ERSA 2003 Congress, 27-30th August 2003, University of Jyväskylä, Jyväskylä, Finland

Fostering Academic Entrepreneurship: New Insights into Incubation from An Evolutionary Perspective

Marina van Geenhuizen *

Faculty of Technology Policy and Management
Delft University of Technology, Delft, the Netherlands; e-mail: m.s.vangeenhuizen@tbm.tudelft.nl

Abstract

This paper addresses the growth of academic spin-off and the incubation policies concerned. To this purpose it presents theory of firm growth and policy theory based on evolutionary principles. This is followed by an empirical analysis of learning by spin-off firms to overcome barriers to growth and of factors that influence growth. Spin-off from Delft University of Technology in the Netherlands serves as a case study. The results indicate that the main barriers are concerned with knowledge (skills) in interaction with the market and in dealing with uncertainty in management, a situation that can be explained by a major change in required routines. Further, the results indicate needs of spin-off firms for external networking and diversity in preventing (solving) problems. This situation points to a preference for incubation policies that have moved away from comprehensiveness and centralisation to policies of customized support and some degree of self-organisation.

Key words: academic spin-off; evolutionary approaches, learning, financial capital, growth, incubation policy models.

1. Setting the Scene

Universities and other higher education institutes can play important roles in regional economic development (e.g. Etzkowitz 2002; Felsenstein 1996; Florax 1992). Universities have extended activities beyond their primary tasks of education and research, into the area of commercialisation of knowledge and business activity. To this purpose they have established a range of new institutions and policies, like technology licensing offices, industry liaison offices, Science Parks, and extensive incubation policies. From a regional economic perspective, policies to enhance spin-off processes and to foster growth of small firms (incubation policies) can be seen as most relevant.

Small firms have attracted attention from regional scientists and policymakers since decades for various important reasons. Birch (1979), for example, forwarded that small firms create more jobs than large firms, whereas Rothwell and Zegveld (1985) argued that small firms have a distinctive role to play in innovation, be-it differently from sector to sector. In the latters' view the dynamic interaction of small firms with larger ones forms the basis for industrial regeneration. In the 1980s also many success stories of local high-technology developments mushroomed, stressing the role of universities in local entrepreneurial culture, e.g. in Silicon Valley and the Cambridge area (UK) (e.g. Rogers and Larsen 1984; Wickstead 1985). This was followed by more solid insights into the generation of local knowledge spillovers by university research (e.g. Acs et al. 1992; Anselin et al. 1997), and the role of supportive local networks, supportive institutions and organisational structures of companies (e.g. Braczyk et al. 1998; Castells and Hall 1994; Saxenian 1994).

This paper addresses academic spin-off firms as a specific category of high-technology firms. In the academic spin-off process, not only the new technology stems from the university but also the new entrepreneurs have their origin here, as graduates or as (former) staff members. For entrepreneurs the business environment of high-technology start-ups is highly different from the academic environment they are used to, in terms of uncertainty perceived and ways to cope with it. This situation might hamper growth of the new firms due to failure of adopting the right business strategy at the right time. Attention paid to differences in the amount of spin-off activity between universities is rather limited (e.g. Di Gregorio and Shane 2003), as is the attention paid to the determinants of growth of academic spin-off and to theory that contributes to a deeper understanding of this growth. We mention the work of

Lowe and Taylor (1996), Reid and Garnsey (1998), and Roberts (1991). Only in the context of particular business locations, i.e. Science Parks, research on growth of academic spin-off has been and still is popular, e.g. During (1998), Felsenstein (1994), Lindelöf and Löfsten (2003), Siegel et al. (2003), and Westhead (1997).

Much policy attention has been given in the Netherlands to high-technology entrepreneurship in the past few years, particularly with the aim to increase the popularity of this entrepreneurship. Entrepreneurship in high-technology fields is not popular, as witnessed by a share of high-technology start-ups of 6 to 7% in all newly established firms (10% on average in Europe and 25% in US). Major obstacles to high-technology entrepreneurship are institutional and typically contribute to an unfavourable entrepreneurial climate (Baljé and Waasdorp 2001; Ministry of Economic Affairs 1999; Meijaard 2001). For example, there is strict regulation for new firm establishment, including the requirement of a mandatory minimum capital (approximately 18,000 Euro) for a limited liability company, and failure (bankruptcy) gives a stigma to the entrepreneur, a situation that hampers to take risks. In addition, at universities the development of entrepreneurial personality traits and skills has been under-examined in the standard curriculum, and important legal matter is not (yet) solved satisfactorily, i.e. how to cope with potential "conflicts of interests" between academic work and the own business. These circumstances fit into generally weak ambitions of Dutch universities to become entrepreneurial.

While this picture is rather negative, it must be stressed that both from the side of the Ministry of Economic Affairs and the side of university boards quite some improvements have been introduced recently in their policies to enhance high-technology (academic) entrepreneurship (van der Laag and Snijders 2003). This has manifested itself *inter alia* in a relaxation on regulation concerning new firm establishment and in extension of training in entrepreneurial skills in the curriculum of universities.

