Biotechnology spin-outs at the University of Otago: networks for growth

Stuart King
School of Management,
University of Otago,
Dunedin, New Zealand
E-mail: sking@business.otago.ac.nz

Matthew Belk
School of Management,
University of Otago,
Dunedin, New Zealand

Colin Campbell-Hunt
School of Management,
University of Otago,
Dunedin, New Zealand
E-mail: CCampbell-Hunt@business.otago.ac.nz

ABSTRACT
University spin-outs are increasing in economic importance; yet the process by which these firms develop remains only partially understood. This is a study of four biotechnology spin-outs from the University of Otago in Dunedin, New Zealand. Their lack of resources curtails the extent of their growth. They cannot devote their limited resources to basic science. Moreover, they lack the resources to become involved in the sales and marketing of their products. They must operate in a valley, using scientific research conducted externally to develop commercially-viable products, then passing them off to other companies to distribute. For this reason, networks and alliances with other firms and organisations are essential for the successful growth and development of the university spin-off.

Keywords: Spin-outs, Technology Transfer, Knowledge, Networks

Introduction

In recent times the economic importance of small technology-based firms spun-out from universities has increased significantly; and their creation and development has become a prominent policy issue in many countries (Vohora *et al*., 2003; Lockett *et al.*, 2003). These spin-outs, with their basis in high-level scientific research, are a manifestation of knowledge transfer in action and, as such, are a site for greater understanding the properties of knowledge. Despite this importance, the phenomenon is not well understood. As Debackere and Veuglers (2005) note:

> In the literature on start-ups and spin-offs, careful attempts at matching empirical results and economic theories are still at the pioneering stage. As a consequence, the motives for spinning off in innovative, high-tech industries and the processes governing their formation are not well understood.

Consequently, an 'abundance of research opportunities' exist within this field (Mowrey and Shane, 2002). This paper aims to increase our understanding of the processes by which a firm is spun-out from the university. Four biotechnology spin-outs from the University of Otago in

Dunedin, New Zealand are examined. The histories of these four companies will be studied within the context of international literature, with the aim of revealing the similarities and divergences between their experiences and those predicted in theory. It is intended that this be a prolegomenon to a more expansive attempt at matching empirical results and economic theories in the field of spin-out research.

Theoretical Overview

Nicolaou and Birley (2003) note that, since the pioneering work of Roberts (1968) and Cooper (1971), the number of studies addressing university spin-outs has been limited. This lacuna has been reduced in recent years, in large part due to the increasingly significant economic role these types of firms play. The first section of this paper draws on this expanding literature to construct a theoretical framework of the process by which firms are spun-out from university research.

The development of the spin-out

This paper follows Wright *et al*. (2004) in basing its research upon two streams of literature. Firstly, the stage-based literature, with its focus on the development of the new venture over time. Secondly, the resource based view (RBV) of the firm. According to RBV the resources available to a firm determine that firm's performance (Penrose, 1959; Barney, 1991): Wernerfelt (1984) describes resources as sources of strength and weakness tied semi-permanently to firms. Importantly, as West and DeCastro (2001) draw attention to, lack of resources can be a major impediment to firm development. Wright *et al*. (2004) give the following justification for using these two theoretical constructs in the examination of university spin-outs:

> Through a juxtaposition of these two literatures, a new venture can be viewed in terms of its collection of resources that will need to develop over time if it is to progress through different phases of development.

Vohora *et al*. (2003) use a stage-based and resource-based theory to see spin-out development as a non-linear, iterative process. Their description of the process sees the spin-out go through a number of phases in its history: (1) Research Phase, which involves the perfection of basic research and publication towards a particular scientific community; (2) Opportunity Framing Phase, in which the academic works with the technology transfer office to evaluate the commercial prospects for the research; (3) Pre-Organisation Phase, in which decisions are made about what resources and knowledge should be acquired, where and how to get these, and how to co-ordinate the resources once acquired; (4) The Re-Orientation Phase, in which the spin-out first reaches the marketplace, and engages in a dynamic and 'continuous repackaging' to ensure market fit; and (5) Sustainable Returns Phase, in which the spin-out, having 'addressed many of the early uncertainties via the resolution of its precise business model,' emerges with a firm commercial presence. At the interstices between these phases spin-outs face ''critical junctures' (that need to be overcome) in terms of the resources and capabilities they need to acquire to progress to the next phase.' These critical junctures are (1) opportunity recognition, (2) entrepreneurial commitment, (3) venture credibility, and (4) venture sustainability. To summarise:

