Innovation forecast: un-avoidable *and* context dependent

Alexandra Waluszewski
Uppsala University

Malena Ingemansson
Uppsala University

Håkan Håkansson
BI Norwegian Business School

This is the authors' accepted and refereed manuscript to the article published in

***Industrial Marketing Management,* 43(2014)6:1045-1052**

DOI: 10.1016/j.indmarman.2014.05.017

Publisher's version available at http://dx.doi.org/10.1016/j.indmarman.2014.05.017

Alexandra Waluszewski[1]

Malena Ingemansson[2]

Håkan Håkansson[3]

Abstract

Given an interdependent business landscape, there are at least two major context related aspects that intervenes in the innovation forecast. First, the actor that makes the forecast is embedded into a specific context. Secondly, the potential innovation is probably stemming from a specific environment, and will during the innovation journey be related to other environments in a producing and using setting, and other investments in place. In this paper we examine an innovation forecasts made by three different economic actors, including how the context is assumed to influence the ability to transform a scientific discovery to a successful innovation. The empirical findings suggest that the promises of the innovation forecast is dependent on what abstraction of the business landscape, at what level, that the forecasting actors explicitly or implicitly is utilizing

Key words: Innovation, forecast, context

1. Introduction: Forecasts as a context dependent phenomena

In the late 1990s a radically new way of carrying out DNA sequencing was presented in an article in *Science*.[4] In the wake of the HUGO era, both the researchers behind the method and

[1] Corresponding author. Adress: Uppsala University's Center for Science & Technology Studies (STS), Box 513, 751 20 Uppsala, Sweden. Email: alexandra.waluszewski@sts.uu.se

[2] Adress: Uppsala University's Center for Science & Technology Studies (STS), Box 513, 751 20 Uppsala, Sweden

[3] Adress: Norwegian Business School, BI, Department of Innovation and Economic Organisation, 0442 Oslo, Norway.

[4] ***Science*** 17 July 1998, Vol. 281. no. 5375, pp. 363 – 365, 'DNA SEQUENCING: A Sequencing Method Based on Real-Time Pyrophosphate', by Mostafa Ronaghi, Mathias Uhlén and Pål Nyrén.

a number of economic actors were considering the possibility to turn the invention into an innovation which could contribute with scientific, technological and economic benefits. At least one thing stood clear in beforehand: to transform a theoretically described method to a user friendly commercial analytical instrument should be a rather costly process.

Thus, what all of these economic actors experienced, was the need to make forecasts. The uncertain but necessary future earnings had to be forecasted and compared with immediate and future costs. However, to make reliable innovation forecasts; covering the final outcome in terms of both costs and benefits, is a recognized challenge. For example, metaphors as "the innovation journey" and "moving in a rugged landscape" has been used as illustrations of all the in beforehand hidden "hills", "curves" and unexpected events that an any invention has to pass before eventually becoming a widespread innovation. (van de Ven et al, 1999, Håkansson et al, 2009) Hence, to make innovation forecast is both necessary – and difficult.

The aim of this paper is to shed light over the phenomena of innovation forecast in an interdependent business landscape; i.e. characterised by exchange of resources which are economically heterogeneous and which value are dependent on how they are combined across organisational borders. (Håkansson et al, 2009) Based on this presupposition, our research proposition is that forecasting is a context dependent phenomena. The overall research question concerns the relation among the context logic the forecast explicitly or implicitly is resting on and the estimations made.

If we accept that the innovation journey is context dependent, there are at least two major context related aspects that intervenes in the forecasting process. First, the actor that makes the forecast is embedded into a specific context – which affects the forecasting. The forecasting actor probably have specific relations to some counterparts, where resource investments have been made, which will affect the expected role of the innovation. Secondly, the invention is probably stemming from a specific environment and will during the innovation journey be related to other environments, where the actors making the forecast might have a role – but also other actors, representing other relations and investments in place. (Håkansson et al, 2009, Tidd & Bessant, 2013, van de Ven et a, 1999)

In order to shed light over the research question, we will utilize an empirical investigation concerning the forecasts made by three different economic actors. What these actors have in common is that they are all engaged in making forecasts concerning the opportunity to invest

the transformation of a research discovery to an innovation, including estimating the impact of the context were it is assumed to be commercially utilized in. Based on the recognition that the discovery corresponded to an important societal and economic need; to carry out fast and accurate DNA analysis, two of the economic actors; a venture capital firm and a governmental policy agency, forecasted a very successful outcome. A third economic actor – a process equipment company – was however a bit more sceptical. In the following sections we will take a closer look at on what logic each forecast was made, i.e. what aspects of the context each forecast was resting on. We will also consider what aspects of the context that actually intervened in the trials to transform the new solution to a successful innovation.

The paper is organized as follows: In section 2 the need for making forecasts is discussed, and the research design is presented. In section 3 the innovation and the innovation process in focus is presented. In section 4 the different types of forecasts used by three actors described and analysed. And in chapter 5, finally, the role and function of economic forecasts are discussed.