Note that in the past few years the relationship between university, industry and government has changed importantly. In this context, Etzkowitz (2002) puts emphasis on a shift in relationships from a one-way linear flow - from basic to applied research to production - to an interactive two-way flow with involvement of many organisations within the university, industry and government. Accordingly, incubation takes place at many places within the university departments (not just in one incubator site) and as part of many networks within

and outside the university. Moreover, the borders between interests and roles of the organisations involved are blurring, witness the emergence of academic industrialists and entrepreneurial universities, etc. (Gibbons 1994; Nowotny et al. 2001). In the case of science, there is now a higher democratic content and increasing need for legitimation and public responsibility of science. As a consequence of all this, there is a trend for knowledge creation and economic utilisation of knowledge to become more volatile within fast shifting network configurations and to become more complex. This situation leads to an increased uncertainty in incubation policies. The development of new technologies in a business environment adds to this uncertainty, for example, concerning issues of protection of intellectual property, acceptability of products by consumers, matching with environmental and safety standards, and economic viability and profitability (e.g. Kowol and Küppers 2003).

In this study of academic spin-off evolutionary principles are adopted that enable to perceive firms and policy actors in their changing environment and to focus on adjustment over time. The questions addressed are: (1) Which is the motivation to start a business as academic spin-off and how is this connected to the pattern of learning and capital investment? Which situations are seen as problematic and which factors influence growth of academic spin-off? (2) How can results on problems and factors that influence growth contribute to an improved policymaking for incubation, given the changing relationship between university, industry and government?

The structure of this paper is as follows. First, key evolutionary notions on strategy development and survival by firms are discussed, and this is followed by a discussion of evolutionary notions on policymaking (Section 2). Next, case study results on spin-off from Delft University of Technology are highlighted. An analysis of the motivation to start a firm (Section 3) is followed by an analysis of learning behaviour and capital investment (Section 4). In Section 5 the focus is on problematic needs and factors that influence growth, including the estimation of a growth model. The paper proceeds with an analysis of trends in incubation policies (Section 6). In a concluding section, the outcomes of the study are evaluated in view of the design of new incubation policies.

2. An Evolutionary Approach to Firms Behaviour and Policymaking

Applied to firms, evolutionary approaches seek to explain the movement of these units over time and the causes of their state at one point in time in terms of how they got there. The movement of firms refers to their patterns of adaptation to change in the selection environment, including the

role of learning (Dosi and Nelson 1994; van Geenhuizen 1999; Krohn and van den Daele 1998). Resource dependence views are useful in this context, because these provide notions about fast changing needs of firms, recognise knowledge as an important resource, and connect with evolutionary approaches in putting emphasis on different resource availability in the environment and different abilities (skills) of firms to utilise them (Pfeffer and Salanchik 1978; Reid and Garnsey 1998).

Evolutionary approaches and the related management literature provide the following important notions for the analysis of the behaviour of high-technology start-ups over time (Arthur 1994; Baaij and van den Bosch 1999; Dosi and Nelson 1994; van Geenhuizen 1999; Nelson and Winter 1982; Senge 1990):

- *Firms* are subject to various forms of selection, with the market as the single most important *selection environment*. In addition, there are selection environments such as government regulation and patenting regimes (institutions). With regard to high-technology firms, the technology is increasingly seen as an important selection environment. Competition, be-it for customers or for major inputs like government research budgets, is generally the main mechanism of selection.
- Different from Darwinian theory, the survival of firms does not rest on mutation by chance but on active *adaptation* to the environment. The process of adaptation is mainly directed by *routines*, i.e. forms of rule-guided behaviour that are largely invariant to fine changes in the environment. Routines function as stable carriers for knowledge and are based upon the learning history of the firm (entrepreneur).
- Routines are associated with *incremental* adjustments, i.e. close to pre-existing patterns. In such adjustment pattern there is the danger that firms' behaviour becomes *path-dependent*, a situation in which it is difficult to abandon once selected directions, e.g. technologies and product-markets, due to an accumulation of investment, experience, and solid positions in networks. In circumstances that are significantly new, however, firms are able to experiment and discover novel behaviour, including imperfect adaptation and new discovery based on failure.
- A situation of *stress* arises when changes in the environment are occurring too fast for a timely adaptation or when firms (entrepreneurs) undertake too many adaptations at the same time (van Geenhuizen and Nijkamp 1996). Stress may be solved by a

comprehensive and often shock-wise adjustment of the firm to its environment (restructuring).

- The need for adjustment causes a continuous need for *learning*. In terms of what is learned one may distinguish between (1) learning about specific fields like a technology and its application, (2) learning of specific skills like concerning management and marketing, (3) learning about behaviour of important socio-economic actors in the environment, like investors and potential partners in co-operation, and (4) learning to become a learning organisation. The latter means to prevent cognitive lock-in by remaining open to new information and transforming this new information into strategic action (e.g. Pettigrew and Wipp 1991).
- Resilience is important in the context of survival of populations of firms (van den Bergh and Fetchenhauer 2001). This notion is concerned with the need for diversity among firms, including co-operative networks, e.g. for R&D, marketing, and subcontracting relationships. Although networking bears a risk in itself due to the need for appropriate management of network relations, participation in networks usually reduces risks (Camagni 1991; Johannisson et al. 1994).

