[1]How to Create Lead-Users and New Economic Resources

Debbie Harrison

Department of Strategy and Logistics

Norwegian School of Management, BI

Elias Smiths vei 15, 1302 Sandvika

Norway

and

Alexandra Waluszewski

Uppsala STS Centre and

Department of Business Studies and

Uppsala University

Sweden

How to Create Lead-Users and New Economic Resources

1. An environment breeding success?

Since the Uppsala based biotech company Biacore was born about two decades ago, it has not only survived the innovation journey (Van de Ven et al, 1999), but also managed to become a world leader within its field: real time investigations of interaction between bio-molecules. Biacore supplies about 90 % of all such analytical tools in use. However, this does not at all mean that Biacore is a rich giant – it is working within a research market restricted to about 150-200 new installations each year. Since 1994 Biacore has been profitable, and has been listed on the Stock Market since 1996.

Biacore can, at least at first glance, be regarded as the role model of contemporary innovation and cluster policies (See e.g. Malmberg and Maskell, 2000, for an overview). Biacore has its roots in the interaction between science and industry; it was initiated by some staff of the world leading biotech equipment supplier Pharmacia Biotech (later on Amersham Biosciences, later still GE Healthcare) located in Uppsala, a region known for close co-operation between biotech research and industry for the at least the last seven decades. (Waluszewski, 2004). It also had a close and important technological interaction with scientists at Applied Physics at Linköping Institute of Technology. Further, even at the initial project stage Biacore was provided with a world leadning and engaged potential user, Pharmacia Diagnostics.

Thus, Biacore was born in an environment that could provide all the qualities that according to among others Powell, Koput, and Smith-Doerr, (1996) are "critical to success"; where learning takes place across partners and projects, and where development projects includes working with diverse parties. In other words, it fits nicely in to the ideas brought forward by Arthur (1986), Almeida and Kogut, (1997), Saxenian, (1994), Lorenzoni and Baden-Fuller, (1995), Lorenzoni and Lipparini, (1999), Boari and Lipparini, (1999), Lundvall and Maskell, (2000), who all emphasise how location, proximity and learning processes positively affect both industrial structure and dynamics.

If, as Edith Penrose (1959) suggest, it is the way a resource is activated that creates its "services", then its value is due to how it is combined with other resources – within organisations, within relationships between organisations or even due to indirect interaction over the borders of visible relationships. Thus, in order to grasp such processes, we need a research tool that allows us to capture interaction between technological and organisational interfaces between heterogeneous resources, regardless what actors these are represented by. The setting of this tool, developed in Håkansson and Waluszewski (2002) is the IMP network approach, and its underlying assumption

that a company's technological, social and economic features are the result of its interaction with other companies and organisations. (e.g. Axelsson and Easton, 1992; Håkansson and Snehota 1995; Håkansson and Waluszewski, 2002).[i]

How was a new economic resource co-created in the development and evolution of a new user network in the biotechnology field? In the Biacore user network case there are at least two levels of interaction that are central for the creation of economic value. First, what is the nature of the interaction between Biacore's sales and technical departments and each individual user? How do Biacore employees and a single user co-develop the use of the biotech tool in a variety of practices, and hence embed the tool in a single user context? Secondly, what is the nature of the interaction between the many users of the biotech tool? How do users co-create their use of the biotech tool across multiple user contexts? Users can assist each other through both direct and indirect communication, and hence a user network is created.

In this paper we make three contributions to the lead user networks literature. The first is to illustrate how the label 'lead users' referred to various users over time. Secondly, the paper discusses how a manufacturer was heavily dependent upon users to create use for a new technology. Biacore launched the new instrument and was involved in a co-development period with lead users. Furthermore, Biacore as a producer organisation is not just one independent actor; there was a collection of organisational interfaces in place. The third contribution is in terms of how the nature of the user network, and Biacore's role in this, changed as it developed and evolved.

The paper proceeds as follows. First, we provide an overview of the Biacore case. The case begins in the development of the technology into a biotech instrument, with interactions across research institutions and Pharmacia. Then the failure to embed the new instrument in the diagnostics area is covered: no one wanted to become a lead user! The embedding of the instrument in an "explosion of research applications" is then detailed. Overall, the case covers the co-development of a new resource and a new network. Secondly, we discuss an overview of the lead user and user community / networks literature. Section four of the paper analyses the case by relating this to the literature. Lastly, suggestions for future research are presented.

2.0   Case Study

2.1 To be born with a silver spoon?

What the Biacore story underlines is that knowledge spill-over (wherever it occur) is far from the same as creating a use for the new resource this knowledge gives rise to. Being a newborn company in "cluster" with at least seven decades of life-science/biotech activities, being nurtured both by potential suppliers and users, in many respects must be considered as being born with a silver spoon.

Unfortunately, this is still not the same as being automatically equipped with a set of technological and organisational user interfaces.

Biacore has its organisational roots in Pharmacia Biotech, a company that already during the Pharmacia era was one of the world's largest suppliers of biotech analytical tools. Its technological roots are the so-called SPR technology, "surface plasmon resonance", a light phenomenon that possible to use to trace interactions between molecules. However, the interaction with the one of the leading research units in this area, Applied Physics at Linköping Institute of Technology, was not an ordinary contact for Pharmacia Biotech, but due to earlier educational experiences of one of the instrument developers. At this time, the early 1980s, SPR had been for some decades an internationally well-recognised phenomenon within applied physics. The instrument developer's curiosity in the SPR technology inspired a project leader to consider the possibilities to utilise such sensors in a biotech tool. A small project group was established within Pharmacia Biotech, including one of the research leaders at Linköping Institute of Technology (later on a member of the Biacore board.) The Linköping researchers opened the door to another research unit that was engaged in SPR technology, FOA, owned by the Swedish Defence. Although it was the Linköping solution that became the most influential for Biacore, a group of people with experiences in SPR technology was recruited from FOA.

