Growth challenges across industries: Investigating 'Teecian' heuristics

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Abstract

We explore factors that may explain variation in economic returns to innovation, as appropriated by small high-technology start-up firms. Drawing inspiration from 'Teecian heuristic' we focus our examination on fine-grained aspects of appropriability regimes, the dominant design paradigm, and the availability of complementary assets. Doing so, we seek to answer the following research questions: 1) Why do innovating small high-tech firms often fail to obtain significant economic returns from an innovation?; 2) How do regimes of appropriability, dominant design paradigm, and the availability of complementary assets explain variation of economic returns from an innovation received by small high-tech firms? As an answer to the first research question the entrepreneurship literature suggests that innovations do not turn as such to economic profit; an important ingredient in this process may be entrepreneurship. Preliminary results from studying 'Teecian heuristic' in a sample of new technology-based firms support this view: a direct association is found between entrepreneurship and performance (growth) while between innovativeness and growth such association was not found. Through an interaction model it is found that under industry conditions where the dominant design has been achieved (paradigmatic stage) and complementary assets are available the effect of innovativeness on growth is stronger than otherwise.

Key words: entrepreneurship, innovation, growth, complementary assets, dominant design, appropriability regime

Introduction

The belief in the importance of innovative new technology-based firms as a source for future economic prosperity and well-being is evident. In the US, for example, the long economic boom in the 1980s and 1990s is believed to be driven by growth in information technology industries in a few regional clusters (Bresnahan and Gambardella, 2004). Because of such success stories, policy makers around the world are anxious to find tools that will help their regions emulate the success of Silicon Valley and create new centres of innovation and high technology (Wallsten, 2004) that would be a source for new growing technology firms. Many empirical studies, however, point out that only few firms are able to obtain the economic benefits from being innovative. For example Coad and Rao (2008) found that the returns to IPR are highly skewed and the distribution of growth rates is heavily tailed. That is, only a minority of innovating firms are able to obtain benefit from their innovation activity in form of experienced growth, or high growth. In his study of Finnish innovative start-up firms Autio (2009) discovered that these firms are efficient creators of inventions and IPR, but most of these technological outputs are not converted to firm-level growth. Through studying new technology based firms that had participated in public innovation intervention programs Rannikko (2012) found that annually only around 30% of firms experienced above 30% growth while 30% of firms experienced negative growth. The share of gazelle firms in the same study was between 3 and 5 percent (Rannikko,2012).

In order to understand the relationship between innovativeness and performance several studies have investigated the direct impact from innovativeness to growth. Still, empirical evidence on the relationship remains ambiguous (Heikkilä, 2012). One shortcoming in these studies is that they have ignored the fine-grained nature of the phenomenon. Consequently, in order to deeply understand the conditions under which new innovating firms obtain the benefits from their innovativeness we combine in this paper the entrepreneurial orientation approach with the heuristic

that was originally proposed by Teece (1986). The received model is tested with a sample of Finnish new technology based firms.

To begin with the theoretical model is developed through reviewing entrepreneurial and innovation literatures. After that the data collection and methods of analysis explained. Finally, the results of the empirical analysis are presented and results discussed. This study contributes to previous discussions on innovation and industrial organization (Acs and Audretsch, 1988; Coad, 2007; Coad and Rao, 2008, Teece, 1986), innovation and performance (Audretsch, 1995; Bhide, 2000; Calvo, 2006; Freel and Robson, 2004; Roper, 1997; Thornhill, 2006) and innovation and growth policy interventions (Archibugi, 1988; Covin et al., 1999; North and Smallbone, 2000; Santarelli and Piergiovanni, 1996; Venkataram, 2004).