What is mentioned above for firms is partly also true for policy organisations in a dynamic environment. Thus, learning and adjustment are major issues in evolutionary reflections on policymaking, as is the role of uncertainty in policymaking (e.g. Benz and Fürst 2002). Policymakers may deal in different ways with the uncertainty they encounter, as can be illustrated by the following two extreme models: (1) to prevent any uncertainty and to plan the process and the product of policymaking in a strict and comprehensive way, and (2) to recognise uncertainty as a basic attribute in policymaking and to utilise it in a positive way, by planning incrementally and leaving the process open, while continuously learning from experiments, monitoring of ongoing developments, etc. (e.g. van Geenhuizen and Thissen 2002).

3. Motivation of Entrepreneurs

Spin-off from Delft University of Technology is used as a case study in this paper. Delft University of Technology is in the medium-sized town of Delft, midway the larger cities of The Hague and Rotterdam in the Western part of the Netherlands. The university has adopted a central supporting policy to academic entrepreneurship since 1998. This initiative, named "Technostarters", provides a program of support measures from which start-ups select those

ones that are useful to their personal needs, such as a loan (without interest) to a maximum of 16.800 Euro, use of accommodation at one of the faculties, and coaching by faculty members. The program is open to graduates (including doctorates) while staff members also qualify. Our sample includes both "Technostarters" and firms that received support in other ways from the university (Note 1).

It is interesting to know what motivation lies behind the relatively large "jump" taken by graduates and staff from Delft University of Technology in starting a business. Table 1 shows that motivations related with personal achievement rank high. These motivations are based on personal needs and skills related to independence, self-realisation and satisfaction with work. The desire to be independent ranks first as a motive for establishing a firm.

Table 1 Motivation to start a firm

Motivation		**Average Score (a)**	**Rank**
Personal achievement	To be independent	4.19	1
	To use own creative skills	4.16	2
	To have more satisfaction in work	4.12	3
	To be the decision-maker	3.91	4
Opportunities (e.g. material)	To exploit market opportunities	3.72	5
	To meet a service or need of society	3.09	6
	To make a lot of money	2.93	7
	To have more prosperity in the future	2.86	8
Working conditions	To be able to work at home	1.98	9

a. Based on a 1-5 point scale; number of firms: 43.

Motives like grasping market opportunities and increasing material prosperity rank lower. The wish to work at home receives the lowest score as a motivation. Working at home is not realistic in the case of needs for laboratory experiments. Despite the recognition of various opportunities, starting entrepreneurs are also aware of the large risks taken. For that reason, most start-ups of Delft University of Technology (84%) are founded by more than one person, i.e. 60% by two persons and 24% by three or more persons.

The desire to be independent is reported more often as the most important motive to start an own firm (e.g. Roberts 1991). Accordingly it may be expected that the entrepreneurs are

reluctant to become dependent in other ways, like in building learning relations and attracting capital investment (e.g. Gemünden and Heydebreck 1996).

4. Learning and financial capital

Although relationships between university and industry have become tighter and more varied in the past decade, there remains a gap in routines between learning to do research at a technical university and running a technology-based firm. Undertaking research in technology means to reduce risks, mainly in experimentation (to control for as much influences as possible), whereas running a technology-based company means taking large and often unknown risks. This situation calls for the adoption of significantly new routines aside from maintaining the ones that remain necessary for carrying out high-level R and D. Taking courses is one way of bridging the gap in routines. A majority of the start-ups takes courses provided by Delft University of Technology or external parties (consultancy firms) (65%). It appears that courses on basic entrepreneurial knowledge (skills) for starting and managing a firm receive high scores in terms of importance for business performance (Table 2).

Table 2 Evaluation of courses on importance (a)

Course content		Average score	Rank
Entrepreneurial	Writing/using a business plan	3.62	1
	Communication and promotion	3.57	2
	Market research	3.49	3
	Leadership and motivation	3.46	4
	Selling skills	3.42	5
	How to obtain finance	3.05	8
Planning	Financial planning	3.32	6
	Time management	3.14	7
Operational	Staff training and recruitment	2.84	9
	Book keeping	2.65	10

a) Based on a 1-5 scale; number of firms: 43; 10 most important course contents.

Writing and using a business plan ranks first and is followed on short distance by various components related to interaction of firms with the market, i.e. communication and promotion, market research and selling skills. Leadership and motivation is an equally important component.

In preventing or solving problematic situations, learning from external parties tends to be as important (54%) as learning within the firm, including a new partner (46%) (Table 3). This pattern may indicate a trend for spread of risk and search of diversity, in other words, independence. Such a trend can also be observed with regard to the type of external sources (partners) in learning. It appears that Delft University of Technology is an important partner in achieving knowledge (34% of all sources), but it is certainly not the only one. Next important are customers and suppliers (each around 19%).

