Is it Really Speed We Need?

The Role of Venture Capital in Biotech Start-ups

Alexandra Waluszewski[♠], Torkel Wedin[♣]

Abstract

The involvement of venture capital is often considered a type of salvation, affording projects a means of financing their journey toward becoming established companies. However, only a small percentage of all start-ups manage to attract venture capital, and of those that do, less than three percent survive the development journey. Those who enter a venture capital financed development journey will be strongly influenced by the logic of the financing firm. Generally, the venture capital firm's available capital must be liquidated at a certain date, often 10 years from the day the fund is founded. During this time the venture capital firm must invest in, manage and divest itself of the start-up firms to be able to distribute the proceeds to the limited partners of the venture capital fund. Consequently, the venture capital firm is forced to manage its portfolio firms in a certain direction and at a certain speed. Thus, the development of a start-up company's resource base and subsequently its supplier-customer interfaces, has to fit in with these restrictions. However, is it always speed a new start-up needs? This paper discusses the positive and negative aspects of how some important physical and social resources, and their embedding into user interfaces, are coloured by the logic of the venture capital firm.

[♠] Department of Business Studies, Uppsala University. E-mail: alexandra.waluszewski@telia.se
[♣] Department of Accounting and Managerial Finance, Stockholm School of Economics. E-mail: torkel.wedin@hhs.se

1. The venture capital firm: a supplier of "intelligent" or speedy and directed capital?

When discussing the role of venture capital and the process of developing and commercialising new technologies, whether discussed by researchers, policy makers or journalists, the involvement of this type of financing is frequently considered as a kind of salvation – affording projects a means of financing the journey toward becoming established companies. Prospering companies (most often US companies like Apple, Cisco, Intel, Microsoft, Genentech, Yahoo! and Amazon.com), once financed with venture capital, are often given as examples of what can be created when new ideas are combined with "intelligent" financing. Without venture capital, Gompers and Lerner (2001, p.1) claim, "many entrepreneurs would never attract the resources they need to quickly turn their promising ideas into commercial success". Or, as Powell et al argue (2001, p. 5), "Venture capital is one of the key elements of the infrastructure of innovation".

The venture capital firm is generally seen as a provider of three critical resources to an entrepreneur facing the process of transforming ideas into "commercial successes". First, the venture capital firm is the supplier of money, a critical resource for transforming a new solution, created by individuals or a project, into a company with established customer interfaces (i.e. Barney et al 1996). Second, venture capital firms can bridge the information asymmetries between entrepreneurs and investors, thus adding value to both (Sapienza 1992, Bain 1999, Sahlman 1990, Barney et al 1996). The venture capital firm can help investors assess new ventures as well as guide entrepreneurs in their new roles as managers. Thus, the venture capital firm is not only a provider of capital, but also of other essential resources that the individual or group is thought to lack: knowledge and the ability to foresee risks and opportunities that the entrepreneur faces. As Gompers and Lerner (2001, p. 19) illustrate, "Most high-technology entrepreneurs are convinced that they have exciting and dynamic ideas"..."What most entrepreneurs do not see clearly, however, are the risks facing their business". A similar view is expressed by Powell et al (2001, p 6-7), who stress the importance of the combination of money and knowledge, which is especially common when financing high-tech enterprises. Third, the venture capital firm is a provider of its network of relationships. These relationships might include financial, commercial or technology based contacts. These three venture capital features aim to speed up the commercialisation process;

i.e. to decrease the time from idea or basic research to a materialized product that can create value for the investors and entrepreneurs as well as for society as a whole (Freeman 1999, Gompers and Lerner 2001).

But what effect does a rapid development journey have on the development of a technological solution into a commercial one? Although we are supplied with a significant volume of research on venture capital, most studies focus on the effect on economic growth (often measured in terms of number of employees and turnover), and do not explicitly deal with the issue of how this influences the direction of the development process. In the following discussion of how an increased demand for speed influences a start-up company's journey towards economic sustainability, we use an empirical illustration from a biotech company located in Uppsala, Sweden. Pyrosequencing is a supplier of biotech instruments and is closely related to The Royal Institute of Technology (KTH), Stockholm and to Amersham Biosciences (formerly Pharmacia Biotech, Uppsala). Moreover, Pyrosequencing has been financed by venture capital with demands on both the speed and direction of the development journey. [1] We will explore how this type of financing of an entrepreneurial venture has influenced the firm in various ways: the development of its products and its production facilities, how to manage and control this development, and how it relates, in a larger context, to its suppliers and users. In what situations can speed, including its on-going demand for solutions, identified in early stage development , be beneficial for, or harmful to, the creation of economic value?

1.1 Some basic characteristics of the embedding of new solutions into supplier-customer interfaces

The journey from development project to established company is an uncertain and risky enterprise, an understanding often expressed by practitioners, and underlined by scholars studying technological development in an interactive perspective. When van de Ven et al (1999: ix) describe their impression of a ten-year empirical study of innovations, their transformation into commercial solutions is characterised as being "highly unpredictable and uncontrollable". Tidd, Pavitt and Bessant (1997) draw a similar picture by using the words "messy" when illustrating this process, and "trial-and-error" and "muddling through" when describing possible ways of handling it. These pictures are also close to the thoughts of

[1] For a thorough description of Pyrosequencing and its development journey, see Wedin, 2003, "The Pyrosquencing case" (forthcoming)
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Rosenberg (1982), Hughes (1983), Bijker (1997) and Basalla (1988). What these studies have in common is the interpretation that being involved in an "innovation journey" is to deal with processes that are far too complex to ever completely understand. Or, in the words of Dosi (1988: 222), "Almost by definition, what is searched for cannot be known with any precision before the activity of search and experimentation itself". Thus, such an enterprise consists largely of handling unexpected effects, where new and old solutions are tried and retried.