2. The need for forecasts

Any representative for a private, public or business economy is more or less forced to make forecasts as soon as any decision concerning economic investments has been made; i.e. where there are substantial costs before earnings. A forecast is always as guess about a future state – but in order to make decisions economic actors have to live with this guessing. Taking a private loan for a house or a company loan for a facility – both types of decisions is based on some type of predictions of future events and consequences; i.e. that there are some obvious connections between the present acting and future outcome. Thus, everyday economic actors have to make decisions that are based on more or less explicit forecasts. This is especially the case in innovation attempts; for example as when a larger investment is considered, with the attempt to transform a new idea into a new product and service. When forecasting, for example the sales of a yet not launched product, the expected future will be grounded on a mix of present facts combined with a view of expected future changes.

If, as assumed above, innovation forecast is a context dependent phenomenon, then both the context of the forecasting actor and of the invention/innovation have to be taken into consideration. Every economic actor making a forecast is doing it in a certain context. The actor has usually a certain specific role in relation to the forecasted item and also a set of

specific counterparts. The reasons for doing the forecast are related to this context and so is also the role of the forecast. But this is not the only context that is of importance. The context of the invention/innovation is also important. What kind of industrial structure is the potential innovation expected to be a part of? When doing the forecast the actor must have a view of how this context will look like. Together, it means that these two types of contexts will affect both the way the forecast is done as well as which facts that will be focused. A forecast is in this way never neutral and objective – instead it is a product of the characteristics of the forecasting process. It will be influenced by the context of the actor which will influence the role and function of the forecast and furthermore by the assumed context of the future innovation which will affect the interpretation (consciously or unconsciously) of the history and the present. (Håkansson et al 2009, Tidd & Bessant, 2013)

Given an interdependent business landscape, any forecast will be affected by both these types of contexts and also if they are related in any way. Still, the need for innovation forecast is unavoidable. The three economic actors and their innovation forecasts we will consider all have to take the decision if they are going to invest in an innovation process long before there exist any defined product or any defined used of a product. The forecasts that the actors are making have to be built on some kind of expectation thinking – how the future will be created out of existing circumstances that in turn have more or less of historical roots. In this situation they have all applied, more or less consciously, rather different kind of forecast logics.

2.1 Research design

In order to identify and characterize different forecasts, we will utilise a larger empirical study on the relation among scientific research results and industrial renewal in the life science setting, which started in 2001 and is still on-going. The point of departure was an investigation of the development paths behind the life science companies located to the Uppsala region in Sweden, were the main historical and contemporary resources interfaces of 25 companies, including how these were activated in supplying and a using setting, were investigated.[5] (Waluszewski, 2004)

[5] This meant that the study included all companies in the region which had developed so far that they had a product/service under development, including emerging interfaces with a supplying and user setting. This main part of the study was complemented by an investigation of the policy view on the emergence of this industry. The identified companies were investigated in 2001, 2003 and 2004. A bout hundred personal interviews concerning each company's direct and indirect resources interfaces was carried out. During 2011 the investigation was complemented by collection of secondary data concerning each company's present stage.

One of the development paths mapped in the overall project became the object for three related, detailed studies. This specific development path concerned an attempt to commercialize a new gene mapping method, considered as a significant scientific break-through. A first special study focused on the influence of venture capital in this process. The research question concerned how the venture capital firm's view on the relation among research results and commercialization intervened in the creation of a physical product and in the embedding of this in a supplying and using setting. (Waluszewski & Wedin, 2003, Strömsten & Waluszewski, 2011).

The second, and the most encompassing investigation of this specific development path was undertaken in a PhD study made by one of the authors of this paper, on how the future benefits of the new gene mapping method were considered in three different settings; an academic research setting, a venture cap financed producing setting and a user setting consisting of private companies and public health care organisations. (Ingemansson, 2010, Ingemansson, Waluszewski, 2009) The main research question concerned how the future economic benefits of the new gene mapping method was considered in each setting – and how these were empirically outlined when the method was embedded in each of them. The third study was a complementary investigation of how the future benefits of the gene mapping method in a commercial setting was interpreted by Sweden's Innovation Agency 'Vinnova', which also was one of the financiers' of this process. (Waluszewski, 2011)

We will utilize the empirical data collected in these three studies in order to illustrate how the gene mapping method as a commercial product appears, given the way the forecasting is done. We will illustrate how the forecasting made by three specific actor and related analysis are based on different logics and context related factors. The first analysed actor situation appear when the gene mapping method for the first time is exposed to a forecast in terms of the ability to transform it to a commercial product. The expectations of the actors behind the commercialization attempt is that the future of a product based on the gene mapping method will appear bright enough for one of the world's largest supplier of biotech analytical equipment, Pharmacia Biotech (later merged with Amersham Biosciences, today GE Healthcare), to engage in the commercialization process. It is this actor's use of forecasts that is in the centre of the first analysis.