Table 3 Learning relations

Learning connected with obstacles	**Abs.**	**Share (%)**
Learning from external parties (networks, consultants)	14	53.8
Learning from a new partner	3	11.5
Learning by doing (experiencing) or studying	6	23.1
Learning from new personnel	3	11.5
Totals	26	100.0
External learning sources		
Delft University of Technology	25	33.8
Other university	6	8.1
Customers	15	20.3
Suppliers	14	18.9
Open sources: internet and literature	14	18.9
Totals	74	100.0

A trend for independence is also apparent in the way the new firms attract financial capital. The most important source is own revenues (Table 4). Although each firm has the opportunity to utilize a wide variety of capital sources, almost three-quarters of the firms (72.1%) make use of capital generated in the firm, by e.g. routine experiments or advisory work. Formal investors are only important for a minority of firms (34.9%); particularly venture capitalists lack popularity (7.0%). When compared with research elsewhere it becomes clear that the above pattern of small use of formal investors complies with financial sources in the initial stages of start-ups (e.g. Roberts 1991). There is maybe a small difference in the most important source: many studies report on personal savings as the most available source of capital, not revenues from the own business. In addition, informal investors, like family, friends and wealthy individuals ("angels") seem less important in Delft (11.6%) than in other places.

The strategy of internal investment among Delft's spin-off indeed reduces dependency of entrepreneurs on formal investors. At the same time it causes a limited focus on innovative

activities, potentially leading to delay in market introduction of the innovative products. In the R and D intensive biotechnology, a lack of focus is seen as the major cause of failure of new firms.

Table 4 Sources of financial capital

Source	Frequency of mentioning as an important source	% share of firms (a)
Bank	12	27.9
Venture capitalist	3	7.0
Informal investor	5	11.6
Revenues from own firm	31	72.1
Remaining (b)	13	32.4
Totals	64	

a. A firm can utilize more than one source.
b. For example a loan from TU Delft, funding subsidies, salary (as staff member).

5. Problematic Needs and Growth

The paper now proceeds with an analysis of needs that are seen as problematic by start-ups. Knowledge (skills) appear to be the most important class of problematic needs (51%) (Table 5). These problematic needs mainly refer to interaction with the market, i.e. marketing and sales (each about 13% of all problematic needs), and this complies with the previously discussed high appreciation of such components in courses. It needs to be stressed that markets for high-technology firms are strongly specialised. For example, new types of metal coating (processed using nanotechnology) have potential applications in machinery for food processing and in metal components of ships. Each market has its own structure, with dominant players and networks that need to be sufficiently known by the entrepreneur. At the same time, while penetrating these markets, entrepreneurs are eager not to loose independence. Another market obstacle is the image of start-ups among large customers as not sufficiently experienced. This situation works like a vicious circle. However, if once transactions have taken place with a large customer it is much easier to find subsequent large customers.

Needs for market knowledge and skills are followed by various needs for management skills. In this context, dealing with uncertainty is seen as an important problem (14%). This result illustrates the sharp transition that entrepreneurs are facing, including the adoption of new routines. The capability to deal with many different management tasks simultaneously (overload) is seen as another problem (10%). Aside from knowledge (skills) problems, there are financial problems, particularly shortage of cash flow (14%). All other issues, like accommodation of the start-up and available infrastructure, appear of minor importance. With regard to development

over time, knowledge (skills) problems remain after the first year, while some problems tend to increase or decrease (Soetanto 2002). The problem of skills to handle management overload increases in importance, whereas problems of physical accommodation become less relevant. This pattern complies with resource-based insights (Reid and Garnsey 1998) in that the need for basic resources and concomitant problems change over time.

Table 5 Problematic needs

Problematic need	**Specification**	**Abs.**	**%**	**Rank**
Knowledge (skills)	Marketing knowledge	20	14.5	1
	Dealing with uncertainty	19	13.8	2/3
	Sales skill	17	12.3	4
	Management (overload)	14	10.1	5
Finance	Cash flow	19	13.8	2/3
	Investment capital	9	6.5	7/8
	R&D investment (development)	7	5.1	10
Physical	Accommodation	8	5.8	9
	Infrastructure	5	3.6	11
	Distance	1	0.7	12
Market	Demand	10	7.2	6
Government	Regulation, bureaucracy	9	6.5	7/8
Totals		138	100	