These impressions of developing new technological solutions, including establishing new supplier-customer interfaces, are also close to those described in studies of technological development carried out with an Industrial Network Approach (see e.g. Håkansson ed, 1987, Waluszewski, 1989, Lundgren, 1991, Holmen, 2001, Wedin, 2001, Håkansson & Waluszewski, 2002). With the assumption that resources are heterogeneous, inspired by Penrose (1959) and others, the focus is directed toward how they are combined with other resources – since both the features and the value of the resources are evoked in the combinatory endeavours. Thus, it is an approach coloured by the understanding that developments occur when companies and organizations encounter one another in terms of sets of resources. Since these combinatory efforts, whether within or between organisations, are carried out in relation to other resources, attention is directed to the interplay between resources and those handling them; individuals, projects, companies and other organisations. This interplay is treated as a phenomenon that can have a wide variety of expressions – ranging from distant relationships to close interactions – where both social and technological resources are confronted and adapted. Thus, the interplay of resource development and utilisation is treated as both an organising process with effects on a meso level (for a larger network of related units) and as a development process that is critical for the value creation of the individual company's set of resources. (Håkansson and Waluszewski, 2002, Waluszewski, 2002).

From this perspective, the ability to develop and commercialise a new technological solution – whether by a start-up or an established company – becomes an issue of interaction between those representing both direct and indirect resource interfaces. Since development of new producer-user interfaces includes trial-and-error learning and adapting processes, it is necessary to study possible resource combinations and how they affect established interfaces. When considering development of supplier-user interfaces, the question of time arises. Since the developed and exchanged solutions are not given, but created in the interaction process, they must be, as Kubler (1962) puts it, seen as "the shape of time". Thus, in this perspective time is not only a cost driver, something that must be controlled, but also an important prerequisite for creating value; for adaptation and embedding processes to occur (Håkansson and Waluszewski, 2002).

1.2 Some basic characteristics of how venture capital firms finance their involvement in the embedding process

Venture capital firms invest in new projects, commonly labelled "young entrepreneurial ventures", "technology driven companies", or New Technology Based Firms (NTBFs) (Sahlman 1990, Murray 1996), with the aim of gaining the highest possible return on their investments. The expected high returns are related to the high perceived risk of investing in young ventures – projects that often lack both finished products or prototypes, and consequently, production facilities, relations to suppliers and customers, and especially an organisation capable of handling all these resources. The goal for any venture capital firm is to exit with an initial public offering (IPO) that takes the new venture public and lists it on a stock exchange. Thus, the state of the economy plays an important role in a venture capital firm's ability to divest itself of its investments.

The legal structure of a typical venture capital firm is often a so-called private equity partnership (Sahlman 1990, Gompers and Lerner 1999). A private equity partnership consists of the general partners (the venture capital firms) that manage the firm and monitor the investments, and the limited partners, who put in the lion's share of the money in the fund that is managed by the general partners. The limited partners are often institutional investors such as mutual funds, pension funds or insurance companies.[2] The limited partners commit a certain amount of capital that the venture capital firm then can use for investment. The general partner's role is to find interesting investments, where the limited partner's money can grow over a certain period of time. Thus, private equity partnerships are not meant to last forever. A fund is often designed to last for 10 years, which means that the equity in the fund has to be returned to the limited partners, the investors, after this period. The general partners

[2] The venture capital firm depends on the supply of capital from private and governmental financial institutions, such as mutual funds. The propensity of these financial institutions to invest in private equity is a factor that drives the venture capital industry. In some cases legal causes have played a significant role. In 1979 the U.S Department of Labour clarified the Employee Retirement Income Security Act, a guiding principle that freed pension funds to invest in venture capital. This lead to a sharp boost in the funds dedicated to venture capital (Kortum & Lerner 1995). This dramatic legal shift in the US can be illustrated with a similar, but perhaps not as powerful one in Sweden. In 1996 the government created a state owned pension fund (6Ap-fonden) that was allowed to invest in private equity and new science based start-ups. Even if the amount was somewhat modest, compared to the US conditions, this was an important sign that the government was going to take an active role in the Swedish Venture Capital industry.

make their profit from the management fees, which are often about 1-2 percent of the limited partners' investments. Moreover, the general partners also share in the profits from the venture, generally about 20 percent. If the general partners are successful in attracting capital from institutional investors and they manage to deliver a profit, their own profit will be considerable. (Sahlman 1990, Gompers and Lerner 2001)

The legal structure of a venture capital fund makes time management a significant activity (Freeman 1999, Gompers and Lerner 2001). If the fund is going to last for ten years, the venture capital firm must balance the time of finding innovative projects to invest in, transforming this to firms that have to grow, and managing the divestment period. Evaluation of the general partners is based on the internal rate of return (IRR) they create. To be regarded as successful, a venture capital firm must manage to create an IRR of about 30 percent (according to Freeman 1999). Keeping the time from innovation to growing company as short as possible is therefore a critical issue for a venture capital firm. Or, as Freeman (1999, p. 9) puts it: "Slow growth is as bad as failure for the venture capital firm because of the fixed time cycle for their funds and because their performance is evaluated in annualised terms."

So, how does the venture capital firm become involved in a new start up, manage time to commercialisation, and divest favourably through an IPO? When a venture capital firm becomes involved with a new start-up, a central activity is to establish and follow "milestones". The milestones function as steps in a stage/gate process (see e.g. Cooper 1999), where the aim is to reduce risk as the process of developing the firm continues. The milestones also make it possible to use so-called staged financing (Gompers and Lerner 1999). When a venture capital firm uses staged financing, the portfolio firm must be able to meet some of the initial milestones. One common milestone is that the firm must reach a certain number of employees within a given time. Another is to create a "family of patents". A third is to define a date when the first prototype must be finished. A fourth can be a number of potential customer visits, etc. What all these milestones have in common, is that they are measurable "goals" that should be met before continuing the process of commercialising the technological solution.

