	Change in product portfolio previous three months	0.155	0.189*	0.202*	0.058	0.055	0.124	0.177*
19	New products before competitors	0.088	0.163	0.287**	0.004	0.015	0.002	0.190*

Table 3 Correlation matrix for skills, motivation drivers, behaviour and innovation performance (continued)

	8	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*
Skills											
1 Education level – PhD											
2 Education level – master/bachelor											
3 Other education – business and management											
4 Work experience – business											
5 Importance of work experience – selling											
6 Firm start – importance of R&D-results, university											
7 Firm start – importance of R&D-results, business											
Motivation drivers											
8 Importance of sales growth											
9 Importance of growth of profits	0.277**										
10 Importance of growth of employment	0.021	0.046									
11 Importance of R&D, technology and innovation	0.033	0.058	0.144								
Behaviour											
12 The firm is conservative – focus on growth/R&D	0.266**	0.027	˜0.053	0.308**							
13 The firm follows competitors – market leaders	0.132	0.091	0.014	0.338**	0.389**						
14 Relation to competitors – cooperation or elimination	˜0.135	0.012	˜0.096	0.053	0.068	0.222*					
Innovation performance											
15 Patents	0.180*	0.204*	0.017	0.380**	0.108	0.307**	0.030				
16 Copyrights	0.004	0.017	0.028	0.160	˜0.001	0.042	˜0.042	0.027			
17 Licenses	0.098	˜0.108	0.053	0.143	0.135	0.117	0.191*	0.063	0.227*		
18 Change in product portfolio previous three months	˜0.036	0.030	0.100	0.083	0.054	˜0.048	0.191*	–0.080	0.189*	0.226*	
19 New products before competitors	˜0.009	˜0.025	0.100	0.221*	˜0.038	0.127	0.104	˜0.074	0.390**	0.265**	0.286**

Notes: **, correlation is significant (0.01-level), two-tailed; *, correlation is significant (0.05-level), two-tailed.

Table 4 Correlation matrix for business, external networks and innovation performance