Opportunity Recognition

This juncture involves the synthesis of scientific knowledge with an understanding of market application. The key problem at this point is that while academics know a great deal about science, they are often unable to determine potential applications for their science. The ability to both develop scientific advances and recognise a market opportunity is rare in the same individual (Franklin *et al*., 2001; Vallance, 2001; Vohora *et al*., 2004). Differences in an academic's ability to recognise opportunities is often the product of existing knowledge or access to networks (Shane, 2000; Hoang and Antoncic, 2003).

Entrepreneurial Commitment

In this stage the academic moves from entrepreneurial intentions to dedicated activity that will get the fledgling company off the ground. Vohora *et al*. (2003) note that academics have a 'reluctance to accept and live comfortably with ambiguous situations,' a trait that makes them unwilling to accept that the formation of a company is an inherently uncertain process. Moreover, there is a perception that entrepreneurial activity goes against the accepted norms of the academic profession (Vallance, 2001; Oliver, 2004). To overcome this difficulties a 'surrogate entrepreneur' is sometimes appointed by the university's technology transfer office to oversee the commercialisation process (Franklin *et al*., 2001). At this juncture links and networks between industry and the university are therefore highly important (Zucker *et al*., 1998).

Venture Credibility

Here the academic faces difficulty in gaining resources for the firm as they lack business credibility. This is particularly true when it comes to gaining venture capital, with venture capitalist requiring a strong business case before investing. The issue of venture credibility is recurrent in the literature (Colyvas *et al*., 2003; Lockett *et al*., 2003). As Di Gregorio and Shane (2003) observe: 'gathering the necessary resources to found a company to exploit uncertain new technology is easier when the university's status enhances the entrepreneur's credibility.' To mitigate this problem spin-outs seek alliances with established firms, which provide the resources needed for growth.

Venture Sustainability

This juncture involves the ability to reconfigure the business to sustain growth in a dynamic marketplace. For long-term survival in such environment, Vohora *et al*. (2003) stress the need to constantly innovate and develop new products. To this end the ability to reconfigure the business to meet the needs of customers- in terms of organisational structures, routines, policies, etc., are essential. For this reason an alliance with a large existing firm can be

beneficial at this juncture, by providing contact and interaction with consumers, in addition to managerial experience (Wright *et al*., 2004).

Networks and the development of the spin-off

As can be seen, the growth of the spin-off over time faces a number of constraints. These constraints may be loosened by forming alliances with other organisations and firms, and tapping into their resource base. For this reason successful spin-offs display high levels of network activity; and do so at every stage of their development (Hagedoorn, 1993):

> …the biotechnology industry has been identifies as the industry with the highest alliance frequency among several industries characterised by high alliance activity.

At the most basic level Powell and Owen-Smith (1998) have traced an historical change in scientific activity. They see science and collaboration has gone from 'Mode I', in which new discoveries were inside disciplinary areas and linear, to a second mode. In 'Mode II' science:

> … forms of knowledge span disciplines, are more commonly organised through networks than collegial hierachies, and are characterised by rapid, often non-linear development. Consequently, the internal dynamics of science have generated a new system of knowledge production, in which greater inter-disciplinarity and more collaboration.

This has implications for the formation of firms that have their basis in sophisticated technology. Powell *et al*. (1996) argue that biotech firms are high alliance-formers for two major reasons. The first is strategic- given the cost of research and development and the fact that many different groups of researchers are likely to be working in the same area, the risk of not being the first to commercialise a product are great. Alliances with other firms may at least give a share of the return on the intellectual property. The strategic decision to partner in this way is dependant on firm-size relative to other players and its position in the value-chain. The second reason is that learning is a social process, along the lines of Brown and Duguid's (1991) community of practice model. Thus, the firm participates in these communities to cheaply gain information as to what is happening in the field. Powell et al. (1996) write:

> A network serves as a locus of innovation because it provides timely access to knowledge and resources that are otherwise unavailable, while also testing internal expertise and learning capabilities.

