Implementing the SIV model on an intensively innovation-oriented firm: the case of Autoadapt AB

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Abstract

Purpose – Small to medium-sized enterprise (SME) evaluation models lack a clear coupling to innovation and its impact on firm performance. A model which can achieve this is the Survival Index Value (SIV) model. The purpose of this paper is to demonstrate the ability of the SIV model to indicate and predict the performance of a company. The firm, Autoadapt AB, is an innovation-oriented enterprise, adapting personal cars to be driven by handicapped people. The authors knew in advance about the good performance of the firm and its high efficiency in conducting its operations and expected the SIV model to reflect correctly on Autoadapt's performance. Because the handicap degree of each of the individuals who benefit from the firm activities differs from one person to another, product solutions have to be individually designed. Therefore the firm has had to pursue a high level of innovativeness and it had to abide with this policy right from the start. The product development processes in the firm needed to adapt to such strategies.

Design/methodology/approach – To be able to demonstrate the ability of the SIV model to indicate a positive performance due to the intensive innovation activities of Autoadapt AB, a case study approach was used. Case studies are very suited for in-depth analysis of an object under a longer period of time. It is a widely-used research method in firm performance studies.

Findings – The results of the SIV analysis indicated that the model is able to project correctly the performance of the object firm. At all the four levels of analysis, i.e. SI values, the SPI slope, the survival factors, and the survivability coefficients, the SIV analysis performance indicated a stable positive development of the firm through the life time of the enterprise.

Originality/value – Measuring performance of SMEs is an important issue. There are couple of models stemming from the traditional accountancy disciplines in use; however these models suffer from clear disadvantages. Recently a new model, the SIV model, was introduced and has shown the ability of being a better candidate for performance analysis. The paper demonstrates the ability of the SIV model to judge correctly the performance of an innovative firm.

Keywords Sweden, Small and medium-sized enterprises, Organizational innovation, Organizational performance, Performance evaluation models, SIV model, Firm efficiency, Business platform model, Financial parameters, Non-financial parameters

Paper type Case study

World Journal of Entrepreneurship, Management and Sustainable Development
Vol. 8 No. 2/3, 2012
pp. 122-145

2042-5961
DOI 10.1108/20425961211247743

The working paper upon which this article is based has been presented at the 56th Annual ICSB Conference, Stockholm, Sweden, June 15-18, 2011.

Introduction

The factors contributing to a better performance of small to medium-sized enterprise (SMEs) are in need of more analysis and understanding (Acs, 1999). Coupled to that is the necessity of understanding the environment in which the firm is residing and relating that to its performance (Gnyawali and Park, 2009). The survival analysis is the best technique for firm failure prediction (Keasey *et al.*, 1990). Models of firm performance prediction focussed on failure and neglected other more positive scenarios of firm life cycle. The research which directly examined factors influencing survival of SMEs and incorporated them in model structures is limited (Castrogiovanni, 1996). The variations in the nature of the organizational structure of firms demanded a dichotomy in the way one should looks at firms. The two dominant approaches being the open- vs the closed-system approach (Scott, 2003). There is a clear connection between networking and performance (Wincent and Westerberg, 2005; Wincent *et al.*, 2009). The established strategy of building performance evaluation models is based on computing a large initial set of ratios and then letting statistical methods reduce them into limited group (Keasey and Watson, 1991). Because that approach of the usage of business ratios in developing SME have been criticized (Klofsten, 2010). The purpose of the traditional financial ratio analysis is to detect the company operating and financial difficulties (Altman, 1968). Yazdipour and Constand (2010) criticized the negligence of the financial distress researchers to the managerial decision-making aspects in their approach to firm failure analysis.

Innovation in firms comes in different forms (Trott, 2008) and the impact of the innovation activities vary depending on the structure of organizations (Damanpour *et al.*, 1989; Daft, 1982; Damanpour and Evan, 1984). Damanpour and Gopalakrishnan (1988) looked at the relationship between organizational structure and innovation. To deal with the different types of innovation, a number of approaches were proposed using a spectrum of predictive variables (Downs and Mohr, 1976). Firms in the modern economy obtained new probabilities due to ITCs. The new tools resulted in a more connectivity between firms. As a result, the open innovation paradigm is propagated for by Chesbrough (2001, 2003). Open innovation demands the inventing of new business models which are more open in their nature (Chesbrough *et al.*, 2006). The term "open innovation" was first proposed by Chesbrough (2001) to describe how useful knowledge and technology is becoming increasingly widespread when newly developed technologies and products are benefiting from the integration of knowledge and expertise from multiple sources. Using external knowledge relations influences the way firms are organizing and managing their innovation activities (Teirlinck and Spithoven, 2008). In open innovation, external knowledge relations are considered vital elements and being complementary to the internal research (Cohen and Levinthal, 1990; Veugelers, 1997; Chesbrough *et al.*, 2006). Hedner *et al.* (2011) argued that in their early days the industrial progress was lead through open innovation approach as in case of the pharma industry. It is only later that pharma industry shifted into a more closed system of innovation (Hedner *et al.*, 2011).

Innovation and performance

Innovation is necessary to economic progress (Schumpeter, 1934). The innovativeness of an economy can be achieved by other dynamics where the larger or more mature firms acquire innovative and successful smaller firms (Lindholm, 1994). Studies of innovation in SMEs are still limited as compared to larger firm (Vermeulen *et al.*, 2005). Innovation in small firms tends to follow one of the three themes: how the research and development (R&D) or new product R&D processes are managed; how to best measure innovation and technology management; and how small firms secure competitive advantage of using innovation (Motwani *et al.*, 1999). Innovative SMEs which engage in innovation activities are better performers (Geroski and Machin, 1992; Soni *et al.*, 1993; Freel, 2000). SMEs are more flexible, agile and innovative than larger firms (Qian and Li, 2003; Acs and Yeung, 1999; Vermeulen *et al.*, 2005; Wolff and Pett, 2006). Damanpour *et al.* (1989) studied the impact of adapting administrative and technical innovation on performance of organizations. The first type, the administrative innovation is more coupled to the management innovation, while the technical innovation is more related to product and/or process innovations. Acs and Yeung (1999) indicated that product and process improvements in SMEs can be directly attributed to increased creativity and innovativeness in the firm. Other researchers suggested alternative components other than the ones named by Abouzeedan and Busler (2005) to define the innovative capacity of society. Corley *et al.* (2002) discussed the issue of physical, R&D and human capital. The authors argued that differences across countries and industries in the rate of investment in different types of capital would reflect itself in productivity levels across European Union (EU) and US industries. The success of SMEs innovation activities shown to be related to the owner-manager of the enterprises (Hadjimanolis, 2000). Entrepreneurial managers are key sources of innovative ideas and innovation in the small firms (Vossen, 1998).

SME performance models

Traditional approach to SME performance

SME performance evaluation models have a significant set of deficiencies. Historically, SME performance studies focussed strongly on statistical analysis and modeling. They often neglected non-financial indicators (Houghton, 1984; Libby and Lewis, 1982). SME performance models relied heavily on business ratios and financial parameters. This approach has been criticized (Klofsten, 2010; Keasey and Watson, 1993). The models incorporate the non-financial parameters through their indirect effect on the financial ones (see Altman, 1983, 1968; Altman *et al.*, 1977). SME performance models lack the coupling of firm innovation activities to their performance (cs Mazzarol and Rebound, 2008; Vermeulen *et al.*, 2005; Wolff and Pett, 2006). The models are focussed on failure and bankruptcy analysis and neglected the other aspects of firm performance (Keasey *et al.*, 1990). They neglected the networking impact on firm performance (Wincent and Westerberg, 2005; Wincent *et al.*, 2009). The existing models deal with firms as closed systems in contrast to the open-system approach (Scott, 2003). There are two deficiencies in the existing SME performance models in relation to studying younger firms. First, the models are non-holistic and tend to be more qualitative in their nature. Second, they can not be used for managerial purposes (Davidson and Klofsten, 2003).