	Business	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*
1	Use of business plans														
2	Long-term prognoses of selling	0.460**													
3	Long-term prognoses of market dev	0.499**	0.442**												
4	Studies of competitors	0.371**	0.397**	0.450**											
5	Marketing studies	0.279**	0.302**	0.400**	0.431**										
6	Investment planning	0.405**	0.390**	0.426**	0.329**	0.195*									
7	Long-term analyses of technology dev.	0.438**	0.318**	0.418**	0.518**	0.350**	0.489**								
8	Studies of customers	0.234**	0.195*	0.314**	0.429**	0.379**	0.135	0.564**							
9	Product prices – low – high	0.101	0.216*	0.184*	˜0.009	0.167	0.037	0.060	0.251**						
External networks															
10	Common R&D-projects with univ.	0.274**	0.114	0.122	0.089	0.170	0.224	0.326**	0.177*	˜0.029					
11	Communication with univ. personnel	0.380**	0.172	0.187*	0.052	0.200*	0.237**	0.267**	0.195*	0.054	0.658**				
12	Transfer of R&D-documents-univ.	0.435**	0.049	0.257**	0.120	0.188*	0.302**	0.356*	0.219*	˜0.065	0.709**	0.670**			
13	Use of R&D-equipment-univ.	0.386**	0.143	0.323**	0.130	0.139	0.249**	0.358**	0.275**	0.136	0.635**	0.693**	0.652**		
14	Basic research-university	0.214*	0.049	0.088	0.045	0.253**	0.257**	0.336**	0.272**	0.011	0.620**	0.606**	0.617**	0.559**	
15	Applied research – university	0.400**	0.177*	0.271**	0.199	0.216*	0.259*	0.357**	0.253**	0.088	0.662**	0.710**	0.750**	0.655**	0.654**
16	General development – univ.	0.305**	0.144	0.177*	0.098	0.257**	0.172	0.226**	0.176*	0.016	0.739**	0.633**	0.608**	0.610**	0.525**
17	Advice from banking institution	0.057	0.204*	0.094	0.024	0.099	0.153	0.037	˜0.095	˜0.115	0.117	0.220*	0.093	0.044	0.050
18	Advice from chamber of commerce	0.049	0.131	0.051	0.053	˜0.083	0.236**	0.173*	0.021	˜0.029	0.137	0.136	0.106	0.000	0.055
19	Advice from consultants	0.478**	0.291**	0.192*	0.071	0.035	0.312**	0.219*	0.195*	0.135	0.336**	0.343**	0.252**	0.270**	0.296**
20	Advice from lawyers	0.205*	0.358**	0.116	0.215*	0.112	0.237**	0.193*	0.130	˜0.044	0.173	0.202*	0.104	0.192*	0.136
21	Advice from regional dev. Funds	0.227**	0.135	0.140	0.121	0.220*	0.087	0.295**	0.060	0.020	0.152	0.162	0.124	0.153	0.097
22	Advice from patenting bureau	0.432**	0.208*	0.291**	0.211*	0.062	0.340**	0.463**	0.228**	0.028	0.346**	0.247**	0.326**	0.448**	0.305**
Innovation performance															
23	Patents	0.252**	0.128	0.129	0.141	0.065	0.228**	0.249**	0.227**	˜0.004	0.277**	0.259**	0.233**	0.451**	0.190*
24	Copyrights	0.031	0.187*	˜0.040	0.129	0.113	0.047	0.013	˜0.021	˜0.031	0.0.96	0.139	˜0.033	0.021	0.055
25	Licenses	˜0.007	˜0.056	0.020	0.052	˜0.054	˜0.011	0.043	0.100	0.056	˜0.039	0.009	˜0.006	0.064	0.062
26	Change in product portfolio prev. 3 months	0.085	0.047	˜0.109	0.103	0.072	˜0.045	˜0.012	0.088	0.217*	0.051	˜0.003	˜0.056	˜0.092	0.046
27	New products before competitors	0.022	0.169	˜0.097	0.105	0.022	0.002	0.013	0.088	˜0.131	0.188*	0.195*	0.080	0.021	0.191*

Table 4 Correlation matrix for business, external networks and innovation performance (continued)

Business	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*24*	*25*	*26*
1 Use of business plans												
2 Long-term prognoses of selling												
3 Long-term prognoses of market dev												
4 Studies of competitors												
5 Marketing studies												
6 Investment planning												
7 Long-term analyses of technology dev.												
8 Studies of customers												
9 Product prices – low – high												
External networks												
10 Common R&D-projects with univ.												
11 Communication with univ. personnel												
12 Transfer of R&D-documents-univ.												
13 Use of R&D-equipment-univ.												
14 Basic research-university												
15 Applied research – university												
16 General development – univ.	0.692**											
17 Advice from banking institution	0.045	0.019										
18 Advice from chamber of commerce	0.065	0.069	0.248**									
19 Advice from consultants	0.273**	0.236**	0.107	0.169								
20 Advice from lawyers	0.153	0.148	0.263**	0.242**	0.245**							
21 Advice from regional dev. Funds	0.144	0.193*	0.096	0.314**	0.118	0.175*						
22 Advice from patenting bureau	0.304**	0.251**	˜0.055	0.092	0.440**	0.465**	0.247**					
Innovation performance												
23 Patents	0.258**	0.271**	˜0.124	˜0.011	0.264**	0.359**	0.025	0.645**				
24 Copyrights	0.089	0.180*	0.193*	˜0.002	0.037	0.002	0.010.	˜0.025	0.027			
25 Licenses	˜0.046	˜0.117	0.031	0.044	˜0.073	0.152	0.091	0.015	0.063	0.227*		
26 Change in product portfolio prev. 3 months	˜0.052	0.019	0.057	0.107	0.013	0.006	˜0.027	˜0.080	˜0.080	0.189*	0.226*	
27 New products before competitors	0.166	0.118	0.087	0.110	0.118	0.183*	˜0.028	˜0.018	˜0.074	0.390**	0.265**	0.286**

Notes: **, correlation is significant (0.01-level), two-tailed; *, correlation is significant (0.05-level), two-tailed.