Thus, through the new organisational interfaces between Pharmacia Biotech's Biacore group, Linköpings Insitute of Technology and FOA, knowledge about a new technology was brought into a context full of both images (Czarniawska, 1999) and physical resources (Håkansson, Waluszewski, 2002) concerning biotech analytical tools and methods. The close interaction between Biacore and its supplier of knowledge and experiences reveals kinship with the pattern identified within one of the world's most famous clusters, Silicon Valley; (see e.g. Florida and Kenney, 1988, Schoonhoven and Eisenhard, 1988, Saxenian, 1994, Cohen and Fields, 2000,) that certain internal social conditions of this region, underlined by concepts such as trust, norms, social capital etc., supports knowledge-spillover. The delicate issue was now how the create an economic value out of these experiences.

2.2. Diagnostics application: impossible to embed

From Pharmacia Diagnostics, the main supporter of the Biacore project, not only a first application area was gained, but also experiences of how to develop systems solutions for allergy diagnostics, and how to relate to diagnostic labs. From the sister unit Pharmacia Biotech, Biacore was supplied with knowledge concering development of system solutions for separation and characterisation of bio-molecules, including issues like how to handle suppliers, construction, applications and not

least, how to relate to customers both within academia and industry. Thus, already on a project stage Biacore was supplied with extensive knowledge related to the diagnostic analysis field and biotech instrument, emcompassing everything from how to relate to scientific journals and well-reputed academic institutions to suppliers of metal plating processes.

The main application outlined was aimed as a complement to the existing instruments developed by Pharmacia Diagnostica, in particular the fast protein liquid chromotography system, or FPLC. The idea was to produce an SPR-based analytical instrument, were the medical personnel, instead of sending away the blood test to a special laboratory, could analyse samples on-site. This meant that the price of both each test and the product had to be kept rather low, and the production volume was estimated to about 10.000 items a year. The other application area was much smaller, a research instrument for characterisation of biomolecules. The total cost for the project was estimated to about 400-500 SEK, and the first products were planned to be launched around 1990. According to the general manager of Pharmacia at that time, Erik Danielsson, the potential market both for dignostics and as biotech tool where very large. "Biosensors are what we go hardest for today. If we succeed biosensors have a good prerequisites to be our largest product ever" [ii]. In 1988 the project was presented to the media.

The first warning that main application did not seem to work out came from relationships with customers at diagnostic laboratories. Opinions as to why such an instrument did not fit into the technological and economic logic of the potential users differs, but some of the main explanations are that the new instrument would be too expensive and that more reliable results could be reached with established methods. In addition, in many cases the medical clinic is paid per test sent for analysis by the diagnostic laboratories, which were Pharmacia Diagnostic's main customers. Pharmacia Diagnostics withdraw from the Biacore project. Only a small application area was left; as a research instrument for characterisation of biomolecules. The question was if this restricted application ever would grow big enough to provide the young company with a sufficient user-base.

2.3. Is there anyone that dares to be a lead-user?

The project leaders were very hesitant to promote a new product with such a small application area, based on a totally new technology and launched by a small and unknown company, but they simply had no choice. Biacore had become a headache for both its own managers and for its parent company Pharmacia, which had invested both a lot of financial resources and its reputation in the project. However, during the development of the technology Biacore had recruited many specialists from Pharmacia Biotech, and they were experienced with supplying scientists with tools for investigations of molecule interaction.

The first two applications outlined were characterisation methods such as "epitope mapping" (percieved to be the flagship application) and concentration measurement.[iii] Biacore employees worked on both these two application areas in order to generate an "increasing body of examples". Through people with application experience from Pharmacia Biotech some customers were identified who were interested in creative and new technology research without knowing anything about eventual benefits in advance. Among others, potential interest was found at the University of Leuven, Belgium, Institut de Biologie Moléculaire et Cellulaire, Strasbourg, France, and the Department of Immunotechnology, University of Lund, Sweden. Together with these and other early "opinion-leaders" some characterisation applications were developed. Furthermore, these opinion-leaders supplied Biacore with what is of utmost importance for any producer of research instruments – publications in well-known journals, where academic researchers "confirm" the value of the new solution.

2.4.   Creation of use – being in the hands of the customers

In 1990 the official launching of the Biacore instrument began, and in September 1990 there was the first ever presentation, in Germany (where Pharmacia Biotech had a sales office). The central issue was to provide convincing applications, something that forced Biacore to expose potential customers to in-house experts rather than sales representatives. The launching of Biacore could benefit not only from Pharmacia Biotech's knowledge of where to find curious and skilled biotech tool users, but also by co-operation with this unit's marketing organisation. From the launching of the first Biacore products in 1990 until its introduction on the stock market in 1996, Biacore could utilise Pharmacia Biotech's marketing organisation. This meant that instead of operating as a newcomer in its field, Biacore could launch its product with Pharmacia Biotech's logotype and reputation.

The 'launch presentations', organised more like workshops than ordinary sales meetings, took place throughout Europe between 1990 and 1991. Early users from the Cellular Immunology Unit at Oxford University in the UK attended a meeting at the Pharmacia offices in Milton Keynes. Here, the first customers obtained through Pharmacia Biotech were used as presenters of some first results. The Oxford users were sceptical; this technology perhaps would not work in their area of studying weak interactions in antibody binding. However, on the back of some results, produced in co-operation with Biacore staff, the Oxford lab purchased a biosensor. "What was interesting was that Biacore did not sell the machine for weak interactions"[iv].