However, Decarolis and Deeds (1999) caution against the perception that simple alliance formation will solve the problems of small size, remarking that:

> While the number of alliances represents the number of connections to other research institutions, it does not capture the quality of these alliances, the quality of the partner(s), nor does it capture whether or not knowledge is actually flowing into the biotechnology firm.

Similarly, if a firm is unable to capitalise on the assistance that is gained from the alliance, there will be little return. Powell *et al*. (1996) draw on Cohen and Levinthal's (1990) idea of absorptive capacity, noting that firms need to have a high degree of internal capability to be able to capitalise on their networks. Furthermore, Link and Siegel (2005) argue the absorptive capacity of incubator firms is important in translating knowledge into competitive advantage. Decarolis and Deeds (1999) also refer to absorptive capacity, noting:

> External sources of knowledge are equally critical to innovation. March and Simon (1958) have suggested that 'borrowing' is the catalyst for innovation, not 'invention.' Innovation then, to a large extent, is dependent on a firm's ability to absorb information from the external environment.

Thus, alliances allow a firm to borrow ideas from others to enhance their own products or processes. In this regard Stuart (2000) argues that small firms should partner with large firms with good reputations, a large resource base and an innovative attitude. That way, even if the alliance agreement fails to achieve its objectives, there can still be benefits for the smaller firm.

Networks provide more than just scientific knowledge for the new venture. Rothaermel and Deeds (2004) use March's (1991) explore vs. exploit model of organisational learning to explain alliance behaviour in biotechnology firms. Partly due to the high cost of product development, these firms are often unable to forwardly integrate to independently take advantage of an opportunity. Consequently, they form alliance to exploit a product- the firm

allied with has marketing and distribution competence, for example, and is able to get a product to market faster.

Finally, the need for a spin-off to have a strong network finds reflection in research on the entrepreneur him or herself. Neergaard (2002) examined the importance of the 'alpha' or lead entrepreneur in the growth of new ventures. This person is able to build and use a social network strategically to create and develop a new business. Supporting this idea, the analysis of spin-outs from the Massachusetts Institute of Technology conducted by Shane and Stuart (2002) show that having an existing relationship with an investor make an entrepreneur more likely to obtain funding.

In their development over time small technology-based spin-outs are faced with a number of critical junctures. Networks are important for small technology spin-outs, as they provide access to the resources and capabilities they need to overcome these junctures. As Mustar (1997) puts it:

> The driving force behind the creation of a high-tech enterprise comes from the network . . . researchers who create their own businesses have little in common with the heroic and solitary Schumpeterian entrepreneur. To succeed they need to be integrated into networks allowing interaction between a wide variety of actors.

Research Findings

Methodology

This paper uses the case study method of research, according to the approaches suggested by Eisenhardt (1989) and Yin (1989). As Chetty (1996) has argued, the case-studies method overcomes some of the difficulties of conducting research in a country like New Zealand, where small sample sizes make quantitative methods problematic. Moreover, for a study focused on change over time, the case study method is particularly important as it allows us to see events occurring in their proper context. As Goodman and Kruger (1988) note, historiography provides a strong approach to theory development.

The case studies are based on the fullest possible range of data, including interviews with senior managers who were involved with the companies at the strategic level for a since founding. To complement this, exhaustive searches of all publicly available data about the companies were conducted. Such rigour is necessary to avoid some of the key problems associated with the historiographical approach: most notably, the limited reliability of primary sources.

AlphaTech[1]

AlphaTech was formed by a group of Dunedin-based businessmen and biochemists in the late 1980s as a commercial outlet for Dunedin's scientific and technological expertise. At the time of interview, the firm manufactured two major products - a kit used in diagnostic testing developed in conjunction with the School of Medicine in Christchurch; and a probe used to detect particular fungal infections developed in collaboration with the University of Otago. The second of these products has been subsequently sold-off.