The soft models of SMEs performance

Klofsten (1992a, b) looked at the way technology-based enterprises progress in their development. His focus was on the earlier stages of their lives. The majority of the SME performance models in this group are based on firm life cycle approach. Klofsten

(1992a, b) described couple of models. These models belong to the life cycle approach to firms. The life cycle models postulate a stage-wise progress of the firm. The first group is closed-ending type. The concept of birth and death model proposed by Abouzeedan and Busler (2005) uses both the closed- and open-ending approach. As thus it resembles both the life cycle classical model as well as the evolutionary model (Abouzeedan and Busler, 2005). Evolutionary models, on the other hand, such as the ones proposed by Helms and Renfrow (1994) and Nelson and Winter (1978), postulate the open-end nature of firm progression in its life. The business platform model belongs to this softer type of models (Klofsten, 2010). Klofsten (1992b) has theorized that eight cornerstones need to be in place supporting this business platform. These are idea, product, market, organizational development, core group expertise, prime mover and commitment, customer relations and other firm relations (Klofsten, 1992b). The business platform is belonging to the third group of SME models which are strategy focussed.

The hard models of SMEs performance

This group has been developed based on the accountancy traditions. Historically there are six models in this group of model. These are stochastic models, learning models, hazard rate models, *Z*-scores, Zeta-scores and neural networks (NN). The stochastic theories take the stands that firm growth and firm size are independent variables. The basis of such theorization is the Gibrat Law. Gibrat Law is a theoretical extrapolation stemming out of the frequent observation of the way stochastic models behave (Hart and Paris, 1956). Gibrat's Law postulates that if growth rates of firms in a fixed population are independent of their initial sizes, the growth rates shows no variance with size (Caves, 1998). This means that firms which differ in their size are able to grow at the same rate. The learning model theory of firms assumes that firm do posses a cost parameter (Jovanovic, 1982). Although each firm knows the distribution of this parameter for all firms the true cost is unknown to the enterprise (Jovanovic, 1982). As each period passes the firm revises its beliefs about its true managerial ability based on the previous period's profits and costs. Inefficient unlearning firms decline and exit while efficient learning firms survive and grow (Jovanovic, 1982).

Duration or hazard modeling is used to analyze performance of firms and to examine their survival. The model anticipates a hazard rate which is the probability that a firm closes given that it was alive at the beginning of the analysis period (McPherson, 1995). Hazard models can be in discrete or continuous time, and parametric or non-parametric (McPherson, 1995). *Z*-scores combine traditional financial ratio analysis with discriminant analysis. *Z*-score procedure, combines five financial measures to arrive at an overall credit score (*Z*) (Altman, 1983). The discriminant analysis classifies a company into one of two groups (failed/non-failed) on the basis of a statistic (*Z*-score) (Altman, 1983). The *Z*-score is derived by assigning weights to the variables, such that the variance between the groups is maximized relative to the within group-variance (Keasey and Watson, 1991). In 1977, and using the same technique Altman and his colleagues developed a second-generation failure prediction model, which became known as "Zeta" (Altman *et al.*, 1977). Argenti (1976) expressed doubts whether this method is able to work well for very large or very small firms.

Neural networks analysis is another important decision-making tool in various types of two-group classification problems, such as bankruptcy prediction and new venture success (Jain and Nag, 1997). NN's strongest feature is its ability to learn relationships from data (Gritta *et al.*, 2000). NN do not require a prior specification of the functional relationship between variables. This makes them one of the best when it comes to prediction models based on two-group classification (Jain and Nag, 1997). NN are not a clearly dominant mathematical technique compared to traditional statistical techniques such as discriminant analysis (Altman *et al.*, 1994).

The SIV model, a background

Although the SIV model can be confused to be one of the hard type models, it differs from the rest members of the group in significant aspects. The model incorporate innovation in the form of technology intake and it has a balanced qualitative/quantitative nature. Although the SIV model uses business ratios, it incorporates them in a more simplified way to suit the situation for SMEs. The selection of the parameters in the SIV model is theory driven. The model can be used as a managerial tool. The SIV model takes in account the variations between business sectors and regional contexts. It does relate the performance of the firm to the general situation of the sector within which the firm is active. The SIV model considers the whole spectrum of firm performance including survival and growth. In the work which introduced the SIV model, Abouzeedan (2011) proposed a parameter to evaluate SME performance using an indicator. Known as the survival index (SI) the indicator measures firm performance. The input parameters, which are incorporated in the SIV model, can be divided into "internal" and "external" parameters in accordance with the SPF Classification System (Abouzeedan, 2002). Each of the two groups is divided into subgroups. One of the subgroups of the "internal" group of the parameters is the "structural" parameters subgroup. It consists of the parameters, which are characteristic of the physical structure of the firm (Abouzeedan, 2002). Based on the SPF Classification System, the two most important structural parameters incorporated in the SIV model are firm age and firm size (Abouzeedan, 2011; Abouzeedan and Busler, 2002; Abouzeedan, 2002). The firm age concepts presented in the SIV encompass a new approach, as the enterprise age is related to the youthfulness of the business sector in which the firm is active. To account for the age perspective of the business sector within which the firm is active, Abouzeedan (2011) and Abouzeedan and Busler (2002) introduced a new conceptual parameter of age which they called the average life span. The average life span, which was designated with the symbol (L_j), indicates the youthfulness of the sector in average term. Relating the individual firm age to the age of the whole sector gave better sense of the youthfulness of the firm (Abouzeedan and Busler, 2002). Abouzeedan and Busler (2003) developed further the original SIV model and introduced the concept of "survivability coefficient."

Methodology

Autoadapt AB, the company

To demonstrate the ability of the SIV model to reflect on the role of innovation in enhancing firm performance, we chose to run the SIV analysis on a Swedish SME, which is an active company in the field of health care. The firm, Autoadapt AB is an SME that works with the adaption of personal cars to the usage of the handicapped and disabled people. The SNI codes presenting the activities of the firm are 30,920, 29,200 and 45,310. The firm was selected due to its high level of product development activities. The history of the Autoadapt AB is presented in Appendix 1.

The survival index value (SIV) equation
When we calculate the SI of a firm, we use the SIV equation or SIE. The equation has the following general structure.

The SIV equation:

$$SI_{ij} = SI_{oi} + SI_{ti}$$

The SIV equation incorporates the variables, which determine SME performance, where:

$$SI_{oi} = A_a\left(\frac{Y_i}{L_j}\right)\left(\frac{E_i}{E_x}\right)\left(\frac{F_i}{C_{3i}}\right)P_i + A_b\left(\frac{C_{1si}}{C_{1i}}\right) \quad (1a)$$

and

$$SI_{ti} = A_c\left(\frac{C_{2i}}{C_{3i}}\right) \quad (1b)$$

Such that SI_{oi} is the operating conditions part of the SI, for the ith enterprise, called hereby, operating conditions survival index and SI_{ti} is the technology intake part of the SI, for the ith, called hereby, technology intake survival index; E_i the number of employees of the ith enterprise; E_x the maximum number of employees distinguishing the different categories of enterprises (e.g. for Swedish SMEs, $E_{xs} = 250$ employees or $E_{xa} = 50$ employees); Y_i the firm age, since the ith enterprise has existed, called years of operation; L_j the average life span of the jth business sector; F_i the annual sales (turnover), that the enterprise generates (in US dollar or other currency) per periodicity unit; C_{2i} the intake and absorption of new technologies indicated by the annual investment (in US dollar or other currency), per periodicity unit; C_{3i} the total costs of production (US dollar or other currency), per year; C_{1i} the initial investment costs (US dollar or other currency); C_{1si} the self-financed initial capital of investment (US dollar or other currency); P_i the profit margin (a neutral percent figure); SI_{ij} the SI for the ith enterprise in a jth business sector.

In building up the SIV model the selection of the input parameter was both literature driven (i.e. the most important factors, as the literature survey indicated, were used) and a theory driven. In the theory-driven approach selected parameters were chosen and placed in the model in relation to their ability to reflect a true understanding as to how the different input parameters would contribute to the increasing the efficiency of the firm (Abouzeedan, 2011).

The constants A_a, A_b and A_c are the proportionality factors used to adjust segments of the SIV equation so that the product will be of approximately in power order, to each other. Because the model was constructed and being guided through only mathematical modeling (and not statistical modeling) (see Abouzeedan, 2011), the coefficients had to be chosen to give equal weight for the contributions from the three components of the SI equation, namely the operation segment, the finance segment and the technology-intake segment. The reader need to be reminded that the SIV model is a logic-driven model, expressed mathematically, and not an arithmetically constructed and derived equation.