During these workshops with potential lead users, there was "lots of talking, sharing, and discussing the possibilities. It was not very driven in a sales process sort of way…often there was no sale but it

was a learning process. It also spread the word" [v]. When a potential user / customer was very interested, Biacore staff got the results of experiments for the official application files and the joint work was also part of a sales process for that person. The idea was to get this person "on our side", knowing the product, and having the ability to explain it to others. It was described as a very opportunistic way of working: "we looked all over and took what we could get" [vi].

It was not a process of providing a potential customer with existing information or knowledge. Instead, most of the customer requests meant that the customer and the Biacore staff together had to engage in development of the desired solution. A problem with a sample or an instrument behaving in a particular way would initiate a problem solving process from the customer's site to the lab in Uppsala and back again. "The impulses did travel a lot…it was very much an interconnected community of Biacore users…the ends did not have connections or contacts…but they were linked through us" [vii]. For example, when scientists at the Department of Biology at the University of Leeds in the UK were interested in purchasing a Biacore 1000 in 1993, the head scientist contacted the Head of Research and Development at Biacore, and requested a visit to Uppsala to learn how to use the machine and to conduct some early experiments with Biacore staff. The Biacore Head of R&D had in fact read one of the Leeds scientist's recent papers in *Nature*, and together the researchers tried to replicate this study using Biacore. However, the Leeds users were one of several groups who experienced reliability issues with 'false' interactions of the sensor chip with the sample. Biacore responded to this user-identified limitation of molecule-chip interaction by developing a range of different chips, whereby each chip / sensor surface has its own properties.

The interaction pre-sales was characterised by an intense problem-solving process in order to identity a significant use for the machine. The after-sales process was similar. This included interactions from telephone discussions of data, software updates and application notes to on-site visits and development projects. "We were very much oriented to the relationship, one-to-one interaction, being close to the users, close to changes in the user's environment…" [viii]. This time-consuming training was free at first, but became a "knowledge product" later. One example of how the after-sales process developed into a continuous discussion about how to use the instrument in studies of small molecule interactions is provided by an early user at Astra Zeneca Research and Development in Gothenburg, Sweden. This scientist does not only interact directly with the Biacore staff, but has developed personal interactions concerning how to use the instrument with many of the other early users.

After the launch presentations, different users began to apply "all kinds" of different applications. "There was an explosion in the literature of articles assessing the different ways of using the machine" [ix]. The initial workshops were replaced with organised meetings for users to present their

varied applications. The first 'Biasymposium' took place in 1992. There were relatively few participants in the early meetings, but this soon changed. For Biacore, these meetings were a place for the creation of use, and for the users, "a place to talk 'real science' with others whom were using the same technology in a range of different applications" [x]. However, it was the users' skills in developing applications based on their existing and potential research problems that determined how the Biacore was used, and what application areas it became known for. In other words, Biacore was in the hands of their users.

2.5. A new pattern of user interaction: a network of lead users

The close interaction with customers and the engagement in their problem solving process was both time consuming and costly. In parallel with an increasing volume of users / customers the company was re-organised in 1995. An new manager was brought in, and the mission was to rationalise all of the company, including the sales process. The organisation of marketing and sales was re-organised, among others European Technical Support was decentralised, and Local Technical Support was established in Germany, France, UK, Benelux, Italy, and in-house at Uppsala for the Scandinavian region.

As the volume of customers increased, there was less emphasis on detalied engaged in customer problems. "In 1990, one question could get you lots of attention. We spent lots of time early on with our important and small number of customers. It was important for positioning and credibility". Sales of the Biacore increased, as did the distance between the customer and the company: "…there were so many more customers to care for". The balance was in terms of how much training / real time support each user received, or how expensive it was to generate an experience base: "the balance changed over time". Biacore was not new, lots of people had them, and non-users knew how they worked in principle. "Rather than extensive sampling, we shifted the new user to look at publications…as the body of publications grew….It is an established technique and it is positioned in a research context in terms of what it can and cannot do".

This new way of interacting with customers is reflected in the user's behaviour. To generalise, it is the users from pre-1995 that mainly engaged in developing new applications – and in developing the limits for how to use the machine. The engagement of these early customers and their publications of these acted as indirect but very important user influence "being communicated throughout the user community". The indirect influences are difficult to map, but involve new users reading publications and "having their thinking developed".[xi]

Some of the user-user influences can be mapped more directly. At Astra Zeneca UK, there are five Biacores on-site, and all are heavily used. One of the units purchased a Biacore 3000 for research

into small molecule interactions. The three users within the unit use the instrument "heavily" because of a specific project. Prior to the specific project being in place, the more usual use-dormant-use pattern occurred. The three users are in contact with colleagues in Sweden and the US in discussions related to particular applications, problem solving, and experiences with an instrument. Further, the users in the five on-site units communicate on a regular basis.

Many of these continuing users from pre-1995 are very positive about the instrument. They have use patterns that fit a relatively simple cycle of use-dormant-use-dormant. These users actively combine the Biacore machine with other techniques being used in a particular experiment. Other users do not operate in this cluster pattern, but instead have a continuous use of the instrument. For example, for repetitive, high throughput screening applications at Astra Zeneca UK, multiple instruments are used on a daily basis. This is also the case at the Cellular Immunology Unit at Oxford University in the UK, because Biacore is substantially better than other instruments for studying weak interactions.