Theory

A natural starting point for studying the phenomenon of new technology-based firm growth is to take a look at the empirical research on growth rate distributions. This stream of industrial organisation research examines and models firm growth through areas such as annual changes in sales or employment. Within this research, there is a widely held consensus that empirical distributions of firm growth rates do not follow normal distribution (Coad, 2007). Compared to normal case, empirical growth rate distributions are fat-tailed (Coad, 2007). Consequently, the best fits between empirical distributions and a theoretical distribution have been found using Laplace distribution or symmetric exponential distribution (Coad, 2007). Besides, at an aggregate level, the modelling of firm growth rates through these distributions seems to be robust to disaggregation and has been shown to be stable over time and to have different growth measures (Coad, 2007). Fat-tailed tent shapes mean that extreme growth events, either negative or positive, can be expected to occur relatively frequently and make disproportionately large contributions to the evolution of industries (Coad, 2007). Most estimations of growth rate distributions consider larger firms in manufacturing sectors in which the growth rate distribution becomes closer to the Laplace (Coad & Hölzl, 2009). With micro firms, however, the density becomes “leptokurtic”; this means that it is has a higher-than-normally-distributed variable of values near the mean and higher-than-normally-distributed variable of extreme values (fat tails) (Coad and Hölzl, 2009). An example of small service firms shows that while most firms do not grow in any given year, the share of firms that generated a large employment impact (an increase of over 10 employees) in the 10–49 employee size category was 2.8 percent over a one-year period. The share of firms in the 1–9 employee size category was 3.9 percent over a one year period for an increase of over two employees (Coad and Hölzl, 2009). Using data about innovative new technology based firms in Finland Rannikko (2012) found that annually only around 30% of firms experienced above 30% growth while 30% of firms experienced negative growth. The share of gazelle firms (those firms that experienced three consequent above 30% growth periods) in the same study was between 3 and 5 % (Rannikko,2012). Thus, it seems to reasonable to state that only few technology based firms are able to capture the benefits from innovation.

While empirical growth rate distributions show that only few firms are able grow the empirical research on innovativeness and growth has not really been able whether it is innovativeness that drives growth in successful firms. In general, it has been acknowledged that dynamic change pressures in high technology sectors are based on simultaneous and rapidly changing customer requirements, technological development and shorter market life-cycles of developed products. Therefore, Innovations are essential for small technology firms in order to sustain and /or increase their competitiveness and simultaneously ensure their survival and growth (North et al, 2001). Further, competition has put pressure on firms to continuously innovative in order to produce new

products and introducing new products that may help firms to protect and expand their sale, profit and market position (Schilling, 2008). However, comparatively few longitudinal studies that have examined the impact of conducting innovations and innovative R&D while simultaneously focusing on growth of the firm. The key conclusion from the previous studies of innovation and growth (Arundel and Kabla, 1998; Autio, 2009; Bhide, 2000; Covin and Slevin, 1998; Daviddson and Delmar, 1997; Churchill, 2000; North and Smallbone, 2000; Santarelli and Piergiovanni, 1996) is that innovation could be called "a major suspect" as a firm growth driver (Pender, 2012). Clearly, more fine grained analysis is needed concerning the relationship between innovativeness and growth. In this paper innovativeness is complemented with entrepreneurship. Not all entrepreneurial firms are innovative but when innovativeness is complemented with entrepreneurship, it is believed that more fine grained understanding about innovativeness could be achieved.

An appropriate starting point on the discussion about the association between entrepreneurship, innovativeness and growth is the concept for of entrepreneurial orientation which bridges innovativeness to other aspects of entrepreneurship. Specifically, it refers to a firm's strategic orientation and captures specific entrepreneurial aspects of decision making styles, methods and practices (Davidsson et al., 2006). According to Wiklund (1998), entrepreneurial orientation can be seen as the chief executive officer's strategic orientation, reflecting the willingness of a firm to engage in entrepreneurial behaviour. Thus, it is a self-perception of a firm's strategic orientation and it is likely that, in a small-firm environment, this orientation is closely related to the behaviour of the firm (Aloulou et al., 2005).

Many authors share the view that Miller's (1983) conceptualisation of entrepreneurship laid the foundations of what has since been named entrepreneurial orientation. Miller's study looked for correlates of entrepreneurship in three types of firms: simple, planning and organic. Concerning entrepreneurship, Miller concluded that "previous literature causes us to treat entrepreneurship as a multidimensional concept encompassing the firms' actions relating to product-market and technological innovation, risk taking, and pro-activeness. An entrepreneurial firm is one that engages in product market-innovation, undertakes somewhat risky ventures, and is first to come up with proactive innovations, beating competitors to the punch" (Miller, 1983).