The second and third analysed actors' uses of forecasts are identified when the gene mapping method is exposed to a venture capital firm's attempt to commercialize it. The second analysed forecast is the one made by the venture capital firm, which makes it to invest in a start-up company based on the gene-mapping method. The venture capital finances firm is also applying for innovation support from a governmental policy agency. The forecast made by the governmental policy results in financial support for the commercialization process, and this third one analysed.

Before we will present how these situations appears, we will make a brief overview of the gene-mapping innovation journey.

3. Pyrosequenceing – can a new way of mapping short DNA strings be transformed to successful biotech innovation?

> 'It is realistic that already within one or two years after the project is concluded commercial products will be available on the market.' [6]

The forecast quoted above was made in an application presented to the Swedish industrial policy agency Nutek in 1998.[7] The application concerned a co-operation between a newly established start-up company and an academic research unit that had provided the company with its basic technology; a new gene mapping method, for analysing short DNA strings. The application seemed to be in line with the aim of the policy agency's biomedicine program, which was to strengthen 'the development of networks among biotech science and business', to increase the 'quality in business' and to stimulate 'a more rapid commercial utilization of science based knowledge'.[8]

The project was managed by a venture capital financed start-up company named Pyrosequencing, which also was the name of the gene mapping method it was about to commercialize. The other main participant was the academic research leader behind the invention of the pyrosequencing method, who also represented one of Sweden's most recognized scientific research units within the biotech area; the Department of Biochemistry

[6] Final version of the Pyrosequencing application, 1998-06-18.

[7] Today the Swedish Agency for Economic and Regional Growth.

[8] Nutek annual report 1998.

at the Royal Institute of Technology in Stockholm (KTH).[9] The idea was that the Pyrosequencing company should 'develop and market' an automatized product system based on the method, as well as the reagents necessary for 'reading' short DNA strings. In the wake of the HUGO[10] era the expectations on an increased use of DNA analysis were high, or as expressed in the application to Nutek, an expansion was assumed both within 'today's research market and tomorrow's diagnostic market'.

The pyrosequencing method that had been developed by the researchers at KTH represented a radically new way of 'reading' the DNA code. The established Sanger method[11] was a Nobel prize rewarded investigation method based on electrophoresis. Through the Sanger method, which was utilized in the HUGO project, it was possible to read longer DNA strings. However, the method was partly manual and demanded a skilled user, and was thus considered to have a low productivity. The pyrosequencing method was based on a different technology; it was built on a four enzyme system that reconstructed the DNA string when separate DNA components were added, a process which in turn created a by-product that transformed into a detectible light signal indicating the sequence. While DNA sequencing with the Sanger method took about three days to perform, with the Pyrosequencing method this could be done within a few hours.

At the time when the Pyrosequencing company applied for policy support, the new DNA sequencing method was already acknowledged as a radical breakthrough within science; it had among others been rewarded with an article in *Science*, one of the most prestigious scientific journals.[12] The scientific breakthrough made the pyrosequencing method a valuable resource in the scientific setting; a substantial number of acknowledged new scientific publications were based on it as well as a number of PhD theses, funding was attracted through it, and the research group was enlarged and strengthened. The commercial challenge

[9] Two other small Uppsala based biotech companies had a minor part in the project, Eurona Medical AB and Professional Genetics Laboratory AB.

[10] This was a US governmental project that set out to read the entire human genome. It was instigated in 1990 and considered finished in 2003.

[11] To be added: back ground information on Sanger.

[12] ***Science*** 17 July 1998, Vol. 281. no. 5375, pp. 363 – 365, 'DNA SEQUENCING: A Sequencing Method Based on Real-Time Pyrophosphate', by Mostafa Ronaghi, Mathias Uhlén and Pål Nyrén.

was to embed the new method in an automated, accurate and user friendly product system; an instrument and reagents.

3.1 A scientific breakthrough of with future commercial benefits?

Already before a venture capital financed start-up company was established based on the pyrosequencing method, it had attracted commercial interest. One of the research leaders engaged in the development of the pyrosequencing method at KTH was also engaged as scientific advisor on the board of one of the world's largest producers of biotech instruments and systems, the Uppsala based company Pharmacia Biotech. The discussions in the board resulted in the initiating of a collaboration among researchers at KTH and a specific group at Pharmacia Biotech dedicated to investigations of new, potential technologies, the Exploratory Research Department. While the academic researchers contributed with knowledge about the new enzyme-based DNA sequencing method, the role of the Pharmacia Biotech's Exploratory Research Department was to contribute with insights into how the method could be automated, especially how a flow system could be designed, and furthermore, to consider possible user applications. The participants' expectations on the new method were high, and both the researchers in the academic and the business setting were interested in forming a joint venture to commercialize it.

However, at about the same time as the participants from KTH got their scientific breakthrough published in *Science*, the management of Pharmacia Biotech decided that the company should withdraw from the joint project. The official explanation was an on-going merger with another large supplier of biotech analytical instruments, Amersham International, and that a development project based on the pyrosequencing method did not fit into the strategy of the new constellation Amersham Pharmacia Biotech.