Table 5 Factor analysis[abc]: innovation capabilities variables divided into two factors

Factors	*1 Cooperation with universities (α^d = 0.784)*	*2 Business planning and advice (α^d = 0.895)*
Factor names		
Applied research – university[c]	0.839	
Common R&D-projects with university	0.827	
Transfer of R&D-documents – university	0.823	
Communication with university personnel	0.813	
General development – university	0.806	
Use of R&D-equipment – university	0.801	
Firm start – importance of R&D-results, university	0.610	
Importance of R&D, technology and innovation	0.387	
Education level – PhD	0.374	
Use of business plans		0.636
Studies of competitors		0.613
Long-term prognoses of selling		0.600
Long-term analyses of technology development		0.599
Investment planning		0.556
Advice from patenting bureau		0.456
Advice from consultants		0.414
The firm follows competitors – market leaders		0.323

[a]Rotated factor matrix.

[b]Factor loadings below 0.300 are not included in the table.

[c]Cumulative variance is 48.57%.

[d]α (Cronbach alpha) > 0.50.

Cronbach's alphas for the latent constructs are 0.78 and 0.90 and exceed the minimum value of 0.50. Therefore, the items are considered to be reliable predictors of the latent construct. Small high-tech firms in incubators mean that incubators offer firms an environment that supports R&D-network formation and offer operational management support for firms. Incubators are a particularly suitable location for new businesses, and opportunities exist for incubator managers to develop training and business placement programmes to assist the firms.

Table 6 presents the factor analysis of the innovation performance variables. The innovation performance measure consists of five variables, with 'patents' the only variable in factor 2. Patents are often used as an indicator of technological development, although the propensity to patent varies between sectors, firms and countries. The first factor, product development, contains the other variables (Cronbach's alpha > 0.50). The firms have quite high rates of innovation performance (see Table 2): nearly 43% of firms patent, nearly 24% hold copyrights and 11% are involved in licensing. The other innovation performance measures, change in product portfolio in previous three months (71%) and new products before competitors (almost 44%) show quite high rates of innovation performance (the firms are only 2.8 years old).

The performance innovation measures fall into two latent constructs: product development (licenses, copyrights and operative product development: Cronbach's alpha > 0.50) and patents (measure of patenting activity by firms). All variables have factor loadings above 0.30. The questions in the survey were intended to provide an indication of firms' innovation performance. Many firms employ qualified scientists (nearly 70% of the firms have employees with at least one PhD degree).

Table 6 Factor analysis[abc]: innovation performance variables divided into two factors

Factors	*1 Product development (α^d = 0.586)*	*2 Patent (α^e)*
Factor names		
New products before competitors	0.679	
Copyrights	0.527	
Licenses	0.438	
Change in product portfolio in previous three months	0.434	
Patents		0.575

[a]Rotated factor matrix.
[b]Factor loadings below 0.300 are not included in the table.
[c]Cumulative variance is 29.97%.
[d]α (Cronbach alpha) > 0.50.
[e]Only one variable.

5 Discussion

The objective of this paper is to describe and analyse capabililities critical to innovation performance for very small high-tech firms. We proposed that the chosen five dimensions for capabilities should be related to innovation performance in the special case of very small high-tech firms. We found 20 relationships between the innovation capabilities dimensions and innovation performance, but only 14 relationships between the innovation capabilities dimensions and the four innovation performance dimensions. The dimension patents were strongly correlated to capabilities.

Our empirical data and the statistical analysis examined the association between specific innovation capabilities variables and innovation performance according to the stated research proposition. The findings from this study confirm that the suggested innovation capabilities dimensions have an impact on innovation performance, particularly the dimension patents.