The way of relating to the post-1995 customer is more traditional. In general the support is in terms of how the instrument works, but not as much how it interacts with their research questions. In terms of the current pre-sales customer support process, an Application Specialist demonstrates an instrument either at Biacore or at the customer's site. The Application Specialist then works together with the customer in their lab with a customer-specific sample. This demonstrates the instrument, and allows the customer to gain hands on experience of the instrument.

Then "there is the entire training concept post-sale". There are a number of self-training products, such as CDs and books, alongside a series of Biacore-run training courses. There is also 'general customer support', with advice provided via email or telephone. There may be courtesy visits if a customer has run into problems. If the user is doing something non-standard with a sample, the Application Specialist needs to refer to the publications database when problem-solving. It might be that "the customer needs to just try it out if no one else has done this before".

Not all of the use patterns are positive. Several users have only used the instrument once. In one of the departments at Chalmers in Gothenburg, Sweden, the instrument was used for one specific project. An early user at Astra Zeneca Gothenburg assisted the department. However, the main user obtained a new position in the US in 1998 and the "know how left". At a biotech company in Oslo, Norway, their Biacore is little used. "It is easier to work with the techniques that are "traditional" and are the most familiar. We can find possible applications, but more traditional methods can be used much faster".

Other users, even after substantial trial-and-error activity, have never embedded the instrument in their research context. Norwegian researchers interested in DNA metabolism report, "the idea was

very good in principle, but the use of the machine was more difficult than we expected". For example, the lab has experienced lots of non-specific binding. Biacore staff "…can talk about the machine per se, but "you can't expect them to do your research for you"". The training courses demonstrate the principles of the machine perfectly. But "it works great in their systems, but not in our lab!". Researchers have consulted the publications database in an attempt to find solutions to some of the problems. However, "it is hard to reproduce the results here in the lab".

In summary, although the new way of interacting with customers is more cost-efficient, Biacore also had to pay for it – in a loss of intense application development. However, the sales of the machine are established, with about 150-200 new customers per annum. In total, about 1500 instruments have been installed. In the next section of the paper we provide a brief overview of the lead user and lead user / horizontal networks literature before using this literature to provide one explanation of the case.

3.0. Literature Review: User Networks: What are they?

3.1. Lead Users

It is well established that users or customers have dominant role in the innovation process of novel products or services because users develop many of the commercially successful innovations in their respective industries (e.g. von Hippel, 1976, 1977; Shaw, 1985). Users develop and use innovations, rather than passively waiting for manufacturers to commercialise products, as detailed in the manufacturer-dominated innovation process. In his 1976 study of scientific instruments, von Hippel details the user-dominated innovation process from the user identifying a need and formulating a solution, to building a prototype. Afterwards an instrument manufacturer introduces a commercial product.

The inclusion of the user in the innovation process requires moving the designing of a product to the user's locus of problem solving, where the information is most sticky. Simplistically, user need information resides at the users site or context, and is sticky, to varying extents. The more sticky this is, the more the user should dominate the innovation process because it is expensive and difficult to transfer sticky information between user and manufacturer. Inter-organisational trial-and-error activities are costly. Users problem solve in context, and in doing so reduce the costs of information transfer. In other words, the extent of information stickiness is reduced because supplier and user transfer less information (von Hippel, 1994, 1998).

Not all users innovate to the same extent. The 'lead user' concept is used to describe a type of customer that perceives key economic benefits from an innovation or a solution to a problem, and experiencing needs ahead of the market (and therefore ahead of manufacturer product development). Lead users innovate more than non-lead users, through a process of "applications generation", e.g. new ideas, new applications and new prototype solutions (von Hippel, 1986:796; Morrison et al, 2004). Lead users play a crucial function in the marketing research process, in particular in industries that are 'high-tech or fast-changing'. In such situations, the application of standard market research tools is a poor way to understand future user needs (von Hippel, 1986, 1988).

Suppliers can incorporate lead users into a four-stage marketing research process when seeking to identify their 'pre-market' needs [xii] (Von Hippel, 1986). The four-stage process has been tested in fields subject to rapid change, and those that are "low tech", and considerable overlap in the level of innovating users, and lead users, were reported (Urban and von Hippel, 1988; Hersatt and von Hippel, 1992). Further, lead user 'tool kits' have been discussed as a method for how a lead user can be 'harnessed' in market research and product development for a manufacturer / producer (e.g. Von Hippel and Katz, 2002; Thomke and von Hippel, 2002; Franke and Piller, 2003).

Von Hippel and Katz (2002) argue that innovation tool kits can affect the transferability of sticky information. In other words, the manufacturer does not try and identify user needs from an ivory tower in advance, but shifts the need-related part of the innovation process to users: the location of innovative activity is changed (Thomke and von Hippel, 2002). This argument is especially relevant to situations of high heterogeneity of demand, when products are designed in a standard format for the average user. A kit element facilitates customisation by the user or customer organisation (von Hippel and Katz, 2002; Franke and von Hippel, 2003). A standardised product is modified in the user's context after the manufacturer releases it. In other words, "sometimes lead user problem-solving activity takes the form of applying existing commercial products or components in ways not anticipated by their manufacturers. Sometimes lead users may have developed complete new products responsive to their need" (von Hippel, 1986:800).