However, this was not the only reason for an abandonment of the Pyrosequencing project. There were also managers within Pharmacia Biotech who considered the applications of the new DNA sequencing method to be far too specific and scattered to ever carry the costs of large scale production, marketing and application development.

The manager of Pharmacia Biotech's Exploratory Research Department and the research leaders at KTH, however, made another interpretation. The rough estimation was that the market for instruments and reagents for DNA analysis reached more than €300 million in mid 1990s, and that a third of this market concerned the reading of short DNA strings. It was also

estimated that this market, which was dominated by academic users, should be more 'balanced' already within a decade, in terms of a growing diagnostic market within life science companies and health care organizations. This view was also shared by a Swedish venture capital firm, Health Cap, specialized in the life science area. In Health Caps' opinion, there had been very little progress within the DNA sequencing area since the 1970s when the Sanger DNA sequencing method was introduced. Combined with the increased interest in DNA sequencing that the HUGO project had created, the venture capitalists' interpretation was that there existed a 'great, potential unmet need' for a more rapid and automated sequencing method. The pyrosequencing method was seen as a unique opportunity to produce and market an instrument that corresponded to that demand. From this vision, the company Pyrosequencing was founded in 1997 with full financial support for the next seven years and with the Pyrosequencing patents as its technological base.

3.2 Pyrosequencing becomes a venture capital and policy supported innovation journey

The Swedish policy agency Nutek made the same interpretation as the venture capitalist, and reacted with a positive response on the application for support to the co-operation between the Pyrosequencing company and the researchers at KTH. In September 1998 a project with the title 'Development and marketing of new DNA sequencing technology with application within science and routine diagnostics' was granted with approximately €200, 000. This was 48% of the total project cost. The motivation behind the decision, which followed Nutek's traditional evaluation criteria, was following: [13]

- *Relevance*: The project fulfils the general requirements of Nutek'sBiomedical program.
- *Environmental aspects:* A faster and simpler DNA sequencing is considered as having a positive environmental effect. The project also provides a more rapid and secure diagnostic opportunity for several severe diseases at a lesser cost than available techniques.
- *Cooperation/Financing:* The project consists of a functioning, integrated project group with participants from industry and academics. The participating researchers at KTH are internationally recognized and the company's work is built on their participation and transfer of knowledge.

[13] Nutek protocol 1998-09-29, nr 1N19-98-03316

- *News value:* Great. The new technology has the possibility of going from research to routine with increased security and capacity in the DNA sequencing area.
- *The quality of the research/project group:* Very high. All members are acknowledged internationally and have shown high competence in earlier development projects. Within a short time (about 2 years) the group succeeded in developing two generations of a functional system.
- *Ability to realize the project.* Good. Experienced senior researchers are tutoring doctoral students participating in the project. The project management is convincing and based on genuine experience.
- *Anchoring:* A personal meeting between representatives from Nutek and Pyrosequencing revealed that the project is accepted and prioritized by all participating members. It is also of great importance for the company's further development.

3.3 A new product launched and a new company on the stock market

In the application to the Swedish policy agency the Pyrosequencing company had made the brave estimation that a product would be launched within one or two years after the project was concluded. This was actually delivered with a good margin; the policy supported project should be concluded in 2000, but already in 1999 Pyrosequencing could launch the first product system, the so called PSQ96.

In 2000 Pyrosequencing was introduced on the stock market and valued at about€400 million. In terms of the company's own interpretation, it had managed to transform a scientific breakthrough into a successful business venture:

> 'With only 85 million SKr [around €8.5 million] invested in development costs we have transformed an idea into a globally commercial product' [14]

When Pyrosequencing delivered the final project report to Nutek the same year, the conclusion was that the project had 'reached the goals', that the 'produced results in line with

[14] Pyrosequencing Annual Report 2000, p.3.

what was expected' and that it had 'strengthened the participating business partners' national and international competitiveness'. The understanding that Pyroseqencing was an innovative, commercial success was also shared by external evaluators. The RoyalSwedishAcademy of Engineering Sciences (IVA) named Pyrosequencing as the 'start-up company of the year' in 2001, with the following motivation:

> 'Pyrosequencing has developed an exciting business opportunity from a research environment to a stock market introduced company with a focus on innovation'.

The same year Pyrosequencing was also recognized by Forbe's, which listed it as the 'best newcomer'.

3.4 A remarkable technology with lack of users

However, a bit more than a year after Pyrosequencing's successful epithet it became obvious that the expected 'market expansion' was not realized. Instead of selling the estimated several hundred instruments per year, Pyrosequencing managed to 'place out' about 50 per year, and not all instruments were paid for. Second, the main users were not, as expected initially, life science companies with regular and large scale DNA sequencing activities, but academic or non-profit research units with short term, project based DNA sequencing activities. Third, this meant that it was not only the sale of instruments that was dramatically lower than initially calculated but also the frequency of use of the instruments. This caused even greater problems, since the main income was not planned to be based on sales of instruments, but on a continuous purchase of consumables (the reagent kit). Thus, instead of 'black figures' Pyrosequencing had to report a loss of over €30 million per year. And when Pyrosequencing could not live up to the stock exchange's expectations on increased sales and subsequent increased value of the company, the valuation of the company fell. Just 18 months after its stock introduction the estimate had decreased to a tenth of the original valuation.