The analysis now turns to the extent to which the previously indicated circumstances, like motivation to start a business and problematic needs, influence growth of start-ups. To this purpose a growth model is developed and estimated (Note 2). The reasons why particular explanatory factors are included in this model can be summarized as follows. First, the kind of motivation of the founder (s) to start a firm is expected to play a role (e.g. Watson and Scott 1998). What will make a difference is whether the motivation includes aspects related with independency (and personal achievement) or aspects related with seizing business opportunities (more materialistic reasons). A second factor that is likely to influence growth of start-ups is the (main) founder's rank in the family. Most founders of technology-based firms are first-born children, a phenomenon ascribed to the fact that these children usually take larger responsibilities (e.g. Lowe and Taylor 1990). It seems reasonable that they are also better prepared in preventing and overcoming obstacles in the early growth stages. A third factor of influence is the number of founders. A relatively large growth is expected in a situation of more than one founder because risks are shared and more knowledge and skills are available to tackle problematic situations. Fourth, age of the firm will play an important role in growth. We expect an increase of growth per year with increasing age of the firm,

based on the idea that - after overcoming obstacles of the foundation process - entrepreneurs "climb" on their learning curve and become better adjusted to business circumstances. Making use of support measures is also included in our model as an explanatory factor for growth. This is based on arguments from resource dependence theory. Small high-technology firms lack some basic resources, like capital and particular knowledge (skills). Those who are able to organize access to these resources at the right time have better chances to survive and grow compared with other ones. Finally, it is plausible that facing serious problems in business activity has a hampering influence on growth. We expect a negative influence of knowledge and skills barriers, i.e. concerning marketing, management overload and coping with uncertainty.

On the basis of the above considerations the following equation for growth of start-ups can be formulated:

$$JOBGROWTH = A + B_1 (MOT) + B_2 (FAMRANK) + B_3 (NRFOUND) + B_4 (FIRMAGE) + B_5 (INTSUP) + B_6 (EXTSUP) + B_7 (LACKMAR) + B_8 (MANLOAD) + B_9 (DEALUNCERT)$$

Where:

JOBGROWTH:	Job increase per year in full time equivalent
MOT:	Dummy variable that attains the value 1 if the motivation has to do with independence factors and is zero in all other cases.
FAMRANK:	Dummy variable that attains the value 1 if first-born child and is zero in all other cases.
NRFOUND:	Number of founders (persons).
FIRMAGE:	Age of the firm (in years).
INTSUP:	Dummy variable that attains the value 1 if use of TU Delft support and is zero in all other cases.
EXTSUP:	Dummy variable that attains the value 1 if use of other (external) business support and is zero in all other cases.
LACKMAR:	Dummy variable that attains the value 1 if the firm is facing lack of marketing knowledge (skills) and is zero in all other cases.
MANLOAD:	Dummy variable that attains the value 1 if the firm is facing managerial overload and is zero in all other cases.
DEALUNCERT:	Dummy variable that attains the value 1 if the firm recognises problems in dealing with uncertainty and is zero in all other cases.

We expect the coefficients B_1, B_2, B_3, B_4, B_5 and B_6 to be positive and the other B coefficients to be negative. In the following we summarise the results of the estimation of the model.

Most of the factors discussed appear to play a significant role in the growth of start-ups (Table 6). However, a striking result is that the estimation of the influence of factors associated with

the founder, i.e. his/her motivation and family ranking, does not yield the expected significant results. Thus, there is no evidence that personal independence motives and being a first-born child have a positive influence on growth. What may help understanding this outcome is the frequently occurring situation of multiple-founders, in which the capacity of the main founder is enriched with capacities of co-founders. Also, the estimation of the role of managerial overload does not lead to significant results; there is no evidence of influence of this barrier on growth. A potential explanation is that personal perceptions of the entrepreneur play a role here, i.e. in the qualification of management overload as a problem, aside from the management capacity at hand that differs from firm to firm.

The estimation of all other factors brings to light a significant influence on growth, in most cases with the expected sign. Thus, more than one founder clearly advances growth. Apparently, spread of risk over more than one founder and a broader availability of knowledge (skills) enhance growth. Similarly, age of the start-up influences growth, meaning that older firms tend to grow faster than younger ones. After some time of experience, the crucial business routines are apparently acquired and internalised by the entrepreneurs. Further, the estimation results on the use of support clearly point to influence on growth. However, there is a difference between internal support (from Delft University of Technology) and external support. The sign of the first coefficient is positive as expected, but the latter coefficient is negative.

Table 6 Regression analysis of the growth of start-ups

	Coefficients	**Significance**
Constant	-1.180	
Independence motives	0.161	
Family ranking	- 0.002	
Number of founders	0.680	**
Age of the firm	0.169	**
Internal (TU Delft) support	0.433	**
External support	- 0.346	**
Lack of marketing knowledge (skills)	- 1.016	**
Management overload Dealing with uncertainty	0.289 1.599	 **
R^2	0.710	

** Significant at the 0.05 level.

This result, however, not necessarily indicates a negative influence of external support on growth. What may happen is that most firms seek external support only in a relatively late stage of problem recognition and solving, meaning that the firms' development is already affected by a downward trend. In this situation, using external sources tends to be in vain.