Founder 1 believes success in business is a matter of 'identifying where all your strengths are and sticking with that'. His company's business model is focused on exploring and exploiting new scientific knowledge, pursuing and developing a number of these opportunities to a certain stage of commercial development, then selling some off to focus on those that best fitted their resources and capabilities. As a relatively small company it is unable to become involved in underlying scientific research itself, and must instead leverage off work conducted at larger organisations; in this case primarily the University of Otago.

Manufacturing is as far down the chain as AlphaTech is able to remain involved- it cannot be involved with the marketing and distribution of most of its products. The diagnostic kits are

[1] The identities of the studied firms have been disguised pending their authorisation. All quotations in this section are taken from interviews conducted with the company's founder in 2005. It is hoped that in subsequent drafts this disguise will be removed.

an exception- they are sold directly over the internet through word of mouth. But that is a niche market- they go out ‘to university research institutes throughout the world’- and this method of sales is not typical. Most of the time AlphaTech products are sold through large third-party distributors: a vaccine being sold to the U.K., for example, goes through industry giant Schering-Plough. This results from the fact that the scale of international biopharmaceutical sales is such that it rules out participation by any but a small number of large firms: ‘the scale of distribution involved… it’s just not a game you can play. We can’t do anything else.’ Moreover the regulatory burden faced by biotech companies presents the small firm with large difficulties in building international markets. Lacking the resources to be involved in either research or marketing, the company must, as the literature predicted, seek out alliances with larger firms.

BetaTech

BetaTech was founded in 1999 as a 50:50 venture between a large primary-sector producer and Founder 2, to commercialise research in the field of food quality and traceability. In 1986, Founder 2 entered into a partnership with an external research organisation to establish a specialist unit at the University of Otago. The unit was created to ‘piggy tail’ on U.S.-led research in human genetics, applying the research data to farm animals. The unit developed over the subsequent decade and was soon on the forefront in the application of gene maps for agricultural and biomedical research. While working on this project, Founder 2 became increasingly frustrated: he was ‘disappointed that nobody picked our discoveries up and moved them on.’ He was always searching for ways in which commercial applications could arise from scientific knowledge, stressing themes of convergences and serendipity:

> But if you look at the last big leap that was the IT [Information Technology], but when you look very, very carefully at it what was, how did that happen? Well you have all these roots don't you. You have physics, chemistry that made this, the space program. You had satellite technology and they were all quite disparate and they were all hatching here, and there was the convergence. And people saw the convergence. But there's a lot of serendipity as well. So you say well 'Where the hell's the next convergence? Because I want to be on it, and I want to create the wave, I might live to see it but let's start something.'

An academic's ability to recognise opportunities is often the product of existing knowledge or access to networks (Shane, 2000; Hoang and Antoncic, 2003)- and Founder 2 partially attributes his determination to spot an opportunity for a commercial-viable product to doctoral work conducted with world-leading scientists at Cambridge University. It was at this critical juncture that he came in contact with the chief executive of one of New Zealand's leading primary-sector exporters. The comany was able to provide Founder 2 with the resources he needed to take the ideas generated at the University and use them for the benefit of the New Zealand farming sector.

A lack of credibility in a global marketplace means BetaTech needed to seek out partnerships: 'We have to get to market, you have no credibility… You've actually got to hold hands with someone.' The only way Founder 2 sees BetaTech as having a presence in the international market is 'to find a major manufacturing distribution partner.'

GammaTech

GammaTech was founded in 2001 to commercialise intellectual property developed at the University of Otago. It combines expertise in cancer genetics developed at the University of Otago, with an international network of clinical collaborators. As biotechnology is an example of what Powell and Owen-Smith (1998) term Mode II science, this international network is very important for the research underlying the companies activities. GammaTech has a number of formal scientific collaborations with researchers at Universities in Korea and Japan. It also maintains an agreement with the University of Otago giving it access to new

intellectual property in the fields of 'human genetics and cancer research.' These agreements allow the company to cheaply access a constant stream of new knowledge generated at the University's research laboratories; knowledge that they would not be in a position to otherwise gain.

The company builds on the knowledge it acquires in the field of cancer genetics to develop cancer diagnostic products. GammaTech's strategy is to align itself 'with the leading blue chip diagnostic companies… who provide lab technology to the world clinics.' They provide these companies with the immunological data needed for that technology to diagnose particular kinds of cancer. It is vital for a small company such as GammaTech that relationships with these international players are maintained: 'If you don't have them you're not going to last very long- it's just a completely global net.'