Milestones are used by venture capital firms to evaluate their own firm as well as the management of the firm they have invested in. The management of the emerging company is accountable towards the owners (see Roberts and Scapens 1985, Hopwood 1987 or Miller and O'Leary 1987 for discussions on accountability) for the company's success in reaching the milestones. Staged financing is therefore a way to secure money for the venture capital firm;

milestones must be met before more money is poured into the new start-up. [3] Depending on the design of the compensation system, there may be strong economic incentives for management to meet the milestones. Making managers owners is seen as favourable as it gives them the same priorities as the other owners (Barney et al 1996).

Along with creating milestones, a venture capital firm generally participates in the management of the new company, especially in creating its board (Fried et al 1998). A common board organizational method is to combine people representing the venture capital firm, the new company, and people identified as important “opinion leaders” in the field of the emerging company. Since the board members often are involved with several start-up companies in the same field, their role is also to define potential synergies among an emerging group of organizations.

So, the venture capital firm is a provider not only of money, but of a combination of financial skills, special knowledge and possible methods to speed up the development journey that the entrepreneur is missing. Although it is the entrepreneur who has the unique insight into creating a new technological or commercial solution, this knowledge is seen as concentrated on the new solution itself. In fact, the entrepreneur is thought to lack much knowledge of both the potential supplier and user sides (Sapienza, Manigart and Vermeir 1996, Timmons and Bygrave 1997). It is here that the role of the venture capital firm becomes critical. Along with financing, the venture capital firm can supply a project or a start-up company with, according to Gompers and Lerner (2001), knowledge of how to deal with uncertainty. This uncertainty encompasses critical issues like who the potential users are, who the potential suppliers and other strategic partners are, and knowledge about the size of the potential market. (ibid, p. 20). With these abilities at hand, it is obvious that the role of the venture capital firm is much more than just a passive supplier of financing. In order to take advantage of the venture capital firm’s ability to know where to find profitable applications, and thus, its ability to speed up the commercialisation process, the emerging company has to give this unit influence over its strategic decision-making. Thus, what a venture capital firm contributes is an early identification of producer-user interfaces; an early interlocking of a development paths in terms of what kind of product is going to be used by whom and in what way.

[3] Within the new start up, compensation systems will vary and might lead to private economic benefits that the established firm can never match. Ownership is seen as a strong economic incentive for people in the new ventures. Control of the firms will also be different. People or managers with a personal stake in the firm will work to attain the high valuation that is necessary to maintain control in the next financing round. Priorities may also be focused on a short-term time horizon and an initial public offering.

2. A tool to investigate resource interfaces

If, as suggested by Penrose (1959) and further developed in Håkansson and Waluszewski (2002), the value of a resource lies in how it is combined with other resources, then it is not only the heterogeneity dimension, or the lack of total knowledge of all features of a resource, that makes the innovation journey a risky enterprise. This issue is further complicated by the fact that features of resources are embedded into each other beyond the borders of both companies and visible relationships (Waluszewski, 2002, Wedin 2001). For example, the interaction between a biotech instrument and an analytic material can depend on certain features in the input material of a component like a silicone device or a tube. If the tube supplier starts to use a new kind of input material, which perhaps suits some of its direct customers, this will certainly have effects on all direct and indirect interfaces. If the introduction of a new material for tubes has features that not only are valuable in direct related user interfaces, but can also be embedded into indirect related contemporary development processes, or can reactivate indirect related historical or dormant development processes – then forces are created that will both urge and direct the process in certain directions. On the other hand, if the features created in the direct interface contradict the main part of other indirect related processes, they will act against the embedding of the new solution. [4]

To investigate how the involvement of venture capital intervenes in the process of embedding a new solution into both supplier and user interfaces, we will use a framework, developed in Håkansson and Waluszewski (2002), based on four types of resources developed in different interaction processes. This framework will be used to investigate the role that venture capital plays in the commercialisation process of start-ups. Two resources are primarily social; organisational units, developed in co-operation processes, and organisational relationships, developed in networking processes. Two resources are mainly physical; products, developed in buying-selling processes and production facilities developed in producing-using processes. This tool allows the investigation of how resources are related, confronted and remodelled in relation to each other, within and beyond the borders of companies and organisations.

[4] Håkansson and Waluszewski (2002) use the concept friction as a tool to investigate the consequences that occur when resources are moved in relation to each other. In contradiction to the concept inertia, used by Hughes (1987), Scott (1981) and DiMaggio and Powell (1991), the friction concept allows not only investigation of constraints on change, but of forces that can act both as inhibitors and drivers of change.