3.5 A merger

The difficulties of creating a 'substantial market' led the venture capital firm Health Cap to merge Pyrosequencing in 2002 with another company in its portfolio. The merger was with another Uppsala based biotech instrument company, Personal Chemistry, which was not yet introduced on the stock market. Shortly after this initial merger another acquisition followed. This time an American company, Biotage LCC, became the owner of the two Uppsala based

biotech instrument companies. This also became the new name of the whole company, which mainly was engaged in the production of chromatography equipment.[15]Pyrosequencing was of great importance in this process of mergers and acquisitions. However, this was not due to its technological base, which did not get much attention in the new company constellation.

Instead it was the approximately €10 billion which Pyrosequencing earned in the stock market introduction which made it an invaluable asset. All of this was spent on acquisitions; during the first decade of the 2000s more acquisitions followed, all of them exclusively compatible with the Biotage main technological areas, chromatography.[16] Meanwhile, the work with the pyrosequencing product system and applications was done with the left hand. Thus, the pyrosequencing method which had been the sole technology and focus within the Pyrosequencing company, was more or less put on the shelf, to the benefit of the chromatography technologies represented by the new American owner. This made Pyrosequencing a small, un-prioritized product group within the Biotage business constellation and the sales more or less faded away.

However, this did not mean that all of the commercial use of the pyrosequencing technology also faded away. After the merger a start-up company named 454 Life Sciences[17] showed an interest in the Pyrosequencing technology. The plan at 454 Life Sciences was to put together a 'high throughput sequencing system' with the goal of enabling cheap whole genome sequencing. The idea was to create an automated system for massive DNA sequencing in parallel, thus making whole genome sequencing both faster and less expensive. In this system the pyrosequencing technology was regarded as a valuable component if the read length, along with other features, could be further developed. After a couple of years of development work, the first 454 Life Sciences' instrument based on the Pyrosequencing technology was sold in 2005. Since 2008 the production, marketing and development of user applications of the 454 Life Sciences' instrument takes place as a subsidiary within one of the world's

[15] A technology used for protein purification, i.e. a completely different basic technology compared to the Pyrosequencing method concerning reading of DNA strings.

[16]In late 2008 the division Biosystems was acquired by the German company Qiagen, which is a global provider of sample and assay technologies. One such acquisition was Argonaute which produces consumables for chromatographic equipment.

[17] 454 Sequencing had spun off from American CuraGen, a midsized biopharmaceutical company formed during the beginning of the HUGO-project focusing on identifying disease-causing genes.

leading pharmaceutical and diagnostics companies, the Swiss based multinational Hoffmann-La Roche Ltd.

To summarize, although several of the actors involved in the development of the pyrosequencing method in turning it into a commercial product system ascribed it great benefits, and although there were users who shared this view, the invention never became the successful, wide-spread innovation that initially was forecasted. If the commercialization of the pyrosequencing technology ever takes off and reaches a widespread use through being embedded into 454 Life Sciences' instrument, it will be as an anonymous component in a larger system solution.

4. One invention – two types of innovation forecasts

As reflected in the case above, the individuals engaged in the pyrosequencing innovation journey were to a large extent believing in a successful outcome. They were building their continuous and energetic activities on hope, based the ability of the analytical instrument.

However, three of the involved actors in this innovation process had to make some more or less explicit forecasts. This was the biotech equipment company Pharmacia Biotech, the venture capital firm Health Cap, and the governmental agency Nutek. All these three actors became involved in the innovation journey – and if they would go in, making any investments in relation to it, they also had to carry out some type of forecast to base the decision on; to invest or to not invest. Hence, all three actors were offered an opportunity and they had to assess this from an economic point of view. Two of them had to do it because they were companies with explicit economic goals and one because it had to follow governmental regulations. If the three actors had the need to make forecasts in common; and this is also at about the same time in the innovation process, they made this from the perspective of rather different contexts. They represented different investments in place and different roles in the innovation journey. Furthermore, they were also different in terms of how they regarded the context of the potential innovation. Let us now have a closer look at each of them and their respective forecast.

Pharmacia Biotech's forecast

When the pyrosequencing method entered Pharmacia Biotech as an exploratory commercial endeavour, this company was one of the world's largest suppliers of biotech equipment, from

laboratory instruments over to large scale facility equipment. This means that the company had extensive experience and knowledge of both the producing and using side of this type of equipment. Pharmacia Biotech was since decades a part of a wide-ranging network of direct related suppliers and sub-suppliers, of complementary suppliers and competitors, of customers engaged in academic research and industrial R&D and of customers engaged in large scale biotech based pharmaceuticals.