A seminal contribution to entrepreneurial orientation discourse was Lumpkin and Dess's (1996) study, which clarified the entrepreneurial orientation construct. They argued that entrepreneurial orientation refers to the processes, practices and decision making styles that lead to new entry. Thus, it involves the intentions and actions of key players functioning in a dynamic generative process aimed at new venture creation (Lumpkin and Dess, 1996). The three key dimensions of entrepreneurial orientation consist of (1) a propensity to act autonomously, (2) a willingness to innovate and take risks and (3) a tendency to be aggressive toward competitors and proactive relative to marketplace opportunities (Lumpkin and Dess, 1996). Thus, competitive aggressiveness and autonomy were seen as additional components of entrepreneurship as a firm-level phenomenon. However, later research has predominantly applied Miller's original dimensions (innovativeness, risk-taking, proactiveness). Among the main results of the empirical research on entrepreneurial orientation is the direct effect that entrepreneurial orientation has on performance. In other words, jointly taken risk taking, innovativeness and pro-activeness of management processes is related to firms' performance. Rauch et al. (2009) explored the entrepreneurial orientation–performance relationship through meta-analysis of 51 studies with 53 samples and 14,259 firms, finding a positive correlation of 0.24. They also found that this relationship is robust to different operationalisations of entrepreneurial orientation and over different cultural contexts (Rauch et al., 2009).

As the discussion on entrepreneurial orientation points out innovativeness and entrepreneurship are conceptually close to each other and that it may well be argued that entrepreneurship is something that includes innovativeness. The view is taken here, however, that not all entrepreneurship is innovative. Thus some of the entrepreneurial action is not innovative but rather that either innovativeness or entrepreneurship may be among the drivers of new technology based firms growth.

After having identified entrepreneurship and innovation as possible determinants of new technology based firm growth the analysis now turns into the fine-grained mechanisms that regulate the extent to which innovating new firms obtain economic returns from their innovation activity. As pointed out extant studies on innovation and performance fail to provide comprehensive evidence for this matter. The analysis begins by analysing the Teece (1986) framework that identified asset co-specialization, asset availability, and the strength of the IP regime as important determinants of appropriability. Teece demonstrated that when imitation is easy the profits from an innovation may accrue to owners of certain complementary assets rather than to developers of the intellectual property (Teece, 1986).

According to Teece there are three fundamental building blocks must be put in place in order to analyse the distribution of outcomes from innovation activity: the appropriability regime, complementary assets and the dominant design paradigm. A regime of appropriability refers to environmental factors that govern an innovator's ability capture the profits generated by an innovation. The most important of such a regime are the nature of the technology, and the efficacy of legal mechanisms of protection (Teece, 1986). The existence Dominant design "watershed" has an effect on how the profits are distributed between innovator and follower. When imitation is possible and occurs coupled with design modification before the emergence of a dominant design, it is possible that followers' products become known as the industry standard (Teece, 1986). Complementary assets refer to those assets that are needed in order to successfully commercialize the innovation. If the asset does not need to be tailored to the innovation in question, complementary assets may be called generic. If there is a unilateral dependence between the innovation and the complementary asset, it may be called specialized. Co-specialized assets are those for which there is a bilateral dependence with the innovation.

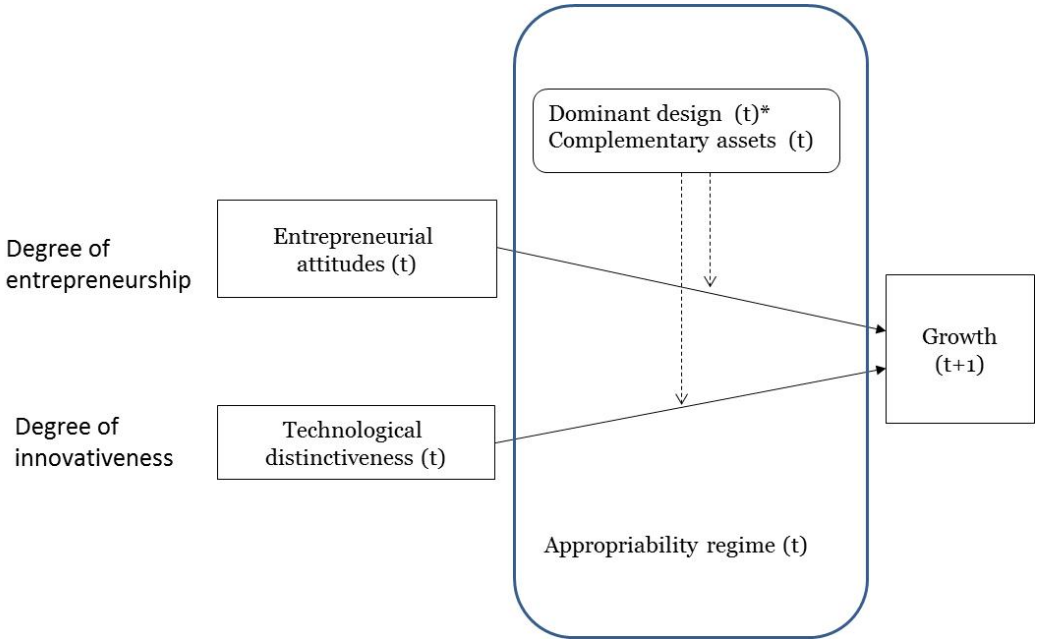
Teece proposed that fundamentally the division of gains from innovation activity is dependent on the appropriability regime. Under a tight regime innovator is assured to translate its innovation to market value. In this case when complementary assets are specialized or co-specialized there might be hazards. Also the industry life-cycle does not cause harm for innovator: in pre-paradigmatic phase protection gives time for innovator to experiment what is the specification that might become the dominant design.