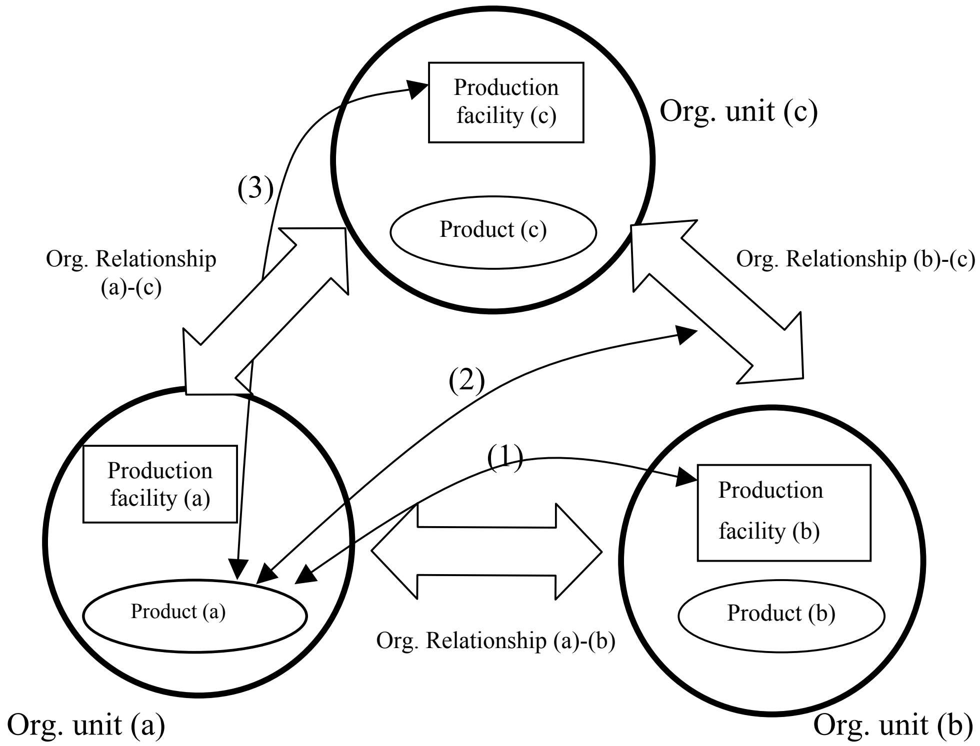

Fig. 1 A tool kit to investigate resource interaction among three organisational units and their interfaces with three other types of resources: products, production facilities and organisational relationships (Håkansson, Waluszewski, 2002, Wedin, 2001).

2.1 The Interaction between Organisational Units and Venture Capital

When considering an organisational unit not only as an actor, but also as a resource unit that can be taken advantage of in combination with other resources, the focus must be on the knowledge and experience features that such units can include. Experiences from long term co-operation with other organisational units can be embedded in an established organisational unit. These experiences include how to utilise and combine its own resources with external ones – how to combine the experiences of its own organisational unit with knowledge available in external ones and how to manage, balance and combine relationships (Håkansson and Waluszewski 2002).

The background of the team behind a start-up company can certainly include such experiences. However, they may concern somewhat complementary processes, involving other product combinations, other facility combinations and other combinations of relationships than those under development. The earlier experiences of co-operation built into the start-up company will affect both how and in what direction the new organisational unit will evolve. Development of an emerging organisational unit will certainly be affected when the venture capital firm, with the above sketched economic logic and need to speed up the development journey, becomes involved. First, supplying the new organisational unit with capital allows it to increase its activities. Second, through its involvement in the management of the new company, the venture capital firm influences how and in what direction the organisational unit will relate to others. By influencing which experiences will be built into the organisational unit, and by formulating strategies, economic goals, scorecards etc, the venture capital firm helps to determine how and with whom the new organisational unit will interact. A venture capital firm with a clear financial logic (a definite time schedule) in focus will probably direct the interaction pattern differently than an investor with a long term perspective.

2.2 The Interaction between Products and Venture Capital

The product-related (physical goods or services) interaction processes create new features of both the product exchanged and the resources activated by the buying-selling sides. Experiences regarding the product and its interface with other resources, from both the selling and buying sides, are brought into the process and can create an imprint on both the product and its related resource interfaces. Compared to a product with an established buying-selling interface, a start-up company is still searching for interfaces where it can contribute an economic value by being combined with other products. Experiences from interfaces with possible direct and indirect related resources are built into the emerging product through interaction processes with potential suppliers and users (Håkansson, Waluszewski, 2002).

When a venture capital firm engages in this embedding process, it is done with a certain logic. Supplying the new organisational unit with capital allows product development activities to increase, but only in a certain direction and at a certain speed. At the stage when a venture capital firm becomes involved in a new start-up, the product is often only an image or a prototype. For the new firm it is a matter of selling this image – to invite continued interaction by both potential customers and the venture capital firm. If the venture capital firm demands an early “freezing” of a new product (to speed up the development process), the possibilities for adaptation to interfaces on both the selling and buying sides decrease. This can certainly create economic advantages if the new early stage product happens to fit into these interfaces already. However, the embedding of a new product is seldom a smooth process. Often it needs adaptations in several related resources, and in the new product itself. Hence, an early freezing can also be a drawback if the product cannot immediately contribute to a positive economic result in the resource combinations where it is going to be used.

2.3 The Interaction between Production Facilities and Venture Capital

The producing-using interaction around facilities also create imprints on both the facility and on the resources activated on the producing-using side. Thus, there are both physical and knowledge interfaces between facilities through their input and output. In most industries facilities are heavy economic investments. Almost all technological development processes include the issue of how new solutions can be combined with existing facilities, by finding new ways of utilising them (Håkansson, Waluszewski, 2002).

The issue of how new facilities must fit into an existing technological system is something that any start-up company, whether building its own or utilising external facilities, has to consider. When a venture capital firm engages in the establishment of producing-using interfaces around facilities, both the content and the direction of this interaction process tend be affected. Whether building its own production facility, or buying space in external ones, both the input and the output of the facility have to be “frozen”. Speeding up the process of going from a “hand made” production of prototypes, where input and output can be adapted, to an industrialized process in a large scale facility can have positive effects. However, this can happen only if the new facility, through its input and output, fits into the interfaces they have with other resources. Otherwise, a too fast interlocking of the features of a facility can be a very expensive venture.

2.4 The interaction between Business Relationships and Venture Capital

As a result of all the interaction processes about how to combine products, production facilities and organizational units, exchange over time tends to result in a rather intricate pattern of relationships. Although these relationships include restrictions, they can always be activated in new ways in order to achieve what has been discussed in different interaction processes. Relationships can be used to improve existing resource combinations, but they can also be used politically, to create or block new ways of combining resources (Håkansson, Waluszewski, 2002).

Compared to the established company, in terms of relationships, the resource base of a new start-up can be very thin. Certainly a new start-up can be populated by people who, through their earlier experiences, have relationships to important potential suppliers and customers. These relationships can be important functional or political tools in the new start-up's endeavours to establish its own interfaces with a supplying-using side. Still, these relationships are due to interaction processes concerning *other* products, facilities and organisational units than those of the new start-up. Relationships with a customer side that can take an economic advantage from the solutions supplied by the new start up are yet to come.