The lead user concept has been applied in a variety of industrial and consumer settings, e.g. PC-CAD development (Urban and von Hippel, 1988), pipe hanger hardware (Herstatt and von Hippel, 1992), semiconductor process machinery (von Hippel, 1977), scientific instruments (von Hippel, 1976); Apache software (Franke and von Hippel, 2003), sports equipment (Franke and Shah, 2003), medical surgery equipment (Luthje, 2003a); outdoor consumer equipment (Luthje, 2002); mountain biking equipment (Luthje et al, 2003) and library software (Morrison et al, 2000; 2004). The studies report varying extents of the frequency of user innovations, from 19% in Apache software and

mountain biking equipment, to 38% in extreme sporting equipment. Lead users were identified from within the group of innovating users.

It is important to note that lead users are not synonymous with early adopters: "…a Lead User is ahead of all the categories of adopter listed on a tradition innovation diffusion curve such as that developed by Rogers and Shoemaker (1971). Lead Users of each new or modified product or service concept exist before any firm has developed a version for sale in the market" (Herstatt and von Hippel, 1992:213). Nevertheless, lead users may be early adopters of a technology, and in addition, play an important role in the diffusion of an innovation (Urban and von Hippel, 1988; Morrison et al 2000a). The key role of the lead user in being early adopters of technology, and then accelerating the time of adoption of a new product, by acting as product champions or opinion leaders was empirically tested by Morrison et al (2004) in the context of IT systems in Australian libraries.

What distinguishes lead users from non-lead users? Luthje (2002) states that more experienced users are more likely to innovate. The likelihood of innovation is based on use experience (based on frequency of use) and product related or technical knowledge (know-how about the product). Of these two user characteristics, use experience was found to be important in distinguishing innovating from non-innovating users. In the case of mountain biking, Luthje, Herstatt, and von Hippel (2002, p.3) found that users develop highly specific innovations to closely suit their own needs. By operating in "low-cost innovation zone", users innovate based on local information already in the user's context that is cheap and quick to access. Other work reports that 'leading edge status' is in fact a continuous variable, rather than a dichotomy of 'lead user' and 'non-lead user' (Morrison et al, 2004).

3.2. User Networks

One key question is to consider how are innovative users connected, and how are innovative and non-innovating users connected? Von Hippel (2002) calls for further studies of the beginning, evolution and maintenance of user networks, and the role for manufacturers within them. Allen (1983) discussed firm-competitor collective innovation in the 19th century UK iron and steel industry. Collective invention to improve the technological basis of the industry was based on free revealing of information across competitor firms [xiii]. The free revealing of innovations has also been studied in user-manufacturer situations (e.g. von Hippel, 1988; Harhoff, Henkel and von Hippel, 2002) and user-user populations (e.g. Franke and Shah, 2003; Luthje, 2000; Franke and von Hippel, 2003; von Hippel, 2002; Lakhani and von Hippel, 2003).

One central issue in the user community / user network studies is that the users innovating in these communities freely reveal or diffuse their innovations to others, for example through source code, journals, face-to-face, on-site demonstrations and conferences (Harhoff, Henkel and von Hippel, 2002; von Hippel, 2002; Franke and Shah, 2003). Private rewards or benefits from free revealing of information include reputation enhancement, learning, enjoyment and community norms (e.g. Allen, 1983; Harhoff, Henkel and von Hippel, 2002). Note that free revealing means that the innovating user reveals information freely, it does not necessarily mean that the information is costless to use for the receiving user (Harhoff, Henkel and von Hippel, 2002).

In particular, recent research in user communities / networks in the sports equipment and open source software areas shifts the focus from the individual lead user to considering the interactions between and across users. Innovation networks can be purely horizontal, or consisting only of users. Such networks can exist when at least two of three conditions can be fulfilled (von Hippel, 2002:3). First, at least some users have sufficient incentive to innovate. Secondly, at least some users have an incentive to voluntarily reveal their innovations, and thirdly, the diffusion of innovations by users is low cost and can compete with commercial production and diffusion. When the third condition does not hold, there is a role for the manufacturer in commercialising the innovation.

The frequency of innovation and the nature of the interaction between the two user communities of sports equipment and open source software are very similar in nature, even with differences in the geographical dispersion of users and the type of products concerned (von Hippel, 2001). The key distinction is in terms of the *role for the producer / supplier* in the user community – von Hippel's (2002) third condition for user networks. In the sports equipment user community, products are designed and revealed by lead users within the community, and the innovation may be later commercialised if it is considered to have sufficient market potential (e.g. mountain bikes case, other sports equipment cases). Open source software programmes are products that are designed within the user community without a role for a manufacturer, and developed and maintained without manufacturer involvement.

Franke and Shah (2003) discuss four 'voluntary special-interest user communities' in the areas of sailplaning, canyoning, boardercross and handicapped cycling. The authors studied the characteristics of the individual innovator, and the characteristics of the innovator's community. Lead users interact more within the community in obtaining advice and assistance from other users; it is fun, provides opportunities for learning and it is a social norm to co-operate with others. This assistance is both direct and indirect (e.g. referrals), with both existing and new links being useful [xiv]. They have also been members of a community for a longer period of time when compared to

non-innovator users. The user community thereby influences the process by which innovations take place.

Open source software products are designed by users to be freely modified by others in the user community without a role for a supplier organisation (e.g. Franke and von Hippel, 2003; von Hippel, 2002; von Hippel and von Krogh, 2003; Harhoff, Henkel and von Hippel, 2003; Lakhani and von Hippel, 2003). As Franke and von Hippel (2003:1205) put it, "Apache, along with other open source software, is not designed in response to information about general market or user needs. Instead, it consists of a collage of contributions from individual users, each motivated by an individual need that may or may not represent a need that is widespread among users".