Pharmacia Biotech's exploratory department was a small internal unit that through a rather informal decision making could engage in the the pyrosequencing method. The idea behind the exploratory departments was that it should carry out initial tests of ideas under development, and identify those with commercial potential down the line after initial testing and prototype development. As such this was a test laboratory detached from the company's other activities, such as production, purchasing, marketing and after-sale support. The structure which the pyrosequencing method would have needed to become a part of, if deemed suitable for commercialisation, was on the other hand an established inter-organisational network of various suppliers and academic and company customers, each representing a particular set of investments in place. Any adaptation of the pyrosequencing method in relation to these investments, or the established network, would mean costs which the sales of the future product would have to be able to carry.

This means that when evaluating commercialisation of the new method Pharmacia Biotech had to consider:

1) *The suppliers*: Would the existing suppliers cover the needs for component and system solution necessary for taking up the pyrosequencing method in production, and if so, how? Or would there have to be additional suppliers brought in?

2) *The customers*: Would the existing customer base also want to purchase the new product, and if so which customers; business or academic, research or large scale producers, and in what volume? Or would new customers need to be identified?

3) *The internal production*: Would Pharmacia Biotech's internal facilities be able to support the new product and if so, how? Or would there have to be changes to the existing production process? In addition, the on-going merger with another world-leading company within biotech tooling, Amersham International, meant that the Pharmacia

evaluation needed to take this merging company's internal and external industrial structure into consideration as well.

The merging of two such extensive supply and customer structures most certainly complicated the situation of actually trying to forecast what investments in the development, production and customer support in relation to a new product based on the pyrosequencing method would mean economically, except for the certainty that it would be a costly journey. After all, in order for the new product to be able to carry its costs it needed to fit into a large-scale production system where the customers, or the using system, would have to correspond to that type of production of this particular type of product. This would require investments both in regard to the internal and external structure connected to the production and sales functions of the company.

Pharmacia Biotech ultimately decided to shut down the project around the new method right as a prototype was starting to take shape. It was needless to take it any further as there did not seem to be any room for such a product in the new company constellation, mostly due to the type of use which it was forecasted to induce; low-scale and highly specific for different types of users, probably most in an academic research setting. Firstly, this was not considered as the type of heavy user setting that an economic adventure such as developing and launching a new product based on a totally new analysing methodology required. Secondly, such an innovation journey did not fit into the current activities related to development, production and user support taking place within the company and its network. And thirdly, it did definitely not fit into the on-going endeavours to merge Pharmacia Biotech with Amersham Biosciences.

The forecast that must be done by an economic actor such as Pharmacia Biotech has to include considerations of how the future context in which the new product needs to fit is related to the own context. Pharmacia Biotech was very much aware of the context expressed in terms of considerations of how a new, pyrosequencing analytical product could function within an already existing production system in a user setting, and in terms of awareness of what elements of that structure that needed to change in order for the new to fit in and create future earnings. Furthermore, the context awareness was expressed in attention to how the new should fit into existing supplier and sub-supplier relationships as well as into the own production structure. In other words, it was the surrounding context of Pharmacia Biotech

(and Amersham Biosciences), which ultimately decided the forecast of whether the new method would be a profitable investment or not.

Let us now move on to consider what type of evaluation that was made by a very different type of actor; namely the venture capital firm.

Health Cap's forecast

Health Cap is the name of a number of funds administered by the firm Odlander, Fredriksson & Co. When this firm was formed in 1996 it became the first Swedish advisory firm for investment funds restricted to the life science area. Presently Health Cap is the largest provider of venture capital within the life sciences in the Nordic countries and one of the largest in Europe. It functions as a consultant for the Health Cap funds, which in turn work as limited partnerships and have diverse large financial actors as owners, such as the National Swedish Pension Funds, large insurance companies and banks.

Committing to support a company formed around the pyrosequencing method would mean that this venture capital firm would act a mediator between the new company and the various investors which had invested in the Health Cap funds. As such its role would be to make sure that these investors got their expected return on investment, which meant creating a suitable "exit" out of the investment that could generate the needed capital within a certain time frame, usually done through a trade sale or a public offering within three to seven years. Thus, in order for the new investment to carry its costs for this firm it needed to be an attractive investment for another company or for floatation on the stock market. Pyrosequencing would then be just one out of a dozen other investments which this firm had in its portfolio and managed at the time, and it was really the total value of this portfolio which was key for the firm's, and its investors', economic situation.

The venture capital firm's most central relationships were those with its investors and its portfolio companies. The relationships with the investors provided the capital needed to create possible profits and the portfolio companies, all in which the firm had more or less central board and management positions, represented investments opportunities to create such profits. This means that when making an evaluation of commercialisation of the new method it was mainly a set of investors, with capital generation as their primary goal, and a variety of other companies, which the venture capital firm managed as an investment portfolio, which was taken into consideration. There was no existing own supply or customer network that the new

product would need to fit into, everything needed for producing and selling the new product would be built up around the new method and its technical qualities. The evaluation that was made stated that the Sanger method was outdated and that users were in need of a more efficient method that was user-friendlier. As such the new method was thought to have no relation to any existing product on the market, nor any existing production or using system that needed to be taken into consideration.