When the appropriability regime is loose innovators must turn to business strategy to keep the imitators at bay. However, the competitive process will vary according to whether the industry is in the paradigmatic or pre-paradigmatic phase. In the former innovator needs to be coupled to the market so that the user needs can fully impact designs. The probability that innovator will enter paradigmatic phase possessing dominant design is higher if cost of prototyping is low and a firm is tightly coupled to the market. In paradigmatic phase and under loose appropriability regime specialized or co-specialised assets become critically important: since the core technology is easy to imitate, by assumption, the commercial success is dependent on the terms and conditions upon which the required complementary assets can be accessed.

Combination of entrepreneurial orientation literature and the heuristic of Teece results in a model presented in figure 1. Entrepreneurship and innovativeness are the key determinants of performance, but they do not need to coexist in order for firm to achieve growth. Not all entrepreneurial action is

innovative and not all innovative action is entrepreneurial. Both are still assumed to be associated with performance. These associations are, however, dependent on mechanisms explained by the Teece heuristic. In the following the specific hypotheses are presented in order to analyse the model.

Figure 1: The dependence of growth on the degree of entrepreneurship and innovativeness



Concerning entrepreneurship in existing organisations, Lumpkin et al. (1996) argued that any firm that engages in an effective combination from the entrepreneurial orientation dimensions of autonomy, innovativeness, risk taking, pro-activeness, and competitive aggressiveness may achieve performance advantages. The empirical research conducted supports the view that there is a positive relationship both between the summarised index of entrepreneurial orientation and small firm performance and between different dimensions of entrepreneurial orientation and small firm performance (Rauch et al., 2009). Thus it is postulated that:

H1: Higher level of entrepreneurship is associated with higher growth of new technology-based firm

The relationship between size, innovation and performance has long academic tradition. Many previous empirical studies have sought to test the Schumpeterian hypothesis that large firms tend to have a resource advantage of smaller ones when it comes to the developing and exploiting technology driven innovations. Further, the age of the firm and its influence on innovation and growth characteristics has been examined in the perspective of life-cycles. The basic assumption of the life-cycle theories is that the development of new and young firms is based on innovation (Churchill, 2000; Davidsson and Delmar, 1997; Scott and Bruce, 1987). Life-cycle theories also focus on the liabilities of smaller and younger firms which are discussed in terms of smallness and inexperience (Wright et al., 2007). This could imply that both age and size influence the innovation

and performance of firms. Moreover, Tether (1998) found that the average value of innovations varied systematically with the size of the innovating firm. Large enterprises were responsible for almost all the high-value innovations, whilst most of the lower-value innovations were introduced by small businesses. Nelson (1993) proposed that new and small firms have introduced extremely high- value innovations, too. There is some evidence that the propensity to create innovations from patents increases with the firm's annual sales growth (Arundel and Kabla, 1998). This finding links the connection between size, innovations and growth of the firm. Based on the prior understanding and empirical findings of innovation and growth phenomenon, a second hypothesis was formulated:

H2: Higher innovativeness is associated with higher growth of a new technology-based firm