A_a is used to adjust the left-side value of SI_{oi} namely:

$$\left(\frac{Y_i}{L_j}\right)\left(\frac{E_i}{E_x}\right)\left(\frac{F_i}{C_{3i}}\right)P_i$$

So that it attains an order of power of magnitude close to the right side of that index, namely:

$$\left(\frac{C_{1si}}{C_{1i}}\right)$$

The profit margin for SIV model is defined as: [(result after depreciation + financial returns)/annual turnover] (cs Abouzeedan, 2001, p. 75).

This can be expressed also as: [result after financial returns and costs/annual turnover].

The production cost, C_{3i}, includes costs of raw material and accessories, additional external costs and costs of labor and human resources.

The proportionality factor, A_b, is used to adjust the value (C_{1si}/C_{1i}). The proportionality factor, A_c, is used to adjust the value of the technology intake survival index, SI_{tj} to achieve the same purpose.

Having emphasized the deductive logic in choosing the coefficients' values, it is important to emphasize that one should use the same coefficients values for firms within the same sector and regional location. This is important for the internal validity of the SIV measurements and for the internal harmonizing of the SIV of the sample firms.

The technology intake segment:

$$SI_{ti} = A_c\left(\frac{C_{2i}}{C_{3i}}\right)$$

The level of innovation activities of the firm is expressed in the SIV model as the annual investments in the intake and absorption of new technologies. The investments in innovation activities of the firm (being products, process and management innovation) are split in the SIV equation in two types. The first type of investments are coupled to the development of own innovations with the firm (so called outward-focussed technology intake). The investments for incorporating and absorbing innovation brought to the company from outside sources (so called inward-focussed technology intake).

For our analysis, the value of E_{xs} was taken to be 250 employees in accordance with the Swedish standard, which is the same definition used for SMEs in the EU definition of small firms. The proportionally factor A_a was taken to be 10,000. The proportionality factor, A_b, was taken to be 10 while the proportionality factor, A_c, was taken to be 1,000. We used the profit margin as a fraction value and not as a non-fraction number (e.g. for 18 percent, we used $P_i = 0.18$). (C_{1si}/C_{1i}) ratio was taken to be 1.0, which is the unity value. This is because and according to the company owner, Håkan Sanberg, all the capital for the establishment of Autoadapt was paid through own-financing. This value will be used as a base-value for the subsequent years even if it was paid at the first years only. This is because self-financing approach to firms has a positive effect through the whole of the life of the enterprise. However, we are aware that such positive impact would propagate for the initial of years but then and as the company will need growth capital its importance will decline.

Thus it may be wise to the limit the number of years of using the initial self-fining ratio. In this paper, we kept the ratio as equal to unit, through the whole period of analysis. A suggestion for the future can be a period of five years as this is the period after which the firm clears the critical stage of their development according to the literature.

Different from standard SMEs models, the SIV does not recognize clear threshold cut value between bankrupt and non-bankrupt enterprises (as does the *Z*-scores and Zeta-scores models) because it see the transition area as region between good performers and bad performers were firms can proceed into worse or better performance. That gives flexibility for the model. It reduces the risk of judging wrongly the future of the firms on the slightest trouble as do models which have cut threshold values such as the *Z*-score and Zeta-scores (Altman, 1968; Altman *et al.*, 1977). Altman (1968) and Altman *et al.* (1977) as well as others have recognized the problem and warned for placing firms in the bankrupt group and such inducing an artificial bankruptcy by preventing the enterprise from getting financial resources a critical stage of their development. Altman (1968) and Altman *et al.* (1977) even introduced an error, which occurs by judging a firm which is having a good potential to be a bad performer with bankrupt possibility.

Selecting the members of the representative sample

We had two sources of information about firms in the sector related to adjusting cars to handicapped people. The first list was provided by Timo Einari Toivonen from Turku School of Economics, Finland, using the ORBIS database. The second list came from Affärdata (a Swedish commercial database). To select the firms, we looked at the codes used to describe the activities of Autoadapt AB. There were basically three of them: 30,920, 29,200 and 45,310 (Appendix 2). We combined two lists, the first list with 48 firms and the second list with 18 firms to produce a new combined list. After eliminating all the firms that we do not have information about their activities and the ones which reported no turn over in the last four years, a primary sample of total of 34 firms was created. Autoadapt AB was designated the firm number (34) for that list, as it is the firm which will be analyzed it stood as the last firm on the list. We also needed to eliminate all the firms which has registration date after April 7, 2000, because the aim of using the sample is to compare it with the activities of Autoadapt AB. This meant that the firm in the sample has to be starting its activities before or at that date. It is clear that as we started to analyze the performance of Autoadapt some firms were registered and we could have included them in the sample, but that would have disturbed the homogeneity of the sample because these firm would have been very early start-ups and that would have caused problems in reliability of the results. That is why we neglected the firms which were established later. Naturally, if we would to study the performance of Autoadapt AB in the future where the reference date have been moved forward, due to new take over or a new merger, these firms need to accounted for. That reduced the list further to its final setting (Appendix 2). The total number of firms in the sample, N^s, was 21 enterprises.

Calculations of different firm age concepts

In this part of the paper, we are reintroducing the different life span concept which was first displayed in Abouzeedan and Busler (2004). We are indicating how they could be calculated for Autoadapt AB. The average firm life of the sector (L_j), as expressed in the SIV equation, is the theoretically optimum value of youthfulness of the sector. Initially, the parameter L_j can obtain a variety of value levels for each specific sector. The investigator need to start with selected sample and would use the sample to make a first guess of the youthfulness of the business sector. That is why such average is called the sample average value and is designated by the symbol (L_j^s). L_j value can be expressed in the following equation:

$$L_j^s = \frac{\sum_{j=1}^{N^s} Y_i}{N^s} \tag{2}$$

where Y_i is the years of operation of the ith enterprise; N^s the number of firms in the sample.

L_j^s is usually calculated as the first time run when one wants to apply the SIV model analysis on a number of firms selected from a specific business sector. The (L_j^s) figure will be improving all the time as one adds move firms to the sample. L_j^s was calculated such that, $N^a = N^s + N^d$ where N^d the additional number of firms added to the original sample.

The subsequent life span parameter is called then the accumulated average life span (L_j^a) and can be calculated using the following equation:

$$L_j^a = \frac{\sum_{i=1}^{N^s} Y_i + N^s \cdot \tau^s + \sum_{i=1}^{N^d} Y_i}{N^a} \tag{3}$$

where Y_i is the years of operation of the ith enterprise; N^a the accumulative number of firms working within the jth sector; τ^s the age increment of the samples' firms relative to the reference date when, the SIV analysis was performed.

As the number of firms is increased in the sub-population, we would be getting close to the actual age of the sector. If the accumulated number of firms became large enough and almost equal the total population of the selected business sector (N^t), within specific geographical area, the average life span calculated in this case will be the real age of the sector within that specific geographical area. That figure is the ultimate average life span and is designated as (L_j^u). Such condition can be expressed as following: if $N^a \approx N^t$, then $L_j \approx L_j^u$.

The exact definitions of these life span forms are displayed in Table I (from Abouzeedan and Busler, 2004). Applying Equation (3), we needed only to account for the time change from the reference date and the date we are making our new evaluation (called evaluation date and designated as, D^e). So in our case D^e are the dates December 31, 2000, December 31, 2001 and so on until we reach December 31, 2010 (cs Table II). In continuation we will write D^e (December 31, 2000) and D^e (December 31, 2001). In all calculations we used the registration date, designated as D^r, as the starting point for the firm age calculation of the sample.

Calculations of the slope of the survival progression indicator (SPI)

Using the survival index curves (SIC) segments slopes it is possible to calculate the slope of the SPI line (Abouzeedan and Busler, 2003). The SPI line slope is designated as (Φ), while the slope of the individual SIC segments is designated as (υ) (Abouzeedan and Busler, 2003) The SPI line slope is also called "survivability coefficient." The two equations used in the calculations of υ and Φ are as following:

$$\upsilon_k = \frac{(SI_i)_{n^o} - (SI_i)_{n^o-1}}{(Y_i)_{n^o} - (Yi)_{n^o-1}} \quad (4)$$

$$\Phi = \frac{\sum_{k=1}^{n_s^o} \upsilon_k}{n_s} \quad (5)$$

where SI_i is the survival index values for the ith; Φ the survivability coefficient; υ the slope of the SIC segment, called survival factor; n_s the number of segments in the SIC; n_s^o the segment number; n the number of points of data making the SIC, such that:

$$n_s = n - 1 \text{ and } n_s^o = n^o - 1$$

where n^o is the data is point number and n is the number of data points.