Further, the estimation of the influence of two problems yields significant results. However, in the case of problems in dealing with uncertainty the sign is different from expected, i.e. positive. This means that entrepreneurs who recognise dealing with uncertainty as a problem tend to perform better than other ones. What may be helpful in explaining this result is to see the recognition of this problem in connection with the development of adequate strategies. Thus, if entrepreneurs consider uncertainty as a problem, they prepare themselves better and develop pro-active and adaptive strategies to deal with large risks. Our final estimation result, i.e. the influence of lack of marketing knowledge (skills) on growth, conforms the expectations. Start-ups that are facing this problem tend to grow on a lower level than other start-ups.

From a policymaking point of view it is now interesting to see which of the above-indicated influencing factors can be brought "under control" by means of policy measures of the university. The following factors lend themselves for such a steering: number of founders, use of internal university support, lack of marketing knowledge (skills), and dealing with uncertainty.

6. Incubation Policies

In general, universities develop policies to enhance survival and growth of start-up firms by providing facilities that match with limited resources of these start-ups and using:

- Selection processes: screening and selection of promising and viable business ideas.
- Monitoring systems: following ongoing developments of start-ups in the frame of identifying policy impacts.
- Seedbed conditions in incubator facilities: supplying a broad range of measures, like cheap and flexible space, shared services (secretarial, cleaning, restaurant), research facilities at the university, courses and mentoring, and access to various networks.
- Specifically financial capital: taking equity shares in start-ups, for example to pay for up-front patenting and licensing expenses, and establishing internal venture capital funds.

How the previous policy is designed and what policy measures are included depends on two dimensions of policymaking that are closely related with valuation of uncertainty at hand and coping with this uncertainty. These dimensions are comprehensiveness of support measures (content) and openness in policymaking (process) (Figure 1). On the first dimension there are two extremes, i.e. policies offering comprehensive packages of support - including subsidised space, shared services, access to networks, etc. - and programs through which start-ups select single or a couple of support measures in a customised way. On the second dimension one extreme refers to centralised (top-down) models of policymaking, i.e. real estate development in one location based on a clear and pre-determined image of how incubators should be, e.g. to serve interaction (learning) between entrepreneurs. These incubators are often "flag ships" of the university through their physical presentation. The other extreme refers to models of open policymaking with a focus on self-organisation of start-ups and with a focus on networking; these models enable both concentration of start-ups (incubator) and spread of them in department buildings and outside the university. Entrepreneurs design the kind of support they prefer and determine the diversity (specificity) provided based on the principle of "the entrepreneur knows best". These ongoing and open processes are accompanied by loose forms of steering on key processes and actors (networks) (e.g. De Bruijn et al. 1998).

Policymaking that fits into the left upper part of Figure 1 aims to prevent or to reduce uncertainty as much as possible and policymaking that fits into the right under part takes advantage of uncertainty by allowing self-organisation and piecemeal planning, including learning from experiments and from monitoring ongoing developments.

Figure 1 Types of policymaking for incubation

Dimensions	**Comprehensive Packages**	**Custom-made packages of single measures**
Centralised (top-down, predetermined, closed)	OLD MODEL	OLD MODEL
Self-organisation and networking (bottom-up, adaptive, diverse, open)	–	NEW MODEL

7. Concluding Remarks

There is no blueprint available for policies that enhance survival and growth of academic spin-off. Local situations may differ significantly, e.g. in terms entrepreneurial culture of universities, size and structure of local and regional economies, and technology specialisation of universities. In addition, valuation of uncertainty differs between cultures in large parts of countries and continents (Hofstede 1997). This means that incubation policies need to be based on a careful matching with these situations. Incubation policies preferably also comply with needs of start-ups. The case study used in this paper has pointed to the following needs:

- Multiple founders.
- Learning about relevant markets and skills to penetrate these markets.
- Learning to cope with uncertainty and to develop adequate strategies.
- Diversity in learning partners.
- Diversity in financial sources and small dependence of formal sources (early stages)
- University support, particularly supplied in a timely manner.

Given the strong role of independence and preference for diversity among start-ups in our case study, models of policymaking in the upper left-hand corner of Figure 1 seem outdated for the situation at universities in Northwest Europe. Rather, up-to-date policymaking models find themselves more down and on the right-hand side. This fits into a broader awareness of a trend for increased complexity in the links between university, industry and governments, mainly the rise of new roles and interests, and volatility in new networks. In such situations, policies are preferably adaptive both in the type of policymaking process and in the measures selected (Walker et al. 2001).

The existing evidence suggests that incubation policies allowing for a certain selection of support in a customised way – the case of Delft – positively influence the growth of academic spin-off. Additional research should be undertaken to determine whether comparable start-ups (age, sector, etc.) in places not affected by an incubation policy perform less well; in other words, a control group needs to be included in the research. A second research avenue would be to identify different models in policymaking for incubation across different cultures, based on a different appreciation of uncertainty, and to determine under which conditions these are successful in stimulating growth of academic spin-off.