The fine-grained mechanisms that regulate the extent to which innovating new firms obtain economic returns from their innovation activity are derived from the Teece heuristic. In paradigmatic phase and under loose appropriability regime specialized or co-specialised assets become critically important: since the core technology is easy to imitate, by assumption, the commercial success is dependent on the terms and conditions upon which the required complementary assets can be accessed. While specialized and co-specialized assets are critically important at this point because they involve significant irreversibilities and they can not be easily accessed by contract also generic assets are important. Especially the firms that control the co-specialized assets such as distribution channels, manufacturing capacity, raw materials and components are advantageously positioned relative to an innovator but in any case all complementary resources are needed. Therefore, in order to examine the role of complementary resources it is postulated both concerning the association between entrepreneurship and growth and innovativeness and growth that:

H3: The availability of complementary resources moderates the relationship between entrepreneurship and growth such that the more available complementary resources are the stronger is the association between entrepreneurship and growth of a new technology based firm when appropriability regime is assumed to be loose and dominant design exists and that;

H4: The availability of complementary resources moderates the relationship between innovativess and growth such that the more available complementary resources are the stronger is the association between innovativess and growth of a new technology based firm when appropriability regime is assumed to be loose and dominant design exists

Methodology

The target population of this study consists of new technology-based firms as well as manufacturing firms and knowledge-intensive service firms in Finland. The sample was drawn from a database collected as part of the longitudinal evaluation project of firms that were financed by the Finnish Funding Agency for Technology and Innovation (Tekes). The project is being carried out by the Small Business Centre of Aalto University.

Data collection has taken place since 2006 and has been planned to continue until at least 2012. The first step after receiving the firm identification information has been to collect financial information on firms, mainly through the Voitto+ -register, which is a privately held source of financial information that is maintained by Asiakastieto Oy. Occasionally, missing values were found from the National Patent and Registry Office or from the firms themselves by emailing or by telephone. The following financial items were specifically attained by the data-collection: sales, number of

employees, operating profit as a percentage of sales, and quick ratio. Additionally, the following items have been reported: firm type, number of subsidiaries, description of the main industry in which a firm operates, location, gender of the management, number of subsidiaries, and the founding year of the company.

The second step in data collection has been to conduct surveys in such a way that all firms first received the base survey and then follow-up surveys each year. All surveys were conducted on-line through the Webropol Internet-based research tool. Base surveys and follow-up surveys differ from each other. New questions were added to later surveys and not all questions have been used in all surveys. There are 182 items across the questions, with each item used at least once by the time of this research. Questions can be broadly classified into the following areas: (1) the firm and its products and services; (2) the firm's resources, organisation and competences; (3) strategic goals and growth strategies; (4) internationalisation, (5) product features and operating environment; and (6) Tekes services. Table 1 reports the response rates for all surveys.

Table 1: Response rates for different surveys.

Target group	Base survey	Follow-up survey	Follow-up survey
2002 firms	22 % (2006)	37 % (2008)	18 % (2009)
2004 firms	37 % (2008)	42 % (2008)	23 % (2009)
2007 firms	28 % (2009)		
NIY firms	67 % (2008->)	23 % (2008/09)	30 % (2009)

The questionnaire and modifications thereto were developed by the six-person research group. Special attention in the development was paid in reducing the potential for method biases i.e. those biases in research results that are due to problems in questionnaire design. The main goals of the questionnaire development were: to have the cover letter motivate recipients to respond to the survey, to make the answering instructions clear, to make the questions clear and unambiguous, and to ensure that items can be answered without excessive effort. All these actions have been seen to reduce the potential of common method bias (Podsakoff et. al.,2003). In the process of developing the questionnaire, the overall areas were discussed first and then specific questions were sought under each area by searching the existing literature. Secondly, questions were written down and circulated among the members of the research group and some modifications were made. After the questionnaire was finalised, surveys were conducted by sending an email to firm representatives, requesting them to log on to the website and fill in the questionnaire. Respondents also provided important feedback that has been taken into account in further modifications of the questionnaire. By the time of the study, one follow-up survey was conducted by telephone in 2010 on NIY firms. The telephone interviewers, who were carefully trained with regard to the questionnaire, contacted firm representatives and requested them to log on to the system and fill in the form. If this was not possible, the firm representatives were asked to answer questions over the phone. The feedback

from telephone interviews was written down and applied to further questionnaire development. The telephone interview responses did not differ from the other responses. Firms that responded by telephone interviews were almost identical in terms of size and foundation year to those that answered through the Internet (Appendix 3). A table in Appendix 2 shows the results of non-respondent analysis, in which the first respondents are compared with those that have been the last to answer. The only difference that can be found is with the "NIY firms" in their base survey. However, this survey is on-going, which means that new firms joining the intervention programme are requested to answer the survey questions as they are accepted. Therefore, it is unlikely that early and late respondents would exist. Overall, it can be concluded that non-response bias is not a problem in this study.