Designation	Name	Member group	Designation	When used
L_j	Average life span	Any number of firms	N	Not specific
L_j^s	Sample average life span	Selected sample	N^s	Alone or combined with SIV application
L_j^a	Accumulated average life span	Both sample and additional firms	$N^a = N^s + N^d$	SIV application
L_j^u	Ultimate average life span	Total population	N^t	Ultimately

Source: "Analysis of Swedish Fishery Company using SIV model: a case study", in Abouzeedan, A. and Busler, M., *Journal of Enterprising Culture*, Vol. 12 No. 4. Copyright @ 2004, World Scientific Publishing

Table I. Usage of average of life span concepts within the SIV model

Period number	D^e	τ^s	Y_{22}	L_j^a
1	December 31, 2000	0.773	0.733	21.503
2	December 31, 2001	1.733	1.733	22.503
3	December 31, 2002	2.733	2.733	23.503
4	December 31, 2003	3.733	3.733	24.503
5	December 31, 2004	4.733	4.733	25.503
6	December 31, 2005	5.733	5.733	26.503
7	December 31, 2006	6.733	6.733	27.503
8	December 31, 2007	7.733	7.733	28.503
9	December 31, 2008	8.733	8.733	29.503
10	December 31, 2009	9.733	9.733	30.503
11	December 31, 2010	10.733	10.733	31.503

Table II. Calculating L_j^a values for the new group based on reference date D^0 (April 7, 2000) and annual periodicity

The SPI angle of inclination (θ), called survivability angle, is defined as:

$$Tan^{-1}(\Phi) = \theta \tag{6}$$

The values of (θ) gives indication to the general direction of the SPI line and help visualizing the performance of the enterprise. The last values of (Φ) and (θ) at the end of the analysis period is called, respectively, the true survivability coefficient, $\Phi^{\perp}$, and the true survivability angle, $\theta^{\perp}$.

Structuring the survival index diagrams (SIDs)
To be able to draw the SPI line, we are using the following equation:

$$(SI_i)^*_{n^o} = \Phi_i\{(Y_i)_{n^o} - (Y_i)_1\} + (SI_i)_1 \tag{7}$$

where n^o is the data-point number.

Calculating of the prediction power of the SIV model
To evaluate the ability of the SIV to reflect better on the survivability of SMEs, we have to consider the level of analysis done. Since the survivability coefficient, Φ is calculated as the average of the slopes of the SIC segments, it is expected that the larger the number of segments in the SID the more power of analysis has our investigation. This is also clear from comparing the results obtained for SIV analysis of the Swedish firms using different periodicity units (Abouzeedan and Busler, 2004). As one goes from two-monthly, quarterly and down to tertiary periodicity, the analysis becomes less stable. When the binominal periodicity analysis is used it produced a contradictory result with a negative Φ value. That gives an evidence of the existence of a breaking point at which the dynamics of the SIV model analysis is not stable. To evaluate that limit or breaking point, Abouzeedan and Busler (2004) introduced a new parameter called, prediction power of the SIV model designated Ψ_i. The new parameter can be defined according to the following:

$$\Psi_i = \Omega \cdot T_i \tag{8}$$

where Ω is the periodicity coefficient of the analysis method defined as the number of period-units per year. For example when a quarterly analysis is used then $\Omega = 4$; T_i the actual age of the firm at the time of the analysis such that,

$$T_i = Y_i(D^e) - Y_i(D^r) \tag{9}$$

where $Y_i(D^e)$ is the years of operation of the ith firm at the evaluation date, shall be called initial value of year of operation; $Y_i(D^r)$ the years of operation of the ith firm at the registration date, shall be called final value of years of operation.

Usually the registration date is the same date when firms are considered to start activity. In that case the value of $Y_i(D^r)$ will be equal to 0. However, we may have a situation when the firm has been in the hand of other owners and thus the firm is older because the initial value of the years of operation will be mathematically negative, inducing a positive increment to the actual age of the firm. On the other hand, may be the firm will start its activity at a later date after its registration. Then the initial value for the years of operation will be positive, reducing the actual age of the firm.

For our current case study the $Y_i(D^r)$ value was taken to be 0. If there was interest in studying the performance of that company during all period since the enterprise was established then we would considered the number of years of operation before the take over as the value for $Y_i(D^r)$, giving it a negative sign. From Equation (8) and Equation (9), the prediction power equation can be rewritten as:

$$\Psi_i = \Omega \cdot [Y_i(D^e) - Y_i(D^r)] \quad (10)$$

We can use the periodicity coefficient to calculate number of periods, with any years of operations interval by the equation:

$$n_p = \Omega \cdot \Delta Y_i \quad (11)$$

where n_p is the number of periods; ΔY_i the interval of years of operation within which the SIV analysis is performed.

We also define a new parameter called periodicity compression coefficient, η, which is expressed mathematically as follows:

$$\eta = \frac{\Omega}{n_p} \quad (12)$$

The new coefficient gives indication of the length of the periodicity unit used in the analysis compared to the total number of periods. A lower, η, value, given same periodicity coefficient, indicates a higher compression and higher evaluations frequencies when the whole period of evaluation is considered. That reflects stronger analysis with a larger number of points. A higher value of η, indicate a weaker analysis with wider time range between analysis points. The reason to do this analysis is be sure that the periodicity used is adequate to run the analysis and give a stable true survivability coefficient. In the case of Autoadapt AB and because we are use extend period of time over the years of operation the compression coefficient is stable at 0.1, regardless of the periodicity used. That is why in the analysis of this enterprise we did not need to calculate the true suitability coefficient for more than the annual periodicity case. In general it is recommended that when the final evaluation period expressed as number of operating years, is short to use more frequent analysis (i.e. high-periodicity coefficient) while when the period is longer to use a longer periods of analysis (i.e. lower periodicity coefficient).

Results and analysis

The accumulative average life span for the total sample

To establish an initial value for the L_j, we used a sample of Swedish SMEs with number of employees below 250. We used the registration date of Autoadapt-Bev AB as the reference date. This is expressed as D^0 (April 7, 2000). Ages of individual firms were calculated starting from the registration date, D^r, and using a reference date, D^0 (April 7, 2000), which is the registration date of the new emerged Autoadapt-Bev AB. Later on the firm returned the original name, Autoadapt AB. The Average Life Span for the original sample was calculated using Equation (2). To calculate the new average life span value after adding the new member to the previous sample, in our case Autoadapt AB, the so-called accumulative average life, L_j^a, we used Equation (3). The average number of days in a month is always taken as 30 days in our calculations. The size of the accumulative number of firms (N^a) is 22. The calculations were used only for one periodicity alternative and that annually. The results of these calculations are shown in Table II.

The SIV

Using the SIV equation, the SIV were calculated for the object firm at two stages. The first stage was to calculate the operational SI. In Table III we calculated the production cost. In Table IV, the profit margin is calculated. In Table V, the operational SI is calculated. From Table V, one can see there are two main jumps in the operational SIV. The first one is between 2000 and 2001, were the SIV increased from −0.64732 to 9.69824, an increment of 15 folds. Another jump occurred between 2002 and 2005 when the operational SI increased 13 folds from +4.43902 and +57.60587. To calculate the technology intake, the development costs were calculated and the results are displayed in Table VI. From the table the development costs range from 4.95 to 10.41 percent, which is a high figure. In Table VII, the SIV are calculated.