DeltaTech

Founded in 2001 to commercialise research on biological control agents developed at a state-owned Crown Research Institute. Funding for the basic science came from interested parties in the New Zealand primary sector. Once the underlying research was complete, the product was taken up by existing Otago spin-out, AlphaTech. This company used its knowledge and networks at the university to develop the scientific knowledge into a commercially-viable product.

DeltaTech has tremendous potential as an export product. However, Founder 4 admits the company lacks the resources to involve itself directly in off-shore marketing:

> [w]e have never envisaged that [DeltaTech] the company, based in Dunedin, as small as we are, will have 40 [DeltaTech] representatives in Citroens running around France bringing the product out of the boot. What we need is an international partnering arrangement with Bayer, AGM, Lever-Kusen, Sumitomo group in

> Japan… and [DeltaTech] becomes a very critical important part of a stable of products, where the field representation, the marketing grunt, the local knowledge about climate and how to do business in the nooks and crannies of France and Italy and so forth have become more relevant to make the product's success.

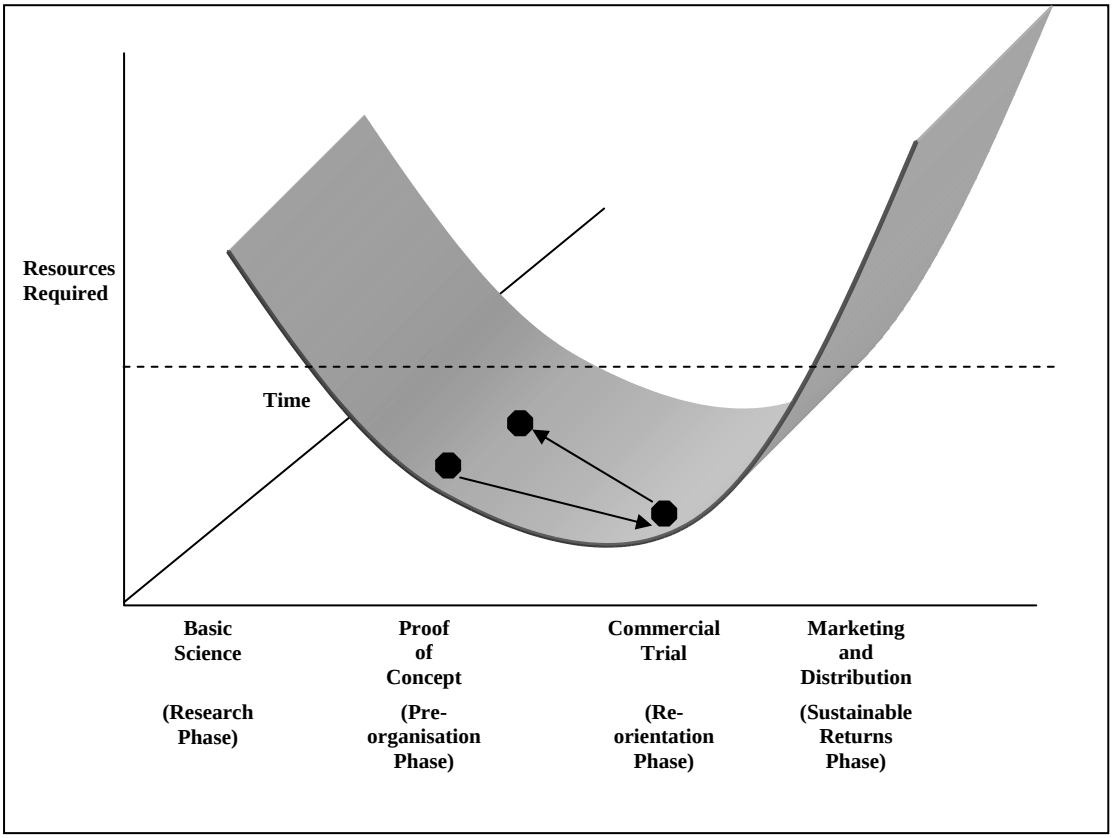
As with all the spin-outs examined, a lack of resources constrains the company's growth. It must seek alliances with larger established companies to overcome critical junctures in its development and reach a sustained level of growth.