The basic principle in this study was that, whenever possible, only previously validated measures of constructs were used. Fortunately, it was possible to find and apply previously validated measures for almost all constructs. In order to assess construct validity, a factor analysis was carried out for all constructs having more than one measurement item. Cronbach's alpha values are above the 0.7 threshold, which implies that they are suitable for research purposes. The constructs are more specifically represented in appendix three.

Table 2: Summary of the variables used

	Measurement	Mean	Std. Dev	Items	Cronbach alpha
Size	Number of employees	21	33	1	-
Age	Year of foundation	1997	6.95	1	-
Growth attitudes	Growth orientation	4.67	1.51	4	0.7634
Location	Dummy whether located in big cities or not	-	-	1	-
Entrepreneurship	Entrepreneurial orientation scale	4.39	1.46	3	0.8538
Innovativeness	Technological distinctiveness scale	5.46	1.17	5	0.8847
Complementary resources	Availability of complementary resources	4.50	1.24	3	0.6677
Dominant design	Environmental dynamism scale	4.08	1.24	5	0.8538
Appropriability regime	Industry dummy	-	-	1	-

To study how selected independent variables may explain variation in selected dependent variables, regression method was utilized, and since the data was collected as panel data specifically, panel regression methods were utilised. There are three alternative ways to carry out panel regression: fixed effect model, between effects model and random effect model (Wooldridge, 2009). Using fixed effect models may make it possible to control for omitted variables that differ between cases (firms) but are constant over time (Wooldridge, 2009). In this case, the only omitted variables that may bias the estimation results are time-varying omitted variables (Wooldridge, 2009). In a firm panel, constant omitted variables could be, for example, stable firm-specific issues such as firm culture. By using between-effects models, it is possible to control for omitted variables that are constant between cases but change over time (Wooldridge, 2009). In a firm panel, these omitted variables could be stable issues such as taxation. Random effect models take into account the fact that some omitted variables may be constant over time but vary between cases and others may be fixed for cases but are constant over time (Wooldridge, 2009).

A panel data regression takes the form Y_i_t = (β_1)((X)_1_i_t)+...+ (β_k)((X)_k_i_t) +(a_i) +(u_i_t), t=1,....T , where β_j are the parameters to estimate, a_i is the unobserved firm specific effect and u_i_t is the idiosyncratic error term (or remainder disturbance) (Wooldridge, 2009). In order to be able to apply fixed or random effects estimation, a researcher must ensure that certain assumptions are met. In particular, for the fixed effects model, it must be possible to assume (i) that there are no perfect linear relationships among the explanatory variables; (ii) that for each period t, the idiosyncratic error (u_i_t) is uncorrelated with each explanatory variable; (iii) that the idiosyncratic errors of different periods are uncorrelated (i.e., no serial correlation of error terms); and (iv) that the idiosyncratic error (u_i_t) is homoskedastic (i.e., that the variance of the idiosyncratic error (u_i_t) is constant). In addition, for random effects modelling one must be able to assume (v) that the unobserved effect (a_i) is homoskedastic; that is, that the variance of the unobserved effect (a_i) is constant; and (vi) that for each time period t the unobserved effect (a_i) is uncorrelated with each explanatory variable (cf. Wooldridge, 2009 chapter 14). The last of these assumptions, (vi), rules out a correlation between the unobserved effect and the explanatory variables and it is the key distinction between fixed effects and random effects (Wooldridge, 2009). In many settings, however, independent variables are outcomes of choice processes and likely to be correlated with the firm-specific unobserved effect, which is also the case in this study; therefore, the use of fixed effects model is supported (Wooldridge, 2009).