Since the venture capital firm is most often involved in several start-ups with similar or complementary activities, it is connecting the resources of the start-up to a larger pattern of resource constellations. The overall goal for the venture capital firm is to maximize the value of the whole portfolio of firms. The venture capital firm will use its relationships to take full economic advantage of all its economic investments. This is not necessarily the way the individual start up would like to use these relationships. Moreover, the way the venture capital firm controls a new start up firm also influences the interface to such outside counterparts as suppliers and customers. Depending on whether or not time is an issue, this will affect relationships with customers and suppliers. Incentives and priorities by the people with a certain time horizon in focus, and being part of the firm, will lead to a certain behaviour in relation to customers.

In the following section we will take a closer look at what happens when the logic of the venture capital firm is brought into a start-up engaged in developing and embedding a new technological solution into supplier-customer interfaces.

3. The Pyrosequencing story – a development journey coloured by the influence of venture capital

Pyrosequencing was founded 6 March 1997 based upon research conducted by a group of researchers headed by Pål Nyrén and Mattias Uhlén at the Royal Institute of Technology in Stockholm. Pyrosequencing's technology is based on short sequencing and detection of single nucleotide polymorphisms (SNPs) – simply put, on analysis of short DNA structures.

From its first days as a company, decades of experiences, both from academic research around the technology and from industrial supply of biotech tools, were embedded into the new company. Through one of the research leaders, the Pyrosequencing technology found its way from KTH to Amersham Biosciences (before 1997 Pharmacia Biotech) one of the world's largest biotech instrument suppliers, in Uppsala. The research leader was on the board of this company, and brought with him the idea of transforming the pyrosequencing technology to a new, complementing product in Amersham Biosciences/Pharmacia Biotech's large instrument supplier portfolio. However, Amersham Biosciences/Pharmacia Biotech never found the project economically promising enough and turned it down. But one of those involved in evaluating the technology, at that time head of explorative research, saw its possibilities. When it became clear that Amersham/Pharmacia Biotech was not interested in investing in the technology he, together with the inventors from KTH, decided to continue on their own. However, capital was needed for a new company to emerge. Along with being on the board of Amersham/Pharmacia Biotech, the research leader from KTH was also on the scientific advisory board for Health Cap, at that time a rather new venture capital firm focusing on the life science/biotech industries. Having invested in just a few firms before, Pyrosequencing became Health Cap´s fourth investment when 17 million SEK was put into the new company in 1997.

3.1 How venture capital influenced the development of Pyrosequencing

The new venture capital firm Health Cap was looking hard to quickly find what is of utmost importance for any such company, especially a new one: a good reference object and an impressive financial track record. Once invested in Pyrosequencing, the venture capital firm and the management started the process of developing "milestones" to be reached within certain time frames.

In order to speed up the development process and get the firm running, the venture capital firm brought in a "serial CEO". This first CEO of Pyrosequencing was a so called venture partner to Health Cap. He had worked as a CEO and as a general manager at several start up firms, and brought with him a "start kit" to get Pyrosequencing up and running quickly. To save time the CEO brought in the same accountants he had used before, the same business reporting system was put into use, the same software company that previously had been used for other companies, etc. Overall, the CEO chosen by the venture capital firm had a strong influence on the development of routines as well as how to relate to other units. In 1998 the CEO was replaced with another CEO, with at background at Pharmacia Biotech and Biacore, another Uppsala based biotech supply company.

Accordingly Pyrosequencing was growing at a very fast pace from its start in 1997. By the end of 2001 Pyrosequencing had almost 200 employees. However, during the fall 2002, the firm started to lay off work force and the number of employees was reduced to 150 in early

2003. The company's head office and production facility was located in Uppsala and a sales office was located in Boston, MA in the US. In Japan and some other countries Pyrosequencing is represented by a distributor. However, keeping such a large number of people on the payroll was costly. Creating sales (building up interfaces to a user side) became of utmost importance. Every month of delay had to be paid for and would affect the future value for the shareholders. Since the Pyrosequencing management also became involved as major shareholders in the company, double incentives to speed up the process were created. Thus, from the day the venture capital firm became involved, Pyrosequencing not only started to grow fast, but it also grew in a certain direction.

3.2 How venture capital influenced the development of the PSQ96 system

In early 2003 there were about 250 Pyrosequencing systems installed in academic and industrial research labs concentrated in a few places in Europe, the US and Japan. The Pyrosequencing product consists of an instrument, a kit of reagents and a software program. The product is developed for analytical issues in so-called applied genetics. This means that the potential users are researchers in academic and other organisations active in such things as drug discovery.

How did the translation of the technology to a product end up as a biotech instrument? The technology could as well have been turned into a diagnostic device, or it could have been used to develop a drug internally within the firm. Since the bulk of the people engaged in transforming the pyrsosequencing technology into a product had their background in one of the world's largest biotech tool companies, Amersham Biosciences/Pharmacia Biotech, with decades of experience in such activities, it was in this area that they were most able to identify possible applications. Morover, Pyrosequencing was located in a geographical area with a heavy tradition of both academic research and industrial activities concerning development of methods and instruments for studying biomolecules. For at least seven decades Uppsala academic researchers and industrial units had developed knowledge and experience in this area (See Waluszewski, 2002, for a more thorough description). For example, when Pyrosequencing was looking for a supplier of a prototype, it found a local company with a long history of developing similar solutions for both biotech and medical equipment companies.

However, it was not only place related features behind the transformation of the new technology to a biotech instrument. This was also a path that appeared attractive to the venture capital firm engaged in Pyrosequencing. Choosing the "biotech tool path" appeared as the fastest and safest way to reach the wanted reference object. First, the people involved in Pyrosequencing had done similar things before. Additionally, it seemed less technically and commercially risky to go for an instrument instead of a method, drug targets or a pharmaceutical product. For example, choosing a tool path instead of a drug discovery direction meant that there was no need to involve regulatory authorities such as the Food and Drug Administration (FDA) in the US. Thus, in the venture capital firms interpretation, the biotech tool path meant that the time from the technology stage to a product ready to launch could be kept as short as possible.