Note 1

The sample represents a selected category of spin-off firms: (1) established after 1995 and survived in 2002, (2) established in Delft and located here in 2002, (3) support from the university (mostly Technostarters program). The original sample size is 64 firms. All of them received a written questionnaire. With a response rate of 67.2%, this has led to 43 valid responses. Non-response seems partly based on unfavourable business development.
A major point is the generality of the results. It is reasonable to assume that the results can be generalised to young start-ups from technical universities and technical faculties within general universities in Northwest Europe under similar institutional conditions as the Netherlands. This would mean that the problems observed in Delft hold true for larger populations of entrepreneurs that have taken a major "jump" in environment and routines.

Note 2

The analysis is limited to those factors that are important according to the literature, or for which plausible arguments are available. It is also limited to factors that show a sufficient differentiation within the sample and which can be considered as statistically independent (Soetanto, 2002).

References

Arthur, W.B. (1994) *Increasing returns and path dependency in the economy*. University of Michigan Press.

Acs, Z. J., Audretsch, D.B. and M.P. Feldman (1992) Real Effects of Academic Research: Comment, *American Economic Review*, 82: 363-367.

Anselin, L.A., Varga, A., and Z. Acs (1997) Local Geographic Spillovers between University Research and High Technology Innovations, *Journal of Urban Economics*, 42: 422-448.

Baaij, M.G. and F.A.J. van den Bosch (1999) Towards an evolutionary framework of strategy (in Dutch), *Bedrijfskunde* 71 (2): 52-59.

Baljé, S. and P. Waasdorp (2001) Entrepreneurship in the 21 century. In: *Entrepreneurship in the Netherlands. New economy: new entrepreneurs!* The Hague/Zoetermeer: Ministry of Economic Affairs and Economic Institute for Small and Medium-Sized Firms. pp. 29-49.

Benz, A. and D. Fürst (2002) Policy Learning in Regional Networks, *European Urban and Regional Studies*, 9: 21-35.

Berg, J. van den, and D. Fetchenhauer (2001) *Beyond the Rational Model: Evolutionary Explanation to Behaviour and Socio-Economic Institutions* (in Dutch). The Hague: NWO.

Birch, D. (1979) *The Job Generation Process*. Cambridge: MIT Press.

Bruijn, J.A. de, Ten Heuvelhof, E. F., and R. J. in het Veld (1998) *Process Management: Design and Decision-making (in Dutch)*. Amsterdam: Academic Services.

BSC (Business Service centre TU Delft) (2002) Gestart in Delft.

Braczyk, H-J, Cooke, P. and M. Heidenreich (eds) (1998) *Regional Innovation Systems. The role of governances in a globalized world*. London: UCL Press.

Camagni, R. (ed) (1991) *Innovation Networks: Spatial Perspectives*. London: Belhaven.

Castells, M. and P. Hall (1994) *Technopoles of the World*. London: Routledge.

Cimoli, M. and G. Dosi (1995) Technological paradigms, patterns of learning and development: an introductory roadmap, *Journal of Evolutionary Economics* 5: 243-268.

Di Gregorio, D. and S. Shane (2003) Why do some universities generate more start-ups than others? *Research Policy*, 32: 209-227.

Dosi, G. and R.R. Nelson (1994) An introduction to evolutionary theories in economics. *Journal of Evolutionary Economics* 4:153-172.

During, W. (1998) Co-operation between Technology-Based Firms in Business and Science Parks: An Exploratory Study of the Situation in the Netherlands. In: Oakey, R. and W. During (eds) *New Technology-Based Firms in the 1990s, Volume V.* London: Paul Chapman, pp. 57-66.

Etzkowitz, H. (2002) Incubation of incubators: innovation as a triple helix of university-industry-government networks, *Science and Public Policy*, 29(2): 115-128.

Felsenstein, D. (1994) University Related Science Parks, "Seedbeds" or "Enclaves of Innovation", *Technovation*, 14: 93-110.

Felsenstein, D. (1996) The University in the Metropolitan Arena: Impacts and Public Policy Implications, *Urban Studies*, 33: 1565-1580.

Florax, R. (1992) *The University. A Regional Booster?* Aldershot: Avebury.

Geenhuizen, M. van, and P. Nijkamp (1996) What Makes the Local Environment Important for High Tech Small Firms. In: Oakey, R. (ed) *New technology Based Firms in the 1990s, Volume II*, London: Chapman, pp. 141-151.

Geenhuizen, M. van, and P. Nijkamp (1998) Improving the knowledge capability of cities: the case of Mainport Rotterdam. *Int. Journal of Technology Management* 15 (6/7): 691-709.

Geenhuizen, M. van (1999) New technology and survival: an evolutionary approach to adaptation of firms in a regional context. In: Dijk, J. van, and P.H. Pellenbarg (eds) *Demography of Firms. Spatial Dynamics of Firm Behaviour*. Utrecht/Groningen: KNAG and RUG, pp. 215-231.

Geenhuizen, M. van, and P. Nijkamp (1999) Regional Policy beyond 2000: Learning as Device, *European Spatial Research and Policy*, 2: 5-20.

Geenhuizen, M. van, and W. Thissen (2002) Uncertainty and Intelligent Transport Systems: Implications for Policy, *Journal of Technology, Policy and Management*, 2: 5-19.