To cope with the above-mentioned conditions in this study, the following measures are taken. For (i), the correlation matrices are analysed in order to detect high correlations between independent variables. For (ii), it is assumed that there is no correlation between the idiosyncratic error and explanatory variables. For (iii) and (iv), the clustered standard error option of Stata, which controls for heteroskedasticity and autocorrelation, is used.

Results

In this section the relationships that were developed in the theory section, are studied in detail through panel regression method. Besides the main effects, this section also analyses the hypothesised moderating effects through access to complementary resources.

Firstly, a correlation matrix is presented below to identify how the different variables are related to each other. Overly high correlations among independent variables pose a threat of multicollinearity. When the correlation is high, it is possible that correlated independent variables will mask each other's effect on the dependent variable. As can be seen from the correlation table below, the correlations among independent variables are relatively low, except for the correlation between growth orientation and entrepreneurial orientation (0.55). Because of this the model was run without the control variable of growth orientation to check the robustness of results and no changes in signs or significances were detected .

Table 3: correlations between variables

	1	2	3	4	5	6	7	8
1 Firm size as employees	1							
2 Growth orientation	-.05	1						
3 Area dummy	-.08	.27	1					
4 Age (foundation year)	-.13	.39	.23	1				
5 Entrepreneurial orientation	-.11	.55	.25	.38	1			
6 Technological distinctiveness	-.09	.07	.08	.00	.31	1		
7 Availability of complementary resources	-.00	.07	.03	-.05	.10	.13	1	
8 Environmental dynamism	.23	-.23	-.25	-.29	-.19	-.00	-.05	1

The regression model is specified in a way that the availability of complementary resources and environmental dynamism create a moderation variable. The third factor of Teece heuristic – approbriability regime- is taken into account by controlling the group to consist other firms than those in IT/software industry in which it, at least, is easy to protect the intellectual property. The results of the analysis show that all models are relevant and the overall-variance explained of the interaction effect model is 26 percent; this is more than 21 percent of the control variable model and 17 percent in the main effect model. Therefore, it seems reasonable to add the main effects and interaction effects above the control variable model.

The regression results indicate that, from the control variables, foundation year is positively associated with sales at the 0.01 level across different models. From the main effect variables entrepreneurial orientation is significantly and positively associated to growth at the 0.01 level with the correct sign in the main effect model other variables are not. For the analysis of interaction hypothesis, it is only necessary to focus on the interaction term (Cohen et. al., 1983). The interaction term which consists of the availability of complementary resources, environmental dynamism and technological distinctiveness is positively associated with sales at the 0.01 level. The other interaction term is not significant. These results give support for our hypotheses one and four while no support is given for hypotheses two and three. Concerning moderation, the result hints that under industry conditions where the dominant design has been achieved (preparadigmatic stage) and complementary assets are available the effect of technological distinctiveness on growth is stronger than otherwise.

Table 4: regression analysis results

Log of sales growth	Model 1		Model 2		Model 3	
	Coeff.	Std. Error	Coeff.	Std. Error	Coeff.	Std. Error
Size (employment)	-.005	.003	-.006	.003	-.006	.004
Growth orientation	-.126	.136	-.218	.151	-.236	.149
Location	.638+	.374	.523	.393	.592	.384
Age (founded_year)	.091***	.024	.076**	.025	.068**	.023
Entrepreneurial orientation			.350**	.130	.491+	.266
Technological distinctiveness			-.026	.127	-.757**	.249
Availability of complementary resources*environmental dynamism			-.004	.021	-.228+	.122
Availability of complementary resources*environmental dynamism * Technological distinctiveness					.046**	.016
Availability of complementary resources*environmental dynamism * Entrepreneurial orientation					-.003	.011
Constant	-183.20	48.23	-154.89	51.63	-135.32	46.56
R-sq	0.1724		0.2154		0.2618	
Wald chi-squared	24.11		27.93		30.99	
Prob>chi squared	0.0001		0.0002		0.0003	
Number of observations	132		132		132	
Number of groups	68		68		68	
Observations per group min	1		1		1	
Observations per group average	1.9		1.9		1.9	
Observations per group max	4		4		4	

Discussion

In this study a framework was developed in which entrepreneurship and innovativeness are the key drivers of new technology based firms' growth. However, instead of these being associated to growth only universally it was pointed out that the association between entrepreneurship and growth and innovativeness and growth may depend on the appropriability regime, access to complementary assets and industry stage (dominant design) as suggested by Teece (1986).