Patenting activity is often used to map aspects of innovation performance and the technological progress of countries, regions, certain specific domains and technology fields and firms. The use of patent statistics to monitor developments in the field of science has expanded and the roles of different types of innovation – patents and product development – are especially interesting. It is difficult to say whether patents are the most suitable performance indicator for small high-tech firms or the most appropriate dimension to relate to capabilities. It has been argued that innovation performance is difficult to measure in terms of both finding an appropriate measure and finding the right metrics (BCG, 2007; Chiesa et al., 1996), and for small, newly established firms where measures such as market share, pace of product change are not feasible, patents are useful. According to Krammer (2009), patents present advantages and disadvantages, but in our case patents, copyrights and licenses are the best available measures of innovation based on availability and number to measure firm performance. In another study on innovation performance, Romijn and Albaladejo (2002) explored the determinants of innovation capability in small UK electronics and software firms. They use an experimental innovation index alongside conventional proxies for innovation performance. Their indicators are correlated with variables capturing a range of potentially important internal sources, such as education, prior work experience and R&D effort, and measures of intensity of external interactions and proximity in network relations. Their findings support the importance of R&D, the key role played by the regional science base in nurturing high-tech spin-offs and proximity to suppliers, but not the current policy fashion for encouraging regional networks revolving around firms in similar business activities and close customer relations. This study does not point explicitly to R&D efforts as being the main capability required for innovation. Rather, it highlights *enabling* mechanisms connected with knowledge generation and knowledge absorption.

The results of the Cronbach's alpha test (reliability test) indicated a high degree of consistency for each of the factors in our study. The factor analysis for the innovation capabilities dimensions reveals two underlying constructs. That is, two dimensions of capabilities that are particularly important for small high-tech firms' innovation performance: cooperation with universities and business planning and advice. The variables that are associated with cooperation with universities are typical of knowledge generation – communication, knowledge transfer, information processing, R&D-equipment, basic and applied research, etc. Research networks are important for identifying opportunities and testing new ideas, and collaboration with universities provides a means of developing technological knowledge and the capabilities that small firms lack to foster knowledge domains in-house. Furthermore, universities and research centres can provide consulting assistance to new firms and opportunities for continuing education. Research collaborations can take many forms from formal research contracts to informal contracts and exchanges of personnel between academia and industry (Quintas et al., 1992).

Our study shows that cooperation with universities is negatively related to patents, one of the innovation performance dimensions. However, this might seem surprising small high-tech firms located in incubators are generally very sensitive to commercial pressures and are not in a position, on their own, to undertake long-term R&D and business development which require financial resources. Small firms usually do not have separate R&D and business development departments and usually depend on a few key persons who are obliged to multi-task. In terms of knowledge absorption (e.g. Cohen and Levinthal, 1990), small firms face difficulties in exploiting the value from cooperation with universities. Firms with more internal resources can more easily absorb the knowledge and technologies cooperatively developed with universities. For small firms, these collaborations consume the resources of small firms. The problem is that academic basic research is too long term to benefit innovative small firms with no long-term financial resources, and the universities are ill-equipped to respond to immediate problem-solving demanded by commercial competition and do not take account of the fact that knowledge absorption differs between small and larger, more established firms. Some studies show that small high-tech firms working with universities can benefit. Proximity between firms and universities promotes the exchange of ideas through formal and informal networks (Deeds et al., 2000). However, our study shows that the capability to use external linkages, like collaboration with universities, do not influence innovation performance positively, possibly due to lack of resources and poor absorptive capacity in small firms thus contradicting the assumption for large firms (e.g. Unn et al., 2010).

Another interesting finding among the totally six variables that negatively affect the innovation capability dimension patents – aside the various forms of university cooperation – are use of business plans and long-term analyses of technology development. These last two activities are in general considered being crucial for any R&D or business planning function in any large firm. However, there is an inherent risk that these capabilities are not dynamic and may not be able to respond to market changes but instead can become rigidities (Leonard-Barton, 1992). Our results show that these activities contradict the innovation performance dimension patents and could be interpreted as showing that the necessary capability for being innovative not at all lies in planning efforts whether business or technology. Rather, adaptation to new markets and being able to make rapid changes are more important.