Open source software communities are web-based, voluntary, widely distributed user communities. The product is a public good and the innovation process is user-driven, e.g. a core user group plays a central co-ordinator role. In other words, the user community jointly practices the development of "free" software products (von Hippel and von Krogh, 2003). Experienced users provide assistance to others without charge via a website, with questions posted and answers provided. The most active users solve the most problems posted by others (Lakhani and von Hippel, 2003).

4.0   The Development of a User Networks: Are There Any Followers?

The experience provided by Biacore underlines that although being born in an environment that most often is characterised as a life science/biotech cluster, i.e. where knowledge is exchanged in a generous, informal interaction, this is not the same as being equipped with an automatic creation of supplier-user interfaces. The question of how to embed a new solution into both technological and organisational interfaces has to be solved in interaction with users.

The engagement in developing technological and organisational interfaces can be regarded as a search for users attracted to engage in trial-and-error-like processes. Biacore's search for and interaction with these early users is close to the observations made by von Hippel (1976, 1977) and Shaw (1985), that users or customers have dominant role in the innovation process of novel products or services. However, the search for a lead-user is not an automatic guarantee for the creation of technological and organisational interfaces between a supplier and user of a new solution. As Biacore's early history reveals, it is essential to first find some customers willing to undertake the technologically and economically demanding role of engaging as lead-users. The main problem with the diagnostic application was that there were no customers willing to engage as such – a situation that forced the company to take another route of development.

In terms of the research application, arguably all of the users became lead users, in that each user developed applications in turn, and this was ongoing as more users joined the Biacore user network.

In finding the early users, the heritage from Pharmacia Biotech was crucial. However, it was not, as von Hippel (1986) describes it, the lead-users that surprised a passive manufacturer with new innovations, but the lead-users were actively searched for in advance. In this way, Biacore was heavily reliant on a set of technological and organisational interfaces developed by Pharmacia Biotech, rather than acting as a single manufacturing company developing a technology.

After Biacore had launched the new instrument into the research application, early lead users such as those from Astra Zeneca Gothenburg, perceived a variety of applications. In other words, the users had started to define the resource – and hence give it value - by connecting it to existing activities. These early users did perceive benefits from using the new instrument 'before the general market', and were risk takers in dealing with the scepticism that existed. Biacore had several ideas regarding potential applications, but these were not fixed, and the "explosion in use" into a variety of applications was user – led.

This process was a co-development between the users and Biacore, and the company developed, and maintains, long term relationships with many of these users. Biacore's role was in assisting the early users in creating a use by using the instrument, or embedding it a situated context. Biacore staff worked directly with customers in connecting the instrument to existing or new activities. Early users were able to conduct existing experimental tasks in a different way, or / and were able to try new experiments. In this way, Biacore at each individual user's site conducted application generation. Further, modifications were made to the instrument range over time, many of which were in response to user feedback.

Biacore's early history can be regarded as an illustration of what among others von Hippel (1986) and Morrison et al (2004) report; lead users innovate more than non-lead users, through a process of "applications generation", e.g. new ideas, new applications and new prototype solutions. Thus, lead users play a crucial function in the innovation and value creation process, in particular in industries that are 'high-tech or fast-changing. However, the Biacore innovation journey illustrates also that although gaining creative and engaged lead-users is a necessity in order to develop supplier-user interfaces, this is not the same as the creation of a fortune. Instead, interacting with lead-users engaged in application development is time-consuming and costly. In order to economise on the engagement in lead-users, there must be followers whom can "adopt" the new solutions with less personal engagement from the supplier.

Nevertheless, regardless of how engaged, skilled and well-reputated a lead-user is, it is not possible to know whether the new application or solution can be economised in terms of followers of the innovation. (Håkansson and Waluszewski, 2002). If there really is anyone following the solutions worked out in time-consuming and costly interaction with a lead-user is always a question for the

future. However, in order to provide a potential user with possible applications (especially those who do not engage like lead-users but want to "push the button"), the manufacturer needs to make these experiences possible to communicate. Thus, the supplier must engage in the process of handling what von Hippel (1988) labels as "sticky information". According to von Hippel, the more sticky the "information" is, the more the user should dominate the innovation process, because it is expensive and difficult to transfer sticky information between user and manufacturer. However, this advice still leaves the question of how to economise on the experiences made by the lead-users.

Biacore could not afford to interact with a growing body of users in a creative yet time-consuming way, and after 1995 the company were forced to develop a new, less intense way of interacting with its customers. Many other users engaged in using the Biacore machine, and the joining rate was more rapid now that the technology was more established. Instead of engaging in the development of customer applications, Biacore focused on training and demonstrating how the instrument itself works when assisting users to embed the instrument in a use context.

In order to economise the innovation journey and create technological and organisational interfaces between the supplier and users, a key question is to consider how are innovative users connected, and how are innovative and non-innovating users connected? One possible solution is the free revealing of innovations, studied in user-manufacturer situations (e.g. von Hippel, 1988; Harhoff, Henkel and von Hippel, 2002) and user-user populations (e.g. Franke and Shah, 2003; Luthje, 2000; Franke and von Hippel, 2003; von Hippel, 2002; Lakhani and von Hippel, 2003). One central issue in the user community / user network studies is that the users innovating in these communities freely reveal or diffuse their innovations to others, for example through source code, journals, face-to-face, on-site demonstrations and conferences.

Biacore's user community was linked indirectly through a substantial and increasing database of publications, alongside annual Biasymposia. Biacore had strong incentives to act in a central co-ordination role. The free revealing of innovations does take place in a variety of ways. But, as the literature suggests, it certainly is not cost-free for the receiver to use this information. Further, other groups of users, such as those in Astra Zeneca and other large organisations, operated their own Biacore user groups, initiated by lead users in the company. Users within large organisations were linked via direct connections for support and problem solving. There are also examples of users in universities and companies being directly linked, alongside university-university linkages.