The postulated model was statistically examined with a sample of new technology based firms for which the appropriability regime was assumed to be weak. That is, those firms that operate in IT industry that was assumed to represent tight appropriability regime, were excluded from the analysis. According to the results, under the given assumptions, 'Teecian' heuristic may be useful in examining how innovativeness and entrepreneurship are associated with growth.

The finding that entrepreneurial orientation is significantly and positively associated to growth at the 0.01 level with the correct sign while innovativeness is not hints that it may be reasonable to separate conceptually innovativeness from entrepreneurship. Not all entrepreneurial action is innovative and not all innovative action is entrepreneurial. Instead of innovativeness being helpful as such it may be that the relationship moderative i.e. the benefits from innovativeness on growth are greater for those firms that accompany innovativeness with entrepreneurship.

The other finding was that the interaction term, which consists of the availability of complementary resources, environmental dynamism and technological distinctiveness is positively associated with sales at the 0.01 level. This would mean that under industry conditions where the dominant design has been achieved (preparadigmatic stage) and complementary assets are available the effect of innovativeness (technological distinctiveness) on growth is stronger than otherwise. The result leaves open how exactly for example the impact of innovativeness on growth varies for given level of dominant design and varying level of access to complementary assets. However, it shows that 'Teecian' heuristic may be an appropriate approach when studying the impact of innovativeness on growth.

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APPENDIX 1 NON-RESPONSE ANALYSIS

	Early respondents mean (s.d.)	Late respondents mean (s.d.)	t	df	Sig (two-tailed)
2007 Base survey					
Employment	363 (1980)	435 (1550)	-0.21	101	0.83
Founded year	1972 (131)	1990 (13)	-1.02	55	0.31
N of customers	4.50 (1.37)	4.45 (1.68)	0.18	103	0.85
2008 (Niy, base)					
Employment	3.33 (4.29)	6.33 (7.34)	-1.76	43	0.08
Founded year	2006 (1.39)	2005 (2.81)	1.61	38	0.11
N of customers	1.92 (1.23)	3.34 (1.29)	-3.53	50	0.00
2008 (Follow-up)					
Employment	515 (2595)	528 (2530)	0.02	100	0.97
2008 (Follow-up, Niy)					
Eployment	1.6 (1.34)	8.25 (10.5)	-1.25	3	0.29
2009 (Follow-up)					
Employment	1024 (5256)	40 (54)	1.04	30	0.30
2009 (Follow-up, Niy)					
Employment	6.87 (5.33)	5.71 (4.88)	0.43	12	0.66

APPENDIX 2 TELEPHONE INTERVIEW ANALYSIS

	By telephone interviewed mean (s.d.)	Answers through internet mean (s.d.)	t	df	Sig (two-tailed)
Employment	10 (23)	8 (9)	0.52	55	0.59
Founded year	2006 (1.42)	2006 (1.73)	0.03	56	0.97

APPENDIX 3 MEASUREMENT SCALES

Factor loadings of the entrepreneurial orientation variable

	Factor loadings
In general, our managers prefer high risk and return to low risk	0.7907
Bold moves are often necessary to meet our goals	0.8039
In uncertainty, we prefer to act rather than wait	0.7659

Factor loadings of the innovativeness variable

	Factor loadings
Our products and services are based on high technology	0.7454
We invest heavily in R&D	0.7417
Our products are unique in the market	0.7203
Our technology is better than competitors'	0.8606
Our competitive advantage is based on our technology	0.8234

Factor loadings of the complementary resources variable

	Factor loadings
The availability of the production resources	0.6586
The availability of the raw materials, components	0.6405
The availability of the raw materials distribution resoures	0.4758

Factor loadings of the dominant design variable

	Factor loadings
In this business firms' business models are well established and known	0.7325
Customers are familiar with our product concepts	0.5462
In this business everyone knows who the competitors are	0.7106
Customers have well established procurement budgets for our products	0.6087
In this business product and service standards are well established	0.7663
There exists a 'dominant design'	0.7267

Factor loadings of the growth orientation variable

	Factor loadings
We aim for high profitability even if we had to sacrifice growth	0.7299
We prefer longevity over growth	0.7841
Sales growth objective importance	0.5620