Since small firms see patents and new products as opportunities to increase revenues and achieve competitive advantage, competition over these rights is often contentious (Phillips, 1991). This supports the finding that patents are an appropriate innovation performance indicator for small firms. A firm's external networks, in our study, R&D networks and business networks, seem to be major contributors to the firm's innovation performance, both directly in terms of possible knowledge absorption and indirectly in terms of attractiveness. The firm's ability to mobilise resources, attract researchers at the universities, attract financial resources. Identifying entrepreneurial opportunities also depends on the firm's external networks and social relations.

Our second underlying construct, business planning and advice, refers to the firm's business planning and business network. The firms, in our study, are very small and have few resources for businness planning and business analysis; they rely on the incubators for these services. For larger firms, these activities are taken for granted in the management of the firm and do not always promote innovativeness; for small firms, they are directly related to innovation performance. The small high-tech firm context is characterised by a complex and dynamic environment, including high technology, product/service changes due to intense competition and activities aimed at advice and support which are crucial for understanding the market context.

This study has several limitations in addition to the limitations typical of survey research. The incompleteness of the set of innovation capabilities variables is a central one; from our construct, two were found particularly important for innovation performance which could imply there are other, not investigated here, dimensions that have strong impact on innovation performance. Thus, in the future, there is a need to continue the investigation of what are capabilities for innovation in small firms; this study with its construct for investigation serves as a contribution to that. Also, the measures used for innovation performance are simplifications compared to reality, but in our view they reflect performance and enable us to identify the relationships with certain capabilities. The aim is not to measure innovation performance *per se* but to measure its relationship to certain capabilities so that change and development may be enabled.

6 Conclusions

In this paper, we show that it is possible to design a construct for investigating the innovation capabilities of small high-tech firms. We have also pointed out their relation to innovation performance using metrics that are easily monitored. Our study shows that the most important capabilities for innovation can be grouped into cooperation with universities and business networks, i.e. these two groups of capabilities are the most important for innovation performance, but in different directions. The variables chosen to measure innovation performance – new products before competitors, patents, licenses, copyrights and change in product portfolio in previous three months – fall into two categories based on the factor analyses where patents are the only variable in one of the groups. Patents are the variable with the strongest relation to all the measured capabilities for innovation. We thus show that there is a significant influence on innovation performance of the dimensions chosen for our construct. Furthermore, innovation performance can be argued to be positively influenced by the latent constructs cooperation with universities and business planning and advice. The necessary capabilities required seem to be drive and enthusiasm and a good level of education.

Our study shows that the capability to use external linkages, like collaboration with universities, does not influence innovation performance in small firms positively due to their lack of resources and lack of absorptive capacity, which contradicts the assumpition for large firms. The small high-tech firms in our study are too small to benefit from open innovation notions such as complementary knowledge and additional perspectives capabilities that they thought are crucial for innovation. This paper contributes to the stream of literature on organisational capabilities. In contrast to most existing studies, we have addressed the notion of capabilities for small firms as first and especially small high-tech firms as second. We have discussed the key notion of relating capabilities to innovation performance measures and presents a construct for that.

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Appendix

Regression analyses

Table A1

Model[abc]	*Standardised coefficients, β*	*t*	*Significance*	*Correlation*[d]
Constant		–1.960	0.053	
Education level – PhD	0.186	2.024	0.046*	0.292**
Firm start – importance of R&D-results, university	0.006	0.056	0.955	0.333**
Importance of sales growth	0.026	0.341	0.734	0.180*
Importance of growth of profits	0.124	1.577	0.118	0.204*
Importance of R&D, technology and innovation	0.113	1.272	0.206	0.380**
The firm follows competitors – market leaders	0.110	1.347	0.181	0.307**
Use of business plans	–0.075	–0.781	0.437	0.252**
Investment planning	0.075	0.845	0.400	0.228**
Long-term analyses of technology development	–0.216	–1.977	0.051	0.249**
Studies of customers	0.068	0.717	0.475	0.227**
Common R&D-projects with university	–0.044	–0.337	0.737	0.277**
Communication with university personnel	0.021	0.173	0.863	0.259**
Transfer of R&D-documents – university	0.012	0.083	0.934	0.233**
Use of R&D-equipment – university	0.225	1.933	0.056	0.451**
Basic research – university	–0.025	–0.233	0.816	0.190*
Applied research – university	–0.166	–1.166	0.246	0.259**
General development – university	0.058	0.484	0.629	0.271**
Advice from consultants	–0.079	–0.878	0.382	0.264**
Advice from lawyers	–0.074	0.904	0.368	0.359**
Advice from patenting bureau	0.530	5.131	0.000**	0.645**

[a]Dependent variable: patent.