Once this evaluation was made and the investment decision was that the firm would support a start-up company around the new method for the next seven years another early decision was that the product be standardised and locked to as few applications as possible. These decisions reflect a view of users as moving freely on a "market" in which purchasing decisions are made from the standpoint of what is the most effective solution at each given moment. It does not reflect the image of users being tied to earlier investments or relationships, or having different types of needs. The evaluation was based on there being a potential market for these kinds of instruments once the HUGO projects was finished, and the possibility of obtaining a "share" of that market.

Again the forecast can very much be explained by the context this actor is acting within. That context is very much a financial one and not as in the Pharmacia Biotech case dominated by the industrial structure related to the innovation. The question is more if the investments is fitting into the total structure of investments by the VC-firm. In this case the actor has to make a very simplified forecast for the future context of the innovation dominated by a comparison of the new product with existing ones.

Finally, let's consider the evaluation of yet another type of actor; a public funded policy unit.

Nutek's forecast

Nutek was a Swedish governmental unit formed in 1991 with the role of supporting the growth of trade and industry, later divided into Vinnova; Sweden's Innovation Agency, and the Swedish Agency for Economic and Regional Growth. In today's terms it was an innovation policy actor, with the possibility to support new ventures and commercialisation projects in accordance with specific requirements which the ventures needed to fulfil. This means that the role of this actor was to identify development projects which needed financial support for a limited time period. In addition, as the application for financial support for commercialising the pyrosequencing method came to Nutek they were part of a biomedicine

program with the aim of strengthening ‘the development of networks among biotech science and business’, to increase the ‘quality in business’ and to stimulate ‘a more rapid commercial utilization of science based knowledge’. Also, support should especially be directed to research areas characterised by ’scientific strength’.

The evaluation criteria to which this unit needed to relate its “investments” were clearly stated and to take some examples it was about the ‘relevance’ of the project, its ‘news value’ and ‘the quality of the research/project group’. The relevance had to do with how well the project, in this case the pyrosequencing method, strengthened the networks among scientists and business and presented good opportunities of commercial utilisation. This was a well description of the new method as this was exactly what it was doing; there was great interest from both scientists and business people which created connections between them, and there were plans of how to make it into a user-friendly commercial instrument. The project, or the new method, also represented “strong” science as there was a good scientific foundation of publications and researchers on which the method was based. There was also no question that the news value of the method was great, as it was about a new scientific breakthrough which also indicated good quality of the research group, but who other than scientists and investors that would value this type of news was not considered. And therefore, the decision was to financially support the new method, as it fit into the evaluation criteria so perfectly.

Again the context of the actor is very much influencing the way the forecast is done and which the selected factors are. For this actor the quality or use of the new product was evaluated according to criteria that were based on the idea that as long as the new project showed good scientific quality and involved experienced and devoted business people, users would appear and chose this product over other established ones. Just as in the case of the venture capitalist this indicates a view of products existing on a “free market” where earlier investments and relationships are of little importance. The forecast was based on there being a market waiting to react to new offers and where more efficient or cheaper solutions would be chosen over others. The context of the innovation was in this way, as in the venture capital case, simplified to a broad comparison between the characteristics of the new product in relation to existing ones.

5. The innovation journey forecasted from two different perspectives, the context based respectively the market based.

An innovation forecast is affected by the context of the actors doing the forecast. This is at least what the empirical study presented above suggests. Hence, the above presented research proposition can be expressed in terms of a more precise statement: The forecast is dependent on what abstraction of the business landscape, at what level, that the forecasting actors explicitly or implicitly is utilizing. Below we will take a look at the latter statement more in detail.

If the economic actor is close to the context of the innovation, i.e. already related to this producing and using environment, the forecast will concern how this context will be affected by the innovation. (Håkansson & Waluszewski, 2007, Utterback & Abernathy, 1975) The point of departure will very much be the investments in place. I.e. the innovation is assumed to be affected by a context full of material and immaterial investments which are related – across company borders, and were the new has to contribute with positive economic effects in order to be embedded. Thus, the context is assumed to have a substance, in terms of resources that are adapted in relation to each other; for example products, facilities, organisations and relationships, and this substance will determine the economic future of the new. This type of forecasting can, for example, be based on a network model. In this case the connection between an investment decision and the economic outcome is assumed to be influenced by the existing substance in terms of business relationships and network connections.

Although Pharmacia Biotech's decision was not consciously based on a network model, it definitely had the characteristics of practical based network thinking. The relation among investment and outcome was thought to be highly influenced by existing investments; internal as well as external ones, and physical as well as organisational ones. The forecast made was that this structure of related investments in place would not be able to benefit from the potential innovation to any larger extend, and would therefore act like a hindrance for the embedding of this in a large scale production and use.