Conclusion

The histories of the four spin-outs provide both support and challenges for the theoretical ideas that we have outlined. It is quite clear in these cases that networks and alliances were important in allowing companies to gain the resources they needed to overcome critical junctures in their history. BetaTech provides the clearest example of this. To return to the model of Vohora *et al.* the Research Phase of BetaTech's history starts with Founder 2's work at the University, in which he was always looking for a scientific idea that could be developed commercially. This ability to recognise an opportunity was a consequence of his personal experiences and knowledge, and took him past the first critical juncture, to the opportunity framing phase. It was at this point that he allied himself with a leading New Zealand primary-sector producer. This company provided the resources, credibility and market knowledge to help him develop his products and reach the re-orientation phase. As yet the company is too young to fully determine if it can continue the constant innovation needed to reach a stable existence in a dynamic marketplace.

AlphaTech provides an example of a company that does seem to have reached that phase in its existence. It looks through research conducted at universities and research institutes, using the capabilities and experience it has acquired to recognise an opportunity to commercially exploit an idea. That idea is turned into a product, which is then passed onto a large firm to be delivered to the market. AlphaTech lacks the resources to conduct research or sales itself.

Figure 1: Development of the Biotechnology Spin-Out over time



This is a core idea that arises from the examined spin-out companies. A small company lacks the resources to conduct basic science and marketing and sales itself, and must form alliances with research institutes and multi-national companies. We represent these constraints in Figure 1 by showing the resource portfolios required by the spin-outs to preclude activity both upstream and downstream from the commercial trial phase where these firms are located. The dotted line in this graph shows the amount of resources available to the firm. Any stage in the process of innovation that lies above it, such as basic science, is not a stage the firm can become directly involved in. The curved line represents the amount of resources required by the company at each stage in the process of innovation. Its shape is the function of relative difficulty of these different stages. The nature of basic science requires a large amount of resources, which can often only be provided by research institutes or universities, with the help of government or industry-wide funding. AlphaTech, for example, is a highly-innovative company: but its innovations were built from ideas first generated at Universities.

GammaTech seeks networks with a range of international universities. The companies can only afford to conduct research where proof of concept already exists.

Likewise, the international distribution and marketing of the scientific products requires the level of resources that only a large well-established company can offer. Most AlphaTech products are sold internationally through large third-party distributors, such as industry giant Schering-Plough. Founder 2 states that BetaTech needs a 'major manufacturing partner' before they can build markets overseas.

Most of the companies studied are too young to know if they are capable of reaching the sustainable returns phase of their development. Nevertheless, based on the model sketched here we are able to speculate on how this stage might be reached. Sustainable returns requires the ability to constantly innovate and develop new products (Vohora *et al*. 2003). To do so the company must go back to basic science, taking with them the knowledge gained of the marketplace. This model can be presented metaphorically, as a skateboarder's half-pipe, with the company founder as the skateboarder. Using basic science to discover something new, the entrepreneur pushes off. Putting this new idea through commercial trials, the entrepreneur incorporates knowledge from the market, and swings back towards the basic science stage to improve the product. This improved product is then taken out to the major marketing and distribution stage. The feedback from the international marketplace gives the innovator the momentum to skate back towards the basic science stage, to either continue to improve the existing product or create something new. To make this process of skating back and forth easier, the entrepreneur must seek out shallow valleys instead of canyons: that is to say, fields where their resources are such that they can become more directly involved in either the basic science or marketing stages.

Examination of the history of these four biotechnology spin-outs supports a number of ideas. In their development over time small technology-based spin-outs are faced with a number of

critical junctures. Small companies lack the resources to get involved in basic science or in marketing and sales. Therefore they must seek alliances, leveraging off scientific research conducted at research institutes and universities, and taking advantage of the credibility and experience offered by large firms that are well-established in the marketplace. Networks are important for small technology spin-outs, as they provide access to the resources and capabilities they need to overcome the critical junctures in their development.

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