The process of translating the new technology to a product was also permeated by the venture capital firm's formulation of milestones to be reached in a certain time. Or as one of those involved in the development of the product puts it: "Everything was designed to shorten the time to achieve different milestones. Time objectives were of great importance. The quality as well was certainly important, but cost was never an issue".

After three years as a company, Pyrosequencing launched its first product, PSQ96, in 2000. The tough time schedule meant that the product (which can be characterised as a production facility when delivered and used by a customer) was developed rather close to the original idea of how the technology could be used. A main user area was thought to be in drug discovery activities, in the process of identifying target molecules for drug design. The PSQ96 product could facilitate this identification process through a so-called Single Nucleotide Polymorphism (SNP) analysis, in an automated and, for the customer, simplified and safe way. The PSQ96 product consisted of three parts, the instrument, a reagent kit and software . The idea was to use a "razor blade" business model, selling hardware systems that in turn consume reagents, where the profit was going to be made. PSQ96 could read 96 tests simultaneously and manage about 5,000 tests a day. Capacity-wise this would surpass alternative technologies (such as Sanger sequencing). The software program should be able to foresee theoretical results for the analysis, and create a database for the SNP sequences and enable a qualitative assessment of the data collected.

Many, if not all, of the milestones developed around the product were also met. In fact, Pyrosequencing seemed to be able to fulfil most of the goals created by the venture capital firm. CEO Erik Walldén writes in the year end report for 1999, "We met every key milestone set for 1999, culminating in the commercial introduction and first sales of LUC 96 System…"

[5]. With a robust, simple and safe instrument for DNA analysis at hand, both a technological and commercial success appeared to be within reach. The results from the first installations revealed that the users found the product strong and predictable. Once the customers were educated on the instrument, they did not demand a lot of support to interpret the result of the DNA analysis. However, later on these features, which appeared as an advantage in the buying-selling interaction around the product, presented themselves as a drawback in the producing-using interaction around the same item when embedded into the customers' production system.

3.3 How venture capital influenced the development of Pyrosequencing's production facilities

Considering the interaction around the PSQ96 from the users' perspective, a system consisting of a large number of activities is outlined, where the DNA analysis is only the last one in a chain of closely related items. Before being used in the PSQ96 instrument, a choice of which SNPs to analyse must be made. This choice is dependent on the application area and the numbers of SNPs in focus. These can vary from one single SNP to hundreds of SNPs. Second, the organisation must design and develop an assay for each one of the SNPs. This central activity is time consuming and also labour intensive. How labour intensive depends on the analysis system used. The third step involves so called PCR amplification and preparation of the tests. The number of tests per SNP can vary between one and hundreds and the scope of this step also varies among different suppliers' systems. The fourth and last step concerns the DNA analysis, post treatment and evaluation of data. From a user perspective, in order for an SNP analysis to be through and effective as well as time and cost efficient all the different steps must be taken into account. When deciding on what activity to develop in this cycle of activities, Pyrosequencing chose to go for the DNA analysis, partly because this was the activity that was seen as the bottleneck in the process, partly because this made it possible to focus on something manageable for Pyrosequencing. Thus, the firm let the customers manage the rest of the activities themselves. Time-wise this was also a decision that was sound at the time.

For companies supplying other types of solutions for this analysis process the issue addressed itself somewhat differently. For example, Applied Biosystems (ABI) and their TaqMan

[5] After this statement the key milestones are described: Alpha and beta site testing completed, serial production started, commercial availability, sales and support office opened in Boston, USA, sales force established, first order from USA and Europe received, patent portfolio strengthened, private placement raises 120 million SEK (about 13 million EURO).

technology was more complicated to handle than the Pyrosequencing solution when it came to design assays. Therefore, ABI had to be more involved with users than possibly Pyrosequencing had to be, due to a more user-friendly system. ABI was therefore more or less forced to interact with customers concerning how to design assays and what SNPs to analyse[6]. This interaction probably facilitated the development of integrated systems that could deal with all four steps in the analysis of chains of DNA.

For Pyrosequencing, a new, small company struggling to create a stable technological and economic base, this was not an applauded development path. From the venture capital firm's perspective, a rapid increase in the number of installations was preferable compared to an engagement in development of a not yet profitable solution. From the perspective of Pyrosequencing's resource base, particularly in terms of the number of employees with skill to engage in such an endeavour, a concentration on supplying a solution for the final step in DNA analysis also was preferred. However, when other suppliers were able to offer systems integrating the whole process, Pyrosequencing felt forced to engage in similar development activities, and during the fall 2002 a project was initiated to develop a system covering all four steps in the above described analysis chain. In addition, Pyrosequencing started to cooperate with Corbett Robotics that supplies facilities for DNA analysis.

The early outlined route for rapid development and launching of an instrument dedicated to a certain, well-defined production step in DNA analysis also left imprints on the development of Pyrosequencing's production facility. Considerations of how PSQ96 was going to be combined with other instruments or production facilities on the customer side (in which producer-user interfaces was going to be activated), had to be decided in advance. Since a rapid launching of the instrument was such an important issue for the management, to set up its own production unit for the hardware was not a possibility. While the Uppsala based ESSDE was the first supplier used for prototype development, PartnerTech in Åtvidaberg[7] in Southern Sweden later became the main supplier. PartnerTech has made adaptations in its

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[6] Other firms supplying similar solutions are Sequenom and Orchid. Sequenom can be described as a "post genome firm". They sell large instruments that require experts. Orchid has turned out to be more of a service supplier, conducting tests for its customers. ABI is seen as the "giant" within this industry. ABI supplied the important HUGO laboratories with equipment and has a solid reputation.