Period number	F_{22}	Costs for raw material and accessories	$C_{3(22)}$ (divided) Additional external costs	Costs of labor and human resources	$C_{3(22)}$
1	55,882,367	29,570,341	7,193,492	17,882,339	54,646,183
2	73,174,881	33,967,355	8,544,199	21,626,655	64,138,209
3	80,112,860	33,792,522	12,859,122	27,565,851	44,131,503
4	95,240,316	38,118,680	12,822,685	34,131,106	85,072,471
5	96,808,756	38,412,019	14,830,638	34,561,080	87,803,737
6	96,473,603	37,457,893	13,770,468	36,312,853	87,541,214
7	95,855,376	40,160,543	15,868,788	39,541,854	95,571,185
8	110,413,905	44,445,625	17,144,831	40,731,520	102,321,976
9	117,997,357	43,747,958,12	22,906,294	40,300,538	106,954,790
10	126,706,544	50,550,636	24,230,335	42,524,767	117,305,738
11	133,973,961	50,950,000	26,502,764	47,310,383	124,763,147

Table III. Calculating the production costs

Period number	Result after depreciation	Result after financial returns and costs	Annual turnover	Profit margin
1	806,481	−553,628	55,882,367	−0.00991
2	6,012,998	4,531,859	73,174,881	0.06193
3	3,412,697	1,982,825	80,112,860	0.02475
4	8,143,419	6,636,913	95,240,316	0.06986
5	8,272,767	7,824,921	96,808,756	0.08083
6	8,055,580	8,576,798	96,473,603	0.08890
7	−1,863,786	−108,910	95,855,376	−0.00114
8	6,321,035	6,079,736	110,413,905	0.05506
9	8,974,724	8,868,232	117,997,357	0.07516
10	9,007,922	8,921,048	126,706,544	0.07041
11	9,554,297	9,314,450	133,973,961	0.06952

Table IV. Calculating the profit margin

Annual period number	Year	Y_{22}/L_j^a	E_{22}	E_{22}/E_{xa}	$F_{22}/C_{3(22)}$	P_{22}	SI_{22o}^a
1	2000	0.03408	49	0.196	0.97789	−0.00991	−0.64732
2	2001	0.07701	58	0.232	0.87651	0.06193	+9.69824
3	2002	0.11628	70	0.280	0.55087	0.02475	+4.43902
4	2003	0.15235	83	0.332	0.89324	0.06986	+31.56293
5	2004	0.18559	87	0.348	0.90698	0.08083	+47.34827
6	2005	0.21632	82	0.328	0.91326	0.08890	+57.60587
7	2006	0.24481	85	0.340	0.99704	−0.00114	−0.94607
8	2007	0.27130	84	0.336	0.92671	0.05506	+46.51244
9	2008	0.29600	79	0.316	0.90642	0.07516	+63.72283
10	2009	0.31908	82	0.328	0.92581	0.07041	+68.22282
11	2010	0.34070	90	0.360	0.93125	0.06952	+79.40552

Table V. Calculations of the annual-based operational survival index (SI_{io}^a)

Period number	Year	Development costs, $C_{2(22)}$	Turn over, F_{22}	Percent of turn over
1	2000	2,760,018	55,882,367	4.94
2	2001	3,447,795	73,174,881	4.71
3	2002	4,209,846	80,112,860	5.26
4	2003	4,875,198	95,240,316	5.11
5	2004	6,635,323	96,808,756	6.85
6	2005	8,502,855	96,473,601	8.81
7	2006	8,515,044	95,855,376	8.88
8	2007	9,219,604	110,413,905	8.35
9	2008	11,143,266	117,997,357	9.44
10	2009	13,185,500	126,706,544	10.41
11	2010	13,199,898	133,973,961	9.85

Table VI. The calculating of the percent of development costs to the annual turn over

Period number	Year	$C_{2(22)}/C_{3(22)}$	SI_{it}^a	SI_{22}^a
1	2000	0.05051	50.51	59.86268
2	2001	0.05376	53.76	73.45824
3	2002	0.09539	95.39	109.82902
4	2003	0.05731	57.31	98.87293
5	2004	0.07557	75.57	132.91827
6	2005	0.09713	97.13	164.73587
7	2006	0.08910	89.10	98.15393
8	2007	0.09010	90.10	146.61244
9	2008	0.10417	104.17	177.89283
10	2009	0.11240	112.40	190.62282
11	2010	0.10580	105.80	195.20552

Table VII. Calculations of the survival index (annually based) (SI_{22}^a)

The survival factors

Using Equation (4), the survival factor values were calculated for Autoadapt AB using the annual periodicity. The results of these calculations are shown in Table VIII.

The slope of the survival progression indicator (SPI)

Using Equation (5), the survivability coefficient values were calculated for Autoadapt AB using the annual periodicity. The results of these calculations are shown in Table IX.

Constructing the SIDs

The values obtained from the calculations of the SIV (via the SIV equation) and the survivability coefficients obtained from Equation (5), together with Equation (7) where used to construct the SIDs for the firm for the annual periodicity. The calculations for the SPI line are shown in Tables VII and X. The data from that table is used to construct the figure (SID). From Figure 1, one can see that there were two years were the SIV dropped, one at 2003 and a deeper drop in 2007. The data from Table VIII are

Table VIII. Calculations of the survival factor (υ) values for annual periodicity

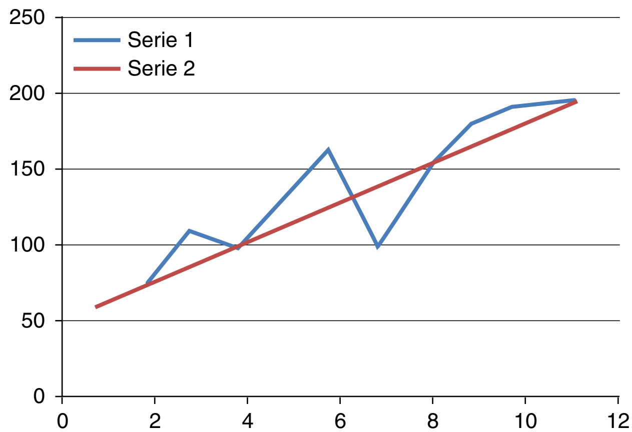
Segment number (n_s)	$\Delta(SI^a_{22})$	$\Delta(Y_{22})$	Survival factor (υ)
1	13.59556	1	13.59556
2	36.37078	1	36.37078
3	−10.95609	1	−10.95609
4	34.04534	1	34.04534
5	31.81760	1	31.81760
6	−66.58194	1	−66.58194
7	48.45851	1	48.45851
8	31.28039	1	31.28039
9	12.72499	1	12.72499
10	4.58270	1	4.58270

Table IX. Calculations for the survivability coefficient (Φ) and survivability angle (θ) based on annual periodicity

Accumulated segment number (n^a_s)	$\sum_{k=1}^{n_s} \upsilon_k$	Survivability coefficient (Φ)	Survivability angle (θ)
1	13.59556	13.59556	85.774
2	49.96634	24.98317	87.708
3	39.01025	13.00342	85.602
4	73.05559	18.26390	86.866
5	104.87319	20.97464	87.270
6	38.29125	6.38188	81.095
7	86.74976	12.39282	85.387
8	118.03015	14.75377	86.122
9	130.76014	14.52890	86.061
10	135.34284	13.53428	85.774

Table X. Calculations for the SPI line based on annual periodicity

Period number	$(Y_{22})_n$	$(\Delta Y_{22})_n$	$(SI^a_{22})_n$*
1	0.773	0	59.86268
2	1.733	1	73.39696
3	2.733	2	86.93125
4	3.733	3	100.46553
5	4.733	4	113.99982
6	5.733	5	127.53410
7	6.733	6	141.06838
8	7.733	7	154.60267
9	8.733	8	168.13695
10	9.733	9	181.67124
11	10.733	10	195.20552



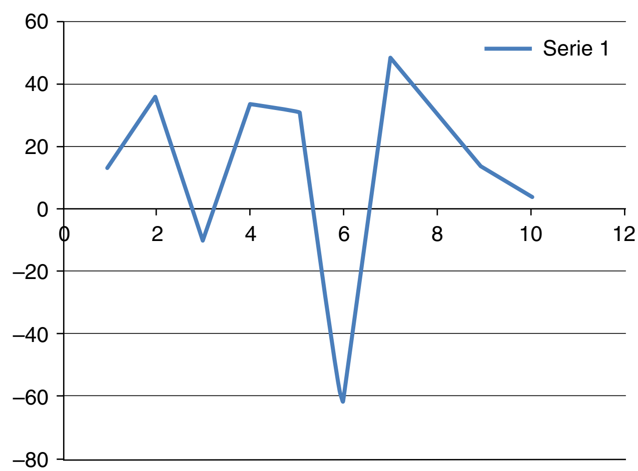
Notes: *x*-axis, years of operation; *y*-axis, survival index; series 2 is the SPI line

Figure 1.
Survival index diagram based on annual periodicity

used to construct Figure 2. From Figure 2, which indicates the value of the survival factor, one can see a clear drop in two points where the performance has worsened. The first one is in 2002-2003 and the more serious one occurred on 2005-2006. The data from Table IX is used to construct Figure 3. In Figure 3, one see that the accumulated value of performance, expressed as survivability coefficient, has been positive all the way. The first years up to the period 2005-2006 were characterized by fluctuation in the performance between improving and worsening conditions. Starting from 2006 to 2007, the performance stabilized at almost at a constant positive average rate of improvement.