[b]Model summary: $R = 0.727$, adjusted $R^2 = 0.529$ and standard error of estimate = 0.36856.

[c]The model: significance = 0.000*** (ANOVA), $p < 0.005$.

[d]Correlations between dependent variable and the independent variables.

*$p < 0.05$.

**$p < 0.01$.

Table A2

Model[abc]	*Standardised coefficients, β*	*t*	*Significance*	*Correlation*[d]
Constant		–0.503	0.616	
Long-term prognoses of selling	0.133	1.470	0.144	0.187*
General development – university	0.156	1.767	0.080	0.180*
Advice from banking institutions	0.153	1.705	0.091	0.193*

[a]Dependent variable: copyright.
[b]Model summary: $R = 0.284$, adjusted $R^2 = 0.080$ and standard error of estimate = 0.41747.
[c]The model: significance = 0.018* (ANOVA), $p < 0.05$.
[d]Correlations between dependent variable and the independent variables.
*$p < 0.05$.

Table A3

Model[abc]	*Standardised coefficients, β*	*t*	*Significance*	*Correlation*[d]
Constant		0.755	0.452	
Importance of work experience – selling	–0.179	–2.037	0.044*	–0.179*
Relation to competitors – cooperation or elimination	0.209	2.379	0.019*	0.191*

[a]Dependent variable: licenses.
[b]Model summary: $R = 0.275$, adjusted $R^2 = 0.076$ and standard error of estimate = 0.30911.
[c]The model: sigficance = 0.009** (ANOVA), $p < 0.01$.
[d]Correlations between dependent variable and the independent variables.
*$p < 0.05$.

Table A4

Model[abc]	*Standardised coefficients, β*	*t*	*Significance*	*Correlation*[d]
Constant		0.608	0.544	
Education level – master/bachelor	0.141	1.681	0.095	0.189*
Other education – business and management	0.178	2.103	0.038*	0.202*
Firm start – importance of R&D-results, business	0.163	1.940	0.055	0.177*
Relation to competitors – cooperation or elimination	0.179	2.109	0.037*	0.191*
Product prices – low, high	0.173	2.024	0.045*	0.217*

[a]Dependent variable: change in products last three months.
[b]Model summary: $R = 0.411$, adjusted $R^2 = 0.169$ and standard error of estimate = 0.42551.
[c]The model: significance = 0.000*** (ANOVA), $p < 0.005$.
[d]Correlations between dependent variable and the independent variables.
*$p < 0.05$.

Table A5

Model[abc]	*Standardised coefficients, β*	*t*	*Significance*	*Correlation*[d]
Constant		–0.663	0.508	
Other education – business and management	0.279	3.177	0.002**	0.287**
Firm start – importance of R&D-results, business	0.111	1.268	0.207	0.190*
Importance of R&D, technology and innovation	0.095	1.028	0.306	0.221*
Common R&D-projects with university	0.118	0.871	0.385	0.188*
Communication with university personnel	–0.059	–0.469	0.640	0.195*
Basic research – university	0.112	0.957	0.341	0.191*
Advice from lawyers	0.148	1.701	0.092	0.183*

[a]Dependent variable: new products before competitors.

[b]Model summary: $R = 0.436$, adjusted $R^2 = 0.141$ and standard error of estimate = 0.46228.

[c]The model: significance = 0.001*** (ANOVA), $p < 0.005$.

[d]Correlations between dependent variable and the independent variables.

*$p < 0.05$.

**$p < 0.01$.