[7] PartnerTech has roots in Facit, until early 1970s one of the world's largest suppliers of mechanical calculators within the Facit Group, which later went bankrupt in 1972. With the mechanical knowledge as a base, PartnerTech has developed to being one of Sweden's largest supplier to biotech instrument and medical equipment companies, with among others Amersham Biosciences, Biacore and xxx as customers.

production facility to adapt to Pyrosequencing's needs, and has also influenced the design of the product. PartnerTech provides the whole physical production process and stock keeping for Pyrosequencing.

In 2000, the decision to use an external supplier of software had to be reconsidered. The choice of Prevas, a software supplier with a background in ABB, was made in order to speed up the development process, but was regarded as including large restrictions on possible solutions.

A production facility that actually was located in-house was dedicated to the technical and economic "heart" of PSQ96, the reagent kits. It was the customers' use of these reagent kits for specific analysis, combined with a tailor made software programme, which should provide Pyrosequencing with a financial gain. The kits would contain all reagents and nucleotides that would be needed to conduct the analysis. The size of the production for reagents was determined in relation to a sales prognosis that was made in the late 1990s, based on the milestones decided upon jointly by the owners and management. Investments were made in a clean room, a filling line, a refrigerating dryer, chromatography instruments etc. Thus, a significant amount of capital was invested in the reagent kit production facility.

Approximately 250 PSQ96 systems have been sold and installed so far, but sales of the reagents have only been a fraction of what was anticipated. There are at least three reasons, all related to different patterns in buy-sell and producer-user interactions behind this complication. First, those buying PSQ96 are not necessarily the same as those using the instrument, a rather common phenomenon whether the users are in the industrial or academic sphere. Before a new research instrument develops from being "window dressing" in the research lab to becoming a useful production unit, the users have to learn how it can facilitate their production processes. Second, although the buyer of the instrument can find it beneficial to be supplied with reagent kits, this is not necessarily the opinion of the users. A research lab is often populated with laboratory assistants and doctoral students trained and skilled in these kind of activities. Third, while the investment in instruments at many research sites, academic as well as industrial units, can be financed through special economic support, reagent kits are often considered as production costs. These activities are often measured in terms of "cost per sample", taking only the variable cost into consideration While the use of the system might possibly decrease overhead costs, increase space utilisation, increase safety in results, etc these variables are more difficult to highlight. Another reason why less reagents are consumed than anticipated is that customers have several systems that they use. Thus, Pyrosequencing's system is only one of several. In those cases competingsystems where the quality demands are less significant, or when time is a high priority (as preparation of tests take some time with the Pyrosequencing system in its present shape). In addition, the diagnostic market which was considered to become an important future market for the company. This market barely exists today.

3.4 How venture capital influenced the development of Pyrosequencing's relationships

Being populated with people who, to a large extent, had their background at Amersham Biosciences/Pharmacia Biotech meant being supplied with people with many personal relationships to important counterparts on both the supply as well as on the user side. Earlier experiences of interacting with everything from suppliers of mechanical parts to important research institutes and "opinion leaders" who could contribute to the creation of user areas was also activated by the new company. However, how to relate to which counterparts was also an issue influenced by Health Cap.

Along with developing relationships with well renowned opinion leaders who, through their publication in prominent research journals, could contribute to the verification of the new method (of utmost importance to any supplier of research instruments), Pyrosequencing also had to relate to the venture capital firm's relationships. [8] And, for Health Cap it was necessary that the development of Pyrosequencing followed such a path that it could be used as a sign to their clients, the institutional investors, that they soon would be able to put the firm on the stock exchange. In 2000, three years after investing in the company, Health Cap could provide their investors with an "exit" when Pyrosequencing went public. Pyrosequencing received some 1 billion SEK, and the company was offered at a price of 10 EURO in 2000 and reached a share price of 20 EURO during the same year.

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[8] For example, when for example one of Health Cap's other investments, the Uppsala based company Eurona faced financial problems in 1999, the venture capital firm encouraged Pyrosequencing to buy some of this firm's patents. Eurona, founded in 1995 by researchers with a background at Amersham Biosciences/Pharmacia Biotech, i.e. a former colleague to several of Pyrosequencing's personnel, was engaged in complementing activities to Pyrosequencing. The company was engaged in exploiting clinical registers and data sources in Sweden for development of pharmacogenetic and diagnostic tools. Eurona used a self-developed pharmacogenomic modeling system and diagnostic Genetic Signature Assays (GSA) in order model prediction of cardiovascular disease, oncology and central nervous system disorders. When Eurona faced severe economic difficulties, its financers, among others Health Cap, decided to sell the company to a British company, Gemini Genomics. However, before selling out Eurona some of its patents of strategic interest to Pyrsequencing were sold to this company, allowing for future development in the diagnostic field. In 2001 the diagnostic application unit was incorporated in the "core" of Pyrosequencing. Gemini Genomics was later acquired by Sequenom, which can be regarded as a competitor to Pyrosequencing. The payment was done with shares in Sequenom, which means that Health Cap now had interests in both companies.

Being a public company meant that, to some extent, Pyrosequencing had to relate to the quarterly financial reports that had to be delivered to the Stockholm Stock Exchange. "To get instruments out to the customers" became one of the most important key ratios at the end of the quarters, as a interviewee put it. Thus, sales and tech support were encouraged to prioritise the placement of new instruments with customers at the end of the quarters. The ability to report this production of sales to Health Cap and to the stock exchange therefore influenced how Pyrosequencing could relate to its users. Even if this was not happening on a daily basis, the included training of personnel had to be squeezed in directly after a purchase at some occasions as the firm was being forced to rapidly conclude the sales process. This could contradict the objective of creating customers that use the instrument frequently, and then continue to buy the economically important reagent kits. The use of scientific instruments, which requires experience and training, often depends on the availability of people who really know the instrument's capabilities and can train other potential users.