In this way, these users were creating and relating to a Biacore user community. The individual user relates to and interacts with the community to obtain advice and assistance. The user community influences the process by which an individual innovator innovates, as the literature would expect. Only small numbers of Biacore users are directly connected, with the more

experienced user solving problems, or at least attempting to solve problems, experienced by new users. This is not an issue of new users posting problems on a website, with the most active users solving these, as in an OSS community. The parallel in this case would be if there is are direct correlations amongst active use, number of publications, and numbers of times those publications are referred to by others, which would be difficult to assess.

It might be that some users view the publications database and other co-ordinated activities as simply a tool, and in this sense the network of users becomes a tool to be used. The interaction with the other users is indirect and based on using publications. Developing close interaction is of less importance, neither is contributing to the community at a later stage. It is only to speculate as to whether Biacore itself views the users as a community or a tool. Perhaps the emphasis shifted after the 1995 internal re-organisation? The early users did have a role in the diffusion of innovation, as the literature would expect. This was in acting as opinion leaders, and in particular in providing the beginnings of a database of journal publications, and presenting material at conferences. This activity is ongoing, as users continue to post application notes and results to Biacore, and these are distributed to other users worldwide. This is also a key method for Biacore employees involved in pre- and post-sales to update their knowledge.

Some of the users became or remained as non-users of the instrument; it is just a burden. Understanding the principles of a technology is one thing; situated use, connected to existing and potential activities, quite another. Obtaining use experience and applying this to meaningful experimental activities is the key issue. Moreover, there is not a simple relationship between the frequency of use of the instrument and the likelihood for user innovation. Instead, the user has to embed the instrument in creating a use.

5.0.   Conclusions

What is this case an example of? First of all, it details a story of the creation of a new resource by a set of linked users that formed a new network. Both resource and network were created as the Biacore was embedded into a research context. There is a paucity of examples in the literature of how a user network develops and evolves over time. Many articles in the existing body of knowledge are concerned with the frequency of the development of new products or modifications to existing products that can be measured. More recent examples regarding explaining why free revealing occurs across users have only a limited role for a producer organisation.

The empirical material has illustrated the need to problematise two important issues. First, to act in an environment characterised by a rich supply of knowledge is not the same as being supplied with automatic creation of supplier-user interfaces. Second, the empirical material has illustrated the

double role of being dependent on lead-users. On the one hand, lead-users are essential in the creation of technological and organisation interfaces for new resources. On the other hand, these lead-users are costly to interact with. Although Biacore through their lead users can benefit from an "explosion of applications" and an "explosion of publications" which have made SPR to an established technique, the customer base has not exploded. The level of new installations has remained at approximately 150-200 machines per year. This means that Biacore is still waiting for the many followers to the lead-users, those who can adopt the earlier experiences and "push the button".

There are several contributions from the example reported in this paper. The first is to illustrate how the label 'lead users' referred to various users over time. Several of Pharmacia Biotech's customers were chosen to be lead users, followed by the early lead users after the Biacore instrument was launched. In the "explosion of applications", many users joined the Biacore user network, many of whom were developing new ideas. This process continues to the present day. In the previous section we mentioned that not all of the users have successfully embedded a Biacore instrument. In this sense, lead users can create new user applications, but they cannot guarantee that followers can take advantage of the new interfaces created.

Secondly, the paper discusses how a manufacturer was dependent upon users to create use for a new technology. Biacore launched the new instrument and was involved in a co-development period with lead users. It was not a question of waiting for lead users to develop prototypes, with the subsequent commercialisation of a product with a fixed use. Furthermore, Biacore as a producer organisation is not just one independent actor; there was a collection of organisational interfaces in place, e.g. with Pharmacia Biotech's customers.

The third contribution is in terms of how the nature of the user network, and Biacore's role in this, changed as it developed and evolved. There is not one, static picture. We have focused on how uses for a new technology are created as the Biacore instrument is embedded in multiple users' contexts. The paper has considered a range of users, and how they do, or in many cases do not, embed a Biacore into a particular use context.

Future research might concentrate more carefully on the connections between and across users, both indirectly and directly, in considering how a new technology is embedded in a network. One possible way to do this would be to combine aspects of the communities of practice literature with the recent work on user networks.

References

Allen, R. C. (1983), Collective Invention, *Journal of Economic Behavior and Organization*, Vol. 4: 1-24.

Franke, N. and von Hippel, E. (2003), Satisfying heterogeneous user needs via innovation toolkits: the case of Apache security software, *Research Policy*, Vol. 32: 1199-1215.

Franke, N. and Piller, F. T. (2003), Key research issues in user interaction with user toolkits in a mass customisation system, *International Journal of Technology Management*, Vol. 26 (5/6): 578-599.

Franke, N. and Shah, S. (2003), How communities support innovative activities: an exploration of assistance and sharing among end-users, *Research Policy*, Vol. 32: 157-178.

Håkansson, H. And Waluszewski, A. (2002), *Managing Technological Development*, Routledge, London.

Harhoff, D., Henkel, J., and von Hippel, E. (2003), Profiting from voluntary information spillovers: how users benefit by freely revealing their innovations, *Research Policy*, Vol. 32: 1753-1769.

Henkel, J. and von Hippel, E. (2003), Welfare implications of user innovation, MIT Sloan School of Management Working Paper 4327-03, June 2003.