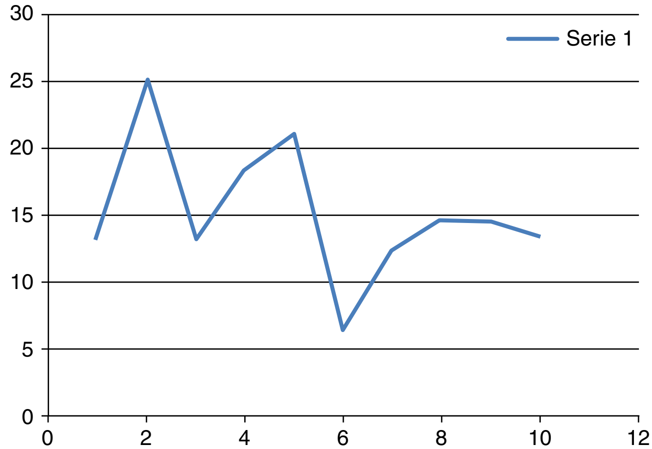
Discussion and analysis

The SIV model has the advantage of doing the analysis at four levels thus increasing the internal reliability of the calculations.



Notes: *x*-axis, segment number; *y*-axis, survival factor

Figure 2.
Survival factor diagram, based on annual periodicity



Notes: *x*-axis, accumulated segment number; *y*-axis, survivability coefficient

Figure 3.
The survivability coefficient diagram, based on annual periodicity

The first level: the SIV. As Figure 1, shows the SIV were all positive which an indication of a good performance is in itself. There are fluctuations between the different periods, but this is natural as firms may do less well in a period than other. However, one should be careful in distinguishing between doing less worse in single periods. Two such worsening periods appear (periods (4) and (7)) (Table VII). Such worsening is not clear indication of bankruptcy. Actually a company may deliberately in single years, spend money, by expanding its production capacity, or investment in a new facility, and thus reducing SIV. This is a strategic decision and not an effect induced by bankruptcy. Bankruptcy requires successive worsening in consecutive periods after a period until the SIV are transferred across the zero line to being negative. That is not enough in itself to judge the firm to be in bankruptcy conditions there must be a continuous increasing in these negative values and not fluctuation across the zero line.

The second level: the SPI line. One can see from Figure 1, that SPI line had a positive slope, above 0.6, indicating a firm that belongs to the category of firms with positive slope (so called: SPI(+)) (see Abouzeedan, 2011).

The third level: survival factors. From Figure 2, one can see that the change in the SIV between the periods were for the most positive except in two occasions. The first is the shift in SIV between periods (3) and (4) and second is the shift between (6) and (7) (Table VIII). That produced two occasions were the survival factors had negative values.

The fourth level: survivability coefficient. In Figure 3, one can see the average value of the accumulated survival factors (so called survivability coefficient) is positive always. It also fluctuates in the beginning (up to the seventh period), and then settle around an average survivability coefficient value of 149, presenting a growth at a fixed rate. This coincides with the literature which indicates that the survivability coefficient within the first five years to be most important in its development. The additional years may be due to the high technology activities of Autoadapt AB.

Conclusions

Measuring performance of SMEs is an important issue. There are couple of models stemming from the traditional accountancy disciplines, used. These models suffer from clear disadvantages. However, recently a new model, the SIV model was introduced (Abouzeedan, 2011). The model has shown the ability of being a better candidate of performance analysis. The purpose of this case study was to demonstrate the ability of the SIV model to judge correctly the performance of an innovative firm. To do that we ran the SIV analysis on a Swedish SME that is active in the health care sector. We knew, beforehand, the situation for the firm, Autoadapt AB as an innovative firm and we wanted to show that the SIV model can capture that impact on the performance. The firm adapt personal cars for the usage of handicapped people.

The SIV model has four level of analysis giving it very high level of internal reliability. At the four levels, the firm showed a positive indication of its performance. By having mostly positive survival factor values, which are single data points, during years of operation, and also having mostly positive survivability coefficient values, which are agglomerate data points, the SIV model proved its functionality. The survivability coefficient curve showed a steady improvement of firm performance due to extensive investment in product development. Clearly, the model has a good potential to be developed and fine-tuned even more.

Future research

Traditional models of SME performance have focussed mostly on financial indicators. Non-financial parameters are, for the most part, excluded from these models. Only minor efforts are recorded in that direction. The SIV model incorporated two non-financial parameters in its structure: firm age and firm size. However, there remains a need to study the ability of non-financial parameters other than age and size to impact the performance of SMEs. There is also a need to further develop the SIV model to study specific cases, such as firm birth at the project stage prior to pre-launching, when the firm is only in the business idea phase. Studying how variations in the business sector and location of firm impact SME performance can be of value to the goal of projecting and investigating firm development.

References

Abouzeedan, A. (2001), *Factors Affecting the Performance of SMEs and the Survival Index Equation: A Quantitative Evaluation (ISBN 91-628-6140-9)*, Washington International University, King of Prussia, PA.

Abouzeedan, A. (2002), "Performance factors of small and medium-size enterprises: a new classification system", in Johansson, I. (Ed.), *Uddevalla Symposium 2002 Anthology (Research Reports 03:1), Innovation, Entrepreneurship, Regional Development and Public Policy in the Emerging Digital Economy*, University of Trollhättan/Uddevalla, Uddevalla, pp. 7-19.

Abouzeedan, A. (2011), "SME performance and its relationship to innovation", Dissertation No. 1364, PhD thesis, Linköping Studies in Science and Technology, Linköping University, Linköping.

Abouzeedan, A. and Busler, M. (2002), "Small and medium-size enterprises performance: an evaluation using the survival index value (SIV) model", Paper No.15, paper presented at the International Conference on Medium Enterprise Development, Collingwood College, University of Durham, Durham, July 14-16 (CD).

Abouzeedan, A. and Busler, M. (2003), "Survivability coefficient; new measurement of SMEs performance", paper presented at ISBA 26th National Small Firms Policy and Research Conference, November 12-14, University of Surrey, Guildford, UK.

Abouzeedan, A. and Busler, M. (2004), "Analysis of Swedish fishery company using SIV model: a case study", *Journal of Enterprising Culture*, Vol. 12 No. 4, pp. 277-301.

Abouzeedan, A. and Busler, M. (2005), "The birth and death model: a new concept of firm life cycle", in Johansson, I. (Ed.), *Uddevalla Symposium 2005 Anthology (Research Report 2006:1) Innovations and Entrepreneurship in Functional Regions*, University West, Uddevalla, pp. 9-25.

Acs, Z.J. (1999), "The new American evolution", in Acs, Z.J. (Ed.), *Are Small Firms Important?*, Kluwer Academic, Boston, MA, pp. 1-30.

Acs, Z.J. and Yeung, B. (1999), "Conclusion in small and medium-sized enterprises", in Acs, Z.J. and Yeung, B. (Eds), *The Global Economy*, University of Michigan Press, Ann Arbor, MI, pp. 164-73.

Altman, E.I. (1968), "Financial ratios, discriminant analysis and the prediction of corporate bankruptcy", *The Journal of Finance*, Vol. 23 No. 4, pp. 589-609.

Altman, E.I. (1983), "Exploring the road to bankruptcy", *The Journal of Business Strategy*, Vol. 4 No. 2, pp. 36-41.

Altman, E.I., Haldeman, R.G. and Narayanan, P. (1977), "Zeta* analysis: a new model to identify bankruptcy risk of corporations", *Journal of Banking and Finance*, Vol. 1 No. 1, pp. 29-54.