After the first impressive year on the stock market the valuation of Pyrosequencing started to go down in 2001. From a market cap in October 2000 on 5 billion SEK (about 600 million EURO), the value plummeted and in 2002 when the market cap of Pyrosequencing was 250 million SEK (27 million EURO). In fact, the equity of the firm was worth more than the market cap of the company. This development influenced the management to focus more on cost reduction and the staff was reduced by 20 percent. In a press release in October of the same year, Pyrosequencing´s CEO promised that the focus now was to reach "near term profitability", moving away from expansion and growth.

What about the future of Pyrosequencing? Even if the firm still struggles, its technology has gained some acceptance. For being such a young company, providing a new solution, the installed base is rather impressive. Furthermore, the installed instruments will be used for decades to come. Even if the firm does not survive, the technology will be there, managed by Pyrosequencing or by some other firm.

4. Surviving the innovation journey – thanks to or despite the engagement of venture capital?

When following the debate – within the academic as well as the political world – it is easy to gain the impression that without engagement of venture capital in its present form, the major part of all these development journeys would never occur. Without the engagement of venture capital firms, says Gompers and Lerner, 2001, p. 2); "many entrepreneurs would never attract the resources they need to quickly turn their promising idea into a commercial success." But is the combination of innovation-venture capital really an "open sesame" solution for this to occur?

First, as the empirical illustration above has indicated, we have to consider that this form of financial founding is directed to a rather restricted area of business activities. According to Powell et al (2001, p. 7), the venture capital firm's rejection rate is extremely high, about 99 %: "As in many other walks of life, many call but few are answered." But is being rejected by venture capital really the same as being forced to close down the development journey? According to the 250 Swedish start-up companies supplied with venture capital that expressed their view in Nutek's (B 1999:3) study, it is not. About 70 percent claimed there were other financial solutions available.

Second, attracting venture capital is no guarantee of safety for a new project. According to Gompers and Lerner (1999), not more than 2 in 10 venture capital financed projects that survive the development journey. The involvement of venture capital is like being in a boat that demands moving in a certain direction at a certain speed. Or, as stated in Nutek's (B 1999:3) study, without venture capital, these companies "would never have grown at the speed they evidently have done"[9] (Nutek, B 1999:3).

On one hand, when considering the logic of the venture capital firm, the tough time schedule included, the eagerness to clear out uncertainties or "pitfalls", as Gompers and Lerner (2001) puts it, appears as very understandable. The advice presented by venture capital scholars, which also was practised by the venture capital firm in the empirical illustration above, can be characterized as meeting uncertainty by identifying it in advance, or as Wheelwrigth and Clark (1992), put it: learning before doing. A venture capital firm skilled in identifying such uncertainties can, according to Gompers and Lerner (2001, p. 40), "get a better sense of the risks"... "set clear goals and timelines"... "communicate clearly"... "think critically about financial and product market cycles", contributing to a shorter and safer way to commercial success.

This linear or rationalist inspired approach (Ansoff, 1965, Tidd et al, 1997) is almost opposite to the way of handling the complexity involved in commercialisation of new solutions suggested by scholars engaged in studying technological development from an interactive perspective. The understanding that our ability both to comprehend the complexity of the present and the uncertainty of the future is limited (Tidd et al, p. 60), undermines any

[9] Author's translation

ambition to create certainty and control over the innovation journey. Practicing strategic planning under such conditions must, according to van de Ven et al (1999), allow for a continuous listening to the "flow", and thus build on a "sharing, pluralistic and objective" leadership.

However, if, in the academic world, it is possible to cope with such completely divergent approaches on dealing with a certain empirical phenomenon, the issue is, as the Pyrosequencing story reveals, a bit more intricate in the industrial world. Being a venture capital financed company means being forced to cope both the linear and non-linear features of business life. In order to have any chance to "go with the flow", or to handle the complications revealed when a new solution is embedded in directly or indirectly related resource interfaces, any new start-up (or established firm engaged in technological and commercial development) has to create a certain space for redirection. On the other hand, in order to have any chance to finance the development journey, the venture capital financed start-up is forced to cope with a rather detailed planning of how to act during the coming days, months and years of its business life. Thus, the for the individual company, the alternatives "to go with the flow" or to "set clear goals and timelines" do not exist – it has to relate to both. Furthermore, the more the company transforms from an idea stage to a materialised structure, the heavier the resource base and the more difficult it is to redirect. On the other hand, the heavier the resource base, the greater the ability to utilise this variety in new combinations possible to be embed in the user's technological and economic logic. Thus, for the individual firm, a certain linearity is necessary – at the same time a certain non-linearity has to be accepted.

Concluding with the questions asked in the introduction: In what situations can speed, including its on going demand for solutions identified at an early stage of the development journey, have positive or negative effects on the creation of economic value? Certainly the answer depends on the chosen perspective. From the logic of the venture capital firm, it seems clear that a quick exit is favourable given the existing legal structure and financial logic. Thus, from the venture capital firm's perspective, the rapid establishment of a company and the launching of an attention- creating product appear to be of utmost importance. For the start-up's long term survival, such a rapid development journey can be successful as well – if the company is lucky enough to find solutions that immediately fit the user's activity system. However, if the first development path appears insufficient and needs to be redirected, a speedy process can be directly detrimental. And, as the empirical illustration reminds us, to embed a new technological solution into a structure on both a supplier and user side is seldom a quick fix. Thus, a financial, technological and industrial logic is rarely a perfect match. To combine these logics, creating interfaces that in different ways can create a positive value for those involved, seems to be an issue demanding meeting and adapting several interfaces on both sides.

From society's perspective one can ask whether those projects that manage to attract venture capital are those best able to be transformed into companies with long term economic sustainability – or just the projects that seem to be most suited for the creation of a rapid exit. Second, one can ask if those who fail the development journey financed by venture capital in its present form (80%), are those whose solutions in the long run cannot contribute to a positive economic value – or if those who fail do so because their embedding processes do not fit into the logic of the venture capital firm?

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