The other two actors, the venture capital firm respectively the governmental policy agency are basing their forecast on some rather different contexts; the venture cap financing system (Gompers & Lerner, 1999, 2001) and the system for commercialization of research (Elzinga,

2004, Eklund, 2007). From an outside perspective, it might look as these two types of forecasts are based on the characteristics of two rather different contexts. However, what they have in common is that they are based on a very high abstraction of the business landscape, strongly influenced by how it is depicted in the market model. (Waluszewski, 2011)

The common point of departure is the preferences of the buyer, i.e. the forecast is based on the relation among an identified demand of a function corresponding to what the potential innovation can offer – in a way that is more efficient compared to established products. Such a type of forecast is also more or less explicitly used by two of the actors presented in the empirical example above; the venture capital firm Health Cape and the governmental policy agency Nutek. Both of these actors were making forecasts where little attention were paid to investments in place on the supplier respectively the user side. The forecasts were instead based on comparisons among the potential innovation and the established solution, in terms of which of them that would best fit with the customer preferences. The Nutek forecast was furthermore based on the estimation of if the project leaders had the skills to design a product with the described capabilities. Both forecasts were thus based on the potential innovation in itself, as an individual project and as a stand-alone machine. Based on the relative performance of the potential innovation in relation to the existing solution, both of these actors forecasted a successful innovation journey and product which would be a sales success.

If both a network and market model inspired decision making addresses the needs for making forecasts; it is obvious that the first includes aspects that not at all considered if based on the latter. A forecast based on a network model is stressing the influence from an existing, elaborated structure of related investments, in both a producer and user setting. Although this structure is understood as changing over time, this change will take place in steps – where the main part of investments in place will be taken advantage of. Hence a network based forecast is not always – as Pharmacia Biotech did in the case presented above – to say ‘no’ to potential innovations which does not fit with the existing structure. It is just to base the assumed forecast among the new in relation to investment in place. This was exactly what the company 4-5-4 Life Sciences based it forecast on, when it decided to invest in a licencing of the pyrosequencing technology. The investments in place in the supplying and using setting were thought to benefit from 454 Life Sciences embedding of the pyrosequencing in their ‘high throughput sequencing system’. If this forecast was right or wrong the future will outline.

5.1 Implications for management and policy

If the business landscape is network-like, then any innovation journey is context dependent; i.e. influenced by investments in place in the settings where the innovation is taken into large scale production and use. Hence, if the business landscape is network-like, innovation forecasts have to a) include a consideration of from what experiences, of what context, the forecast is made, and b) include a consideration of what context, characterised by what investments in place – in terms of both human and physical resources – that the innovation is assumed to contribute with benefits to. To base an innovation forecast on an explicitly or implicitly implied market thinking; i.e. on the assumption that the success of an innovation is related to its ability to correspond to an identified need and its relative performance, can, when the innovation is facing a large scale producer and user context, be to ask for unexpected and unwanted surprises.

REFERENCES

Eklund, M., 2007. *'Adoption of the Innovation System Concept in Sweden'*. Doctoral dissertation. Uppsala Studies in Economic History, 81.

Elzinga, A., 2004. 'The new Production of Reductionism in Models Relating to Research Policy'. In *'The Science-Industry Nexus. History, Policy, Implications'*. Grandin, K., Wormbs, N., Widmalm, eds.,pp. 277.304. Science History Publications, MA.

Gompers, P. & Lerner, J. The Venture Capital Cycle. The MIT Press, Cambridge. 1999

Gompers, P. & Lerner, J. The Money of Invention. Harvard Business School Press, Cambridge, MA. 2001

Ingemansson, I., 2010. *'Success as Science but Burden for Business? On the Difficult Relationship between Scientific Advancement and Innovation'*. Doctoral Thesis, No 148. Uppsala: Department of Business Studies, Uppsala University.

Ingemansson, M., Waluszewski, A., 2009. 'The Relative Benefits of an Innovation: Its Appearance in the Academic, Venture Capital and User Setting'. Special Issue on Science, Technology, Business, *The IMP Journal*, vol. 3, issue 2, pp. 20-56.

Tidd, J., Bessant, J, 2013. 'Managing Innovation: Integrating Technological, Market and Organizational Change', 5th Edition. Wiley.

Van de Ven, A.H., Polley, D. E., Garud, R., Ventkatarman, S., 1999. 'The Innovation Journey'. New York, Oxford University Press.

Waluszewski, A., 2004. "A Competing or Co-operating Cluster or Seven Decades of Combinatory Resources? What's Behind a Prospering Biotech Valley?" *Scandinavian Journal of Management.*

Waluszewski, A. 2011. *The Policy Practitioners Dilemma. The National Policy and the Transnational Networks.* Stockholm: Vinnova report 2011:07.

Waluszewski, A., Wedin, T., 2003. "Is it Really Speed We Need? The Role of Venture Capital in a Biotech Start-up." Proceedings of the 18th annual IMP Conference, Lugano, Switzerland.

Strömsten, T., Waluszewski, A., 2012. "Governance and Resource Interaction in Networks. The role of venture capital in biotech start-up." *Journal of Business Research,* pp. 232-244.

Utterback, J.M., Abernathy, W.J., 1975. 'A Dynamic Model of Process and Product Innovation'. *Omega, The International Journal of Management Science,* Vol. 3, No 6, pp 639-653.