Altman, E.I., Marco, G. and Varetto, F. (1994), "Corporate distress diagnosis: comparisons using linear discriminant analysis and neural networks (the Italian experiment)", *Journal of Banking and Finance*, Vol. 18 No. 3, pp. 505-29.

Argenti, J. (1976), *Corporate Collapse, the Causes and Symptoms*, McGraw-Hill Book Company (UK) Limited, Maidenhead.

Castrogiovanni, G.J. (1996), "Pre-startup planning and the survival of new small businesses: theoretical linkages", *Journal of Management*, Vol. 22 No. 6, pp. 801-23.

Caves, R.E. (1998), "Industrial organization and new findings on the turnover and mobility of firm", *Journal of Economic Literature*, Vol. 36 No. 4, pp. 1947-82.

Chesbrough, H.W. (2001), "Open innovation: a new paradigm for managing technology", paper presented at the OECD Conference on New Business Strategies for R&D, Paris, October 22.

Chesbrough, H.W. (2003), *Open Innovation: the New Imperative for Creating and Profiting from Technology*, Harvard Business School Press, Boston, MA.

Chesbrough, H., Vanhaverbeke, W. and West, J. (2006), *Open Innovation: Researching a New Paradigm*, Oxford University Press, Oxford.

Cohen, W.M. and Levinthal, D.A. (1990), "Absorptive capacity: a new perspective on learning and innovation", *Administrative Science Quarterly*, Vol. 35 No. 1, pp. 128-52.

Corley, M., Michie, J. and Oughton, C. (2002), "Technology, growth and employment", *International Review of Applied Economics*, Vol. 16 No. 3, pp. 265-76.

Daft, R.L. (1982), "Bureaucratic versus nonbureaucratic structure and the process of innovation and change", In Bacharach, S.B. (Ed.), *Research in the Sociology of Organizations*, JAI Press, Greenwich, CT, pp. 129-66.

Damanpour, F. and Evan, W.M. (1984), "Organizational innovation and performance: the problem of organizational lag", *Administrative Science Quarterly*, Vol. 29 No. 3, pp. 392-409.

Damanpour, F. and Gopalakrishnan, S. (1988), "Theories of organizational structure and innovation adoption: the role of environmental change", *Journal of Engineering and Technology Management*, Vol. 15 No. 1, pp. 1-24.

Damanpour, F., Szabat, K.A. and Evans, W.M. (1989), "The relationship between types of innovation and organizational performance", *Journal of Management Studies*, Vol. 26 No. 6, pp. 587-601.

Davidson, P. and Klofsten, M. (2003), "The business platform: developing an instrument to gauge and to assist the development of young firms", *Journal of Small Business Management*, Vol. 41 No. 1, pp. 1-26.

Downs, G.W. and Mohr, L.B. (1976), "Conceptual issues in the study of innovation", *Administrative Science Quarterly*, Vol. 21 No. 4, pp. 700-14.

Freel, M.S. (2000), "Do small innovating firms outperform non-innovators?", *Small Business Economics*, Vol. 14 No. 3, pp. 195-210.

Geroski, P.A. and Machin, S. (1992), "Do innovating firms outperform non-innovators?", *Business Strategy Review*, Vol. 3 No. 2, pp. 79-90.

Gnyawali, D.R. and Park, B-J. (2009), "Co-operation and technological innovation in small and medium-sized enterprises: a multilevel conceptual model", *Journal of Small Business Management*, Vol. 47 No. 3, pp. 308-30.

Gritta, M.W., Davalos, S., Wang, M. and Chow, G. (2000), "Forecasting small air carrier bankrupticies using a neural network apporach", *Journal of Financial Management & Analysis*, Vol. 13 No. 1, pp. 44-49.

Hadjimanolis, A. (2000), "A resource-based view of innovativeness in small firms", *Technology Analysis and Stratgeic Management*, Vol. 12 No. 2, pp. 263-81.

Hart, P.E. and Paris, S.J. (1956), "The analysis of business concentration: a statistical approach", *Journal of the Royal Statistical Society*, Vol. 119 No. 2, pp. 150-91.

Hedner, T., Cowlrick, I., Wolf, R., Olausson, M. and Klofsten, M. (2011), "The changing structure of the pharmaceutical industry – perceptions on entrepreneurship and openness", in Cassia, L., Paleari, S. and Minola, T. (Eds), *Entrepreneurship and Technological Change*, Edward-Elgar Publishing, New York, pp. 73-94.

Helms, M.M. and Renfrow, T.W. (1994), "Expansionary process of the small business: a life cycle profile", *Management Decision*, Vol. 32 No. 9, pp. 43-6.

Houghton, K.A. (1984), "Accounting data and the prediction of business failure, the setting of priors and age of data", *Journal of Accounting Research*, Vol. 22 No. 1, pp. 361-8.

Jain, B.A. and Nag, B.N. (1997), "Performance evaluation of neural network decision models", *Journal of Management Information Systems*, Vol. 14 No. 2, pp. 201-16.

Jovanovic, B. (1982), "Selection and the revolution of industry", *Econometrical*, Vol. 50 No. 3, pp. 649-70.

Keasey, K. and Watson, R. (1991), "Financial distress prediction models: a review of their usefulness", *British Journal of Management*, Vol. 2 No. 2, pp. 89-102.

Keasey, K. and Watson, R. (1993), *Small Firm Management: Ownership,*, Finance and Performance, Blackwell Publishers, Oxford.

Keasey, K., McGuinness, P. and Short, H. (1990), "Multilogit approach to predicting corporate failure, further analysis and the issue of signal consistency", *Omega*, Vol. 18 No. 1, pp. 85-94.

Klofsten, M. (1992a), "Tidiga Utvecklingsprocesser I Teknikbaserade Företag (early development processes in technology-based firms)", No. 24, PhD dissertation, Department of Management and Economics, Linköping University, Linköping.

Klofsten, M. (1992b), "Tidiga Utvecklingsprocesser I Teknikbaserade Företag – En literaturgenomgång", Working Paper No. Code: LIUEKI/WPS-92-9203, University of Linköping, Linköping.

Klofsten, M. (2010), *The Business Platform: Entrepreneurship & Management in the Early Stages of a Firm's Development*, 3rd ed., TII asbl, Luxemburg.

Libby, R. and Lewis, B.L. (1982), "Human information processing research in accounting: the state of the art in 1982", *Accounting, Organization and Society*, Vol. 7 No. 3, pp. 231-85.

Lindholm, Å. (1994), "The economics of technology-related ownership changes: a study of innovativeness and growth through acquisitions and spin-offs", published PhD dissertation, Chalmers University of Technology, Gothenburg.

McPherson, M.A. (1995), "The hazards of small firms in Southern Africa", *The Journal of Development Studies*, Vol. 32 No. 1, pp. 31-55.

Mazzarol, T. and Rebound, S. (2008), "The role of complementary actors in the development of innovation in small firms", *International Journal of Innovation Management*, Vol. 12 No. 2, pp. 223-53.

Motwani, J., Dandridge, T., Jiang, J. and Soderquist, K. (1999), "Managing innovation in French small and medium-sized enterprises", *Journal of Small Business Management*, Vol. 37 No. 2, pp. 106-14.

Nelson, R.R. and Winter, S.G. (1978), "Forces generating and limiting concentration under Schumpeterian competiton", *The Bell Journal of Economics*, Vol. 9 No. 2, pp. 524-48.

Qian, G. and Li, L. (2003), "Profitability of small and medium-sized enterprises in high-tech industries: the case for biotechnology industry", *Strategic Management Journal*, Vol. 24 No. 9, pp. 881-7.

Schumpeter, J.A. (1934), *The Theory of Economic Development*, Harvard University Press, Cambridge, MA.

Scott, W.R. (2003), *Organizations, Rational, Natural, and Open Systems*, 5th ed., Prentice Hall, Upper Saddle River, NJ.

Soni, P.K., Lilien, G.L. and Wilson D.T., D.T. (1993), "Industrial innovation and firm performance: a reconceptualization and structural equation analysis", *International Journal of Research in Marketing*, Vol. 10 No. 4, pp. 365-80.

Teirlinck, P and Spithoven, A. (2008), "The spatial organization of innovation: open innovation, external knowledge relations and urban structure", *Regional Studies*, Vol. 42 No. 5, pp. 689-704.

Trott, P. (2008), *Innovation Management and New Product Development*, 4th ed., Prentice Hall, London.