Herstatt, C. and von Hippel, E. (1992), From Experience: Developing New Product Concepts Via the Lead User Method: A Case Study in a "Low Tech" Field, *Journal of Product Innovation Management*, Vol. 9: 213-221.

Lakhani, K. R. and von Hippel, E. (2003), How open source software works: "free" user-to-user assistance, *Research Policy*, Vol. 32: 923-943.

Lee, G. K. and Cole, R. E. (2003), From a Firm-Based to a Community-Based Model of Knowledge Creation: The Case of the Linux Kernel Development, *Organization Science*, Vol. 14 (6): 633-649.

Liebeskind, J. P., Oliver, A. L., Zucker, L., and Brewer, M. (1996), Social Networks, Learning, and Flexibility: Sourcing Scientific Knowledge in New Biotechnology Firms, *Organization Science*, Vol. 7 (4): 428-443.

Luthje, C. (2002), Characteristics of Innovating Users in a Consumer Goods Field: An Empirical Study of Sport-Related Product Consumers, MIT Sloan School of Management Working Paper 4331-02, January 2002.

Luthje, C., Herstatt, and von Hippel, E. (2002), The dominant role of "local" information in user innovation: The case of mountain biking, *MIT Sloan School Working Paper*, July 2002.

Morrison, P. D., Roberts, J. H., and Midgley, D. F. (2004), The nature of lead users and measurement of leading edge status, *Research Policy*, Vol. 33: 351-362.

Owen-Smith, J. and Powell, W. W. (2004), Knowledge Networks as Channels and Conduits: The Effects of Spillovers in the Boston Biotechnology Community, *Organization Science*, Vol. 15 (1): 5-21.

Riggs, W. and von Hippel, E. (1994), Incentives to innovate and the sources of innovation: the case of scientific instruments, *Research Policy*, Vol. 23: 459-469.

Rosenkopf, L. and Tushman, M. L. (1998), The Coevolution of Community Networks and Technology: Lessons from the Flight Simulation Industry, *Industrial and Corporate Change*, Vol. 7 (2): 311-346.

Shaw, B. (1985), The Role of the Interaction between the User and the Manufacturer in Medical Equipment Innovation, *R&D Management*, Vol. 15 (4): 283-292.

Thomke, S. and von Hippel, E. (2002), Customers as Innovators: A New Way to Create Value, *Harvard Business Review*, Vol. 4: 74-81.

Von Hippel, E. (1976), The Dominant Role of Users in the Scientific Instrument Innovation Process, *Research Policy*, Vol. 5: 212-239.

Von Hippel, E. (1977), The Dominant Role of the User in Semiconductor and Electronic Subassembly Process Innovation, *IEEE Transactions on Engineering Management*, Vol. EM-24 (2): 60-71.

Von Hippel, E. (1988), *The Sources of Innovation*, New York: Oxford University Press.

Von Hippel, E. (2002), Horizontal innovation networks – by and for users, *MIT Sloan School of Management Working Paper number 4366-02*, June 2002.

Von Hippel, E. and Finkelstein, S. N. (1979), Analysis of innovation in automated clinical chemistry analysers, *Science and Public Policy*, Vol. 6(1): 24-37.

Von Hippel, E. and Katz, R. (2002), Shifting Innovation to Users via Toolkits, *Management Science*, Vol. 48 (7): 821-833.

Von Hippel, E. and von Krogh, G. (2003), Open Source Software and the "Private-Collective" Innovation Model: Issues for Organization Science, *Organization Science*, Vol. 14(2): 209-223.

Von Krogh, G., Spaeth, S. and Lakhani, K. R. (2003), Community, joining, and specialization in open source software innovation: a case study, *Research Policy*, Vol. 32: 1217-1241.

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

---

[i] More recent works are available at the website www.impgroup.org

[ii] Interview in the Swedish business magazine *Veckans Affärer*, 1987, No 3, p. 4.

[iii] In essence this application is concerned with how a molecule binds to a particular antibody. This can be performed with other techniques, e.g. Elizia. This activity took place from 1987 onwards. There was a need to detail convincing examples of repeatable applications, and to get re-agents in order to be able to run demonstrations or workshops at customer / user sites.

[iv] Interview with users at the Oxford lab, Summer 2003.

[v] Interview with Biacore technical specialist, December 2003.

[vi] Ibid.

[vii] Ibid.

[viii] Ibid.

[ix] Interview with senior scientist at Astra Zeneca Gothenburg

[x] Interview with senior scientist at Leeds University

[xi] Biacore have developed and maintain a publications database, and in-house reviewers read everything that is published that involves Biacore. Further, there is a database maintained by the R&D department where protocols are posted. These protocols are both developed in house by R&D and are also sent in by customers who are developing new applications. A newsletter is sent to users six times a year. In the newsletter new applications and experiments are posted as new technology notes or new application notes. In addition, the Biajournal goes out several times a year. Each time the journal is focused on life sciences, pharmaceuticals, or food issues (the three main customer areas). "It includes new publications that we really want to promote". Further, the possibility to hear more experienced users at the Biasymposia "changed the direction of more beginner users' research".

[xii] See von Hippel (1986) for a detailed discussion of the 4-stage process and how this can be incorporated in both industrial and consumer settings.

[xiii] "…all existing and potential intellectual property rights to that information are voluntarily given up by the innovator and all interested parties are given access to it – the information becomes a public good" (Henkel and von Hippel, 2003:5).

[xiv] It is important to note that there is an impact of competition regarding how users relate to one another. Generally speaking, assistance is given less often in more competitive settings.