Geenhuizen, M. van (2003) How can we reap the fruits of academic research in biotechnology? In search of critical success factors in policies for new firm formation, *Environment and Planning* C, Vol. 21: 139-155.

Gibbons, M., Limoges, C., Nowotny, H., Schwarzman, S. and P. Scott (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.

Hofstede, G. (1997) *Cultures and organizations; software of the mind.* Ne York: McGraw Hill.

Johannisson, B., Alexanderson, O., Nowicki, K. and K. Senneseth (1994) Beyond Anarchy and Organization, Entrepreneurs in Contextual Networks, *Entrepreneurship and Regional Development* 6: 329-356.

Krohn, W. and W. van Daele (1998) Experimental implementation as a linking mechanism in the process of innovation, *Research Policy*, 27: 853-868.

Kowol, U. and G. Küppers (2003) Innovation Networks: A New Approach to Innovation Dynamics. In: Geenhuizen, M. van, Gibson, D. and M. V. Heitor (eds) *Regional Development and Conditions for Innovation in the Network Society*, Purdue University Press (forthcoming).

Laag, A. van der, and J. Snijders (eds) (2003) *Entrepreneurship in the Netherlands. Knowledge transfer: developing high-tech ventures*. The Hague/Zoetermeer: Ministry of Economic Affairs and Economic Institute for Small and Medium-sized Firms.

Lindelöf, P. and Löfsten, H. (2003) Science Park Location and New Technology-Based Firms in Sweden – Implications for Strategy and Performance, *Small Business Economics*, 20: 245-258.

Lowe, J. and P. Taylor (1996) The Sustainable Academic Spin-Off Enterprise. In: Oakey, R. (ed) *New Technology-Based Firms in the 1990s, Volume II*, London: Chapman, pp. 93-102.

Meijaard, J. (2001) Business Dynamics in a New Economy. In: *Entrepreneurship in the Netherlands. New economy: new entrepreneurs!* The Hague/Zoetermeer: Ministry of Economic Affairs and Economic Institute for Small and Medium-Sized Firms. pp. 11-28.

Ministry of Economic Affairs (1999) *The Entrepreneurial Society* (in Dutch). The Hague.

Nelson, R.R. and S.G. Winter (1982) *An Evolutionary Theory of Economic Changes*. Cambridge: Harvard University Press.

Nowotny, H., Scott, P. and M. Gibbons (2001) *Re-Thinking Science, Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press.

Pettigrew, A. and R. Whipp (1991) *Managing Change for Competitive Success.* Oxford: Blackwell.

Pfeffer, J. and G.R Salanchik (1978) *The External Control of Organizations: A Resource Dependence Perspective*. New York: Harper & Row.

Reid, S. and E. Garnsey (1998) Incubation Policy and Resource Provision: Meeting the Needs of Young, Innovative Firms. In: Oakey, R. and W. During (eds*) New Technology-Based Firms in the 1990s, Volume V*. London: Paul Chapman, pp. 67-80.

Roberts, E.B. (1991) *Entrepreneurs in High Technology. Lessons from MIT and Beyond.* New York: Oxford University Press.

Rogers, E.M. and J.K. Larsen (1984) *Silicon Valley Fever, Growth of a High Technology Culture*. New York.

Rothwell, R. and Zegveld, W. (1985) *Reindustrialization and Technology*. Harlow, Longman.

Saxenian, A. (1994) *Regional Advantage, Culture and Competition in Silicon Valley and Route 128*. Cambridge: Harvard University Press.

Senge, P.M. (1990) *The Fifth Discipline. The Arts and Practice of the Learning Organization.* New York: Currency Doubleday.

Siegel, D.S., Westhead, P. and M. Wright (2003) Science Parks and the Performance of New Technology-Based Firms: A Review of Recent U.K. Evidence and an Agenda for Future Research, *Small Business Economics*, 20: 177-184.

Soetanto, D.P. (2002) Meeting the Needs of Spin Offs: A Reflection of an Incubation Policy. TU Delft, Faculty of Technology, Policy and Management (MSc thesis).

Thierstein, A. and B. Wilhelm (2001) Incubator, technology, and innovation centres in Switzerland: features and policy implications, *Entrepreneurship & Regional Development*, 13: 315-331.

Walker, W.E., Rahman, S.A., and Cave, J. (2001) Adaptive policies, policy analysis and policy-making, *European Journal of Operational Research* 128: 282-289.

Watson, K. and Scott, S.H. (1998) Small Business Start-ups: Success Factors and Factor Implication, *Int. Journal of Entrepreneurial Behaviour & Research*, Vol. 4 (8): 217-238.

Westhead, P. (1997) R&D Inputs and Outputs of Technology-Based Firms Located On and Off Science Parks, *R&D Management*, 27: 45-62.

Wickstead, S.Q. (1985) *The Cambridge Phenomenon: The Growth of High Technology Industry in a University Town*. Cambridge: The Thetford Press.