Vermeulen, P.A.M., Jong, J.P.De. and O'Shaughnessy, K.C. (2005), "Identifying key determinants for new product introductions and firm performance in small service firms", *The Service Industries Journal*, Vol. 25 No. 5, pp. 625-40.

Veugelers, R. (1997), "Interval R&D expenditures and external technology sourcing", *Research Policy*, Vol. 26 No. 3, pp. 303-15.

Vossen, R.W. (1998), "Relative strengths and weaknesses of small firms in innovation", *International Small Business Journal*, Vol. 16 No. 3, pp. 88-94.

Wincent, J. and Westerberg, M. (2005), "Personal traits of CEO, inter-firm networking and entrepreneurship in their firms: investigating strategic SME network participants", *Journal of Development entrepreneurship*, Vol. 10 No. 3, pp. 271-84.

Wincent, J., Anokin, S. and Boter, H. (2009), "Network board continuity and effectiveness of open innovation in Swedish strategic small-firm networks", *R&D Management*, Vol. 39 No. 1, pp. 55-67.

Wolff, J.A. and Pett, T.L. (2006), "Small-firm performance: modeling the role of the product and process improvements", *Journal of Small Business Management*, Vol. 44 No. 2, pp. 268-84.

Yazdipour, R. and Constand, R.L. (2010), "Predicting firm failure: a behavioral finance perspective", *The Journal of Entrepreneurial Finance*, Vol. 14 No. 3, pp. 90-104.

Further reading

Globerman, S., Roehl, T.W. and Standifird, S. (2001), "Globalization and electronic commerce: inferences from retail brokering", *Journal of International Business Studies*, Vol. 32 No. 4, pp. 749-68.

Storey, D.J., Keasey, K., Watson, R. and Wynarczyk, P. (1987), *The Performance of Small Firms*, Croom-Helm Ltd, London.

Appendix 1. History of Autoadapt AB

Before 1991

- Handi Sverige AB was established.
- The company operated a commercial activity to modifying (different applications) to handicapped people. The activities centered on the low platform Chrysler Voyger cars. The customer target group where mostly wheelchair-bound people who drove cars. Later on, when Autoadapt AB, took over, it widened that category to include families with a member which has handicapped status, even when the person is not bound to chair. Autoadapt AB even worked with taxi cars to modify them for handicapped usage.
- Beram AB bought the bankrupted firm Handi Sverige AB.

1991-1994

- In 1992, Beram AB took over the distribution of Invacare products in the marker. Invacare is an American company which produced rehabilitation products such as wheelchairs and ceiling-fixed lifting cranes.

1995-1998

- The activities of car modification for handicapped people were taken over from Invacare by Beram Autoadapt AB which was built by Staffan Ramer and Peter Wahlsten. That occurred in 1996. With the building up of Beram Autoadapt a decision was taken to widen the company's activities to include cars of Volvo model, beside the American car models. A decision was also taken to seek ISO 9002 certification. At that time Peter Wahl ten was responsible for the car modification activities as well as being the service chief for electrical rolling chairs while Staffan Ramer was the general manager of the company. In January 1998, took Håkan Sandberg that position after the resignation of Peter Wahlsten.
- In summer of 1998, Staffan Ramer solid all his shares in the company to Peter Wahlsten. The shares were sold immediately to 6:e AP-fonden.
- Peter Sandberg, the financial manager of Volvo AB, was on the board of the company between September 1995 and March 1997.
- After Peter Sandberg left the board Håkan Sandberg was elected as a general manager and owner in the company. The company is owned by three partners: Peter Wahlsten, Håkan Sandberg and 6:e AP fonden.
- On October 1999, took Autoadapt AB over BEV Euroaid AB and its daughter company, Fastighetsbolaget Sanna AB. BEV has been the largest competitors of Autoadapt in the field of production and selling of adapted personal cars.

2000-2004

- During August 2000, a fusion occurred between Autoadapt AB and BEV Euroaid AB. The resulting company became the leading actor in Europe in the area of adapting personal cars to the usage of the handicapped people. Audoadapt became a company with overall strategy of manufacturing products to move handicapped people from a place to another.

- Autoadpt won the prize of being the year growth company in 2002.
- In December 2002 a new stage in the development of Autoadpt occurred when Bruno Independent Living Aids bought 6:e AP Fondens shares in the company. From that date the company is owned by Bruno, Håkan Sandberg and Peter Wahlsten. Företaget Bruno was at that point one of the largest customers of Autoadapt.
- Autoadapt AB now with Bruno is today the largest developer and producers of car adapting solutions for handicapped people.
- In 2003, the export part of the firm's activities made 65 percent of the total turnover. The company had 30 percent of its market in Sweden.
- During April 2004 the company changed the name to Autoadapt AB, it original name.
- In January 2004 the company had 86 employees and production units in Boräs and Stenkullen as well as a distributor (Autoadapt UK Ltd) in Birmingham. The company exports roughly 70 percent of its turn over outside Sweden. The company exports to 30 countries around the world. The largest export market being North America (USA, Canada and Mexico).

2005-2010

- Under the year 2005 the LEAN concept was introduced to the company while at the same time a lot of re-structuring was performed to allow for future expansion. A lot of the education and training was done both for the top management as the core workers. A lot of energy and time was put to create a production development process. The export part of firm activities was 85 percent.
- In 2006 the company started a new expansion. The board of directors decided to merge the production units in Borås and Stenkullen to a combined unit. As a leading process in this work, a land was bought in Stenkullens Industrial Area. Autoadapt in this point of time had ownership of its facilities via a 100 percent owned company in Borås (Fastighetsbolaget Sanna AB) and in Stenkullen via Fastighetsbolaget Autoadapt AB. The process of selling the two companies and to construct the new facility was finished during autumn of the same year. The new project increased the resources for training the employees continued under 2006. The export part of the activity was roughly 85 percent. The turn over was 105 million Swedish crowns.
- In August 2007 the company moved to its new facilities (Åkerivägen 7, Stenkullen). Most of that year (2007) went into preparation for the moving into the new facilities. The company had its best turn-over under the first half. The turn-over for 2007 was 110 millions.
- In year 2008 Autoadapt AB was awarded "Göteborgs Companipris." The award was to award the good enterprising of the management team. The basic idea is that enterprising is good for the customer, colleagues and owners.
- In the subsequent years 2009-2010, the company continued its growth and it is currently one of the bright of examples of innovative Swedish SME active within health care.

Appendix 2

Firm number	Company name	Registration date (D^r)	Age of firm (years) (Y_i)
1	Ahlberg Rehab AB (1)	December 23, 1994	5.289
2	Artur Heijel Plastvaru AB (1)	October 22, 1962	37.458
3	Atran AB (1)	February 2, 1937	63.161
4	Bergdunge Häst AB (1)	March 21, 1996	4.044
5	CombiMobil AB (1)	November 5, 1993	6.422
6	Cycleurope AB (1)	November 25, 1970	29.367
7	Cycleurope Sverige AB (1)	October 20, 1937	62.464
8	Edsbergs Rullstolstillbehör AB (1)	August 25, 1971	28.614
9	Emmaljunga Barnvagnsfabrik AB (1)	February 17, 1993	7.139
10	ETAC Supply Center AB (1)	January 19, 1981	19.167
11	Handinnova AB (1)	December 14, 1988	11.314
12	Hedemora Anpassning AB (1,2)	September 18, 1996	3.533
13	Helab Produktion AB (1)	July 7, 1989	10.750
14	Invacare Rea AB (1)	July 13, 1965	34.706
15	Jatab Care AB (1)	September 26, 1989	10.553
16	Minicrosser AB (1)	February 20, 1996	4.131
17	OBIK AB (1)	December 9, 1994	5.328
18	Permobil AB (1,2)	November 27, 1967	33.361
19	Permobil Produktion AB (1)	October 28, 1997	2.442
20	Pilen Cykel AB (1)	April 30, 1991	8.936
21	Rex Sport AB (1)	July 7, 1931	68.750
		Summation	456.929
		L_j^s	21.758
22	Autoadapt AB (1,2) (before Autoadapt-Bev AB)	April 7, 2000	0

Table AI. Age of firm for the refined list, age of firm at D^0 (2000-04-07), all firms have <250 employees, and which been registered on 7 April 2000 or before

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