Towards an Understanding of the Internationalisation Process of High-Tech SMEs:

A Case Study of Biopharmaceutical Firms

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Abstract

In this paper, we revisit the topic of the internationalisation of high-tech firms, an area of inquiry that in recent years has been dominated by interest in the 'born global' phenomenon and the applicability of the Uppsala Model. We analyse the internationalisation process of two biopharmaceutical firms over a 20-year period, seeking to understand their pattern of inward and outward international activities. We argue that recent revisions to the Uppsala Model as proposed by Johanson and Vahlne (eg., 2006) can be used to understand the internationalisation of the case firms, but additionally suggest two refinements, that of technological uncertainty and technological development.

Introduction

Interest in the internationalisation of high-tech firms has accelerated since the 1980s, with high-tech firms commonly regarded as following 'born global' internationalisation paths. In particular, debate has centred on the question as to whether the 'Uppsala' model of internationalisation can account for the rapid and early internationalisation of these firms. This debate remains unresolved, while at the same time other dimensions of the high-tech firm's internationalisation process have received little attention. It therefore remains an open question as to how, if at all, high-tech firms constitute a 'special case' of internationalisation. Accordingly, in this paper we revisit the question of the internationalisation process of high-tech firms.

In this paper we proceed by reviewing existing literature on the internationalisation of high-tech firms. We argue that a review of existing empirical evidence and theories on the internationalisation pattern of high-tech firms reveals that while some consensus has emerged, contradictory findings and incomplete explanations remain. We then turn to our empirical evidence, which consists of an intensive comparative case study of the internationalisation path of two SMEs in the biopharmaceutical industry. Our analysis covers the inward and outward cross-border activities maintained by each firm since its beginnings, a period spanning over 20 years. Our analysis leads us to propose two contributions to the debate surrounding the applicability of the Uppsala Model. First, we argue that existing literature applies the original model as proposed in 1977, rather than the revisions to the model which include the role of networks and opportunity development – both of which are critical to an explanation of the internationalisation of our case firms, and in particular the process of technological development. Second, we argue that our case evidence pinpoints the role not just of market uncertainty, but also of technological uncertainty. We propose that technological development and technological uncertainty are two dimensions of the internationalisation process of these firms that are directly related to their high-tech nature, and that assist in explaining the interplay between knowledge and commitment that we observed. We conclude by suggesting future directions in terms of providing a more holistic perspective on the internationalisation process of high-tech firms.

Literature Review

The internationalisation of high-technology firms emerged as a separate topic in the late 1980s and early 1990s. Key contributions and their main findings are summarized in Table 1. Increasingly, research into the internationalisation of high-tech firms has sought to test or develop the 'born global' model. The association between the 'born global' and high technology firm came early on and has persisted. In a widely quoted definition, Knight and Cavusgil (1996) explicitly state that born globals are 'technology-oriented' SMEs. Some researchers define born globals as 'knowledge intensive firms' (Sharma & Blomstermo, 2003) or argue that high-technology firms internationalise more rapidly than their low-tech counterparts (Crick & Spence, 2005). McAuley (1999) noted that the born global literature has been dominated by high-tech examples. A recent review of the 'born global' literature observed that

> The new venture internationalization conceptual approach seems to be better suited to describe and explain the early internationalization patterns of particularly smaller knowledge-intensive firms (i.e. technology-intensive, new businesses) (Rialp, Rialp and Knight 2005, p. 159).

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Table 1 about here

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A dominant theme in this research stream is the extent to which high-tech firms follow an evolutionary, incremental path to international growth as suggested by the Uppsala internationalisation process model (e.g. Bell, 1995; Burgel & Murray, 2000; Hashai & Almor, 2004; Larimo, 2003). In other words, to what extent do high-tech born

globals represent an exception to (or even refutation of) the Uppsala Model? Opposing perspectives can be found. Burgel and Murray (2000) concluded that experiential knowledge was of limited value in explaining the entry mode choices of high-tech firms, while Bell (1995) argued against an incremental 'stage' model holding in the case of small software firms. However, other researchers have argued that even 'early and rapid' internationalisation involves a gradual escalation in market commitment (e.g. Hashai & Almor, 2004; Larimo, 2003).

An attempt to steer a middle course between the challengers and defenders of the model is to argue that it needs to be supplemented rather than replaced. Coviello and Munro (1997) proposed that integrating existing theories would provide greater explanatory power: thus, the internationalisation of high-tech firms can best be explained by combining the Uppsala and network models. Researchers into the internationalisation pattern of high-tech firms have gone beyond the traditional elements of the Uppsala Model – experiential learning and incremental market commitment – and proposed other drivers: the entrepreneurial characteristics of founders (e.g. Andersson & Wictor, 2003; Crick & Jones, 2000), their social and professional networks (e.g. Crick & Spence, 2005; Moen, Galven & Endresen 2004; Sharma & Blomstermo, 2003) and contingency factors external to the firm (Burgel & Murray, 2000; Crick & Jones, 2000). Crick and Spence (2005) have gone so far as to suggest that the internationalisation of high-tech firms is simply non-linear and unplanned, marked by serendipity and chance: that in short, there is no consistent pattern to the internationalisation process.

The growing dominance of the 'born global' explanation has a number of potential limitations. First, researchers need to be careful not to assume that, just as not

all born global firms are necessarily high-tech, not *all* high-tech industries are conducive to the emergence of born globals. Biotechnology has been suggested as one such industry, with Bell, McNaughton, Young and Crick (2003, p. 353) commenting that 'in pharmaceutical or biotechnology sectors, the time scale for new product development may be 3-5 years or longer, during which time costs are being incurred without a supporting revenue stream'. One study – McDougall, Oviatt and Shrader (2003, p. 76) – indeed provides some evidence that the 'drug-related' companies in their sample, 'although poised to become international, had not taken that leap by their sixth year of existence'. Other authors found that multiple pathways are taken by high-tech firms, only one of which is the 'born global' pattern. Thus, Jones (1999) identifies four distinct pathways, while Stray, Bridgewater and Murray (2001) propose three separate types of firms based on their internationalisation patterns. It is still not clear why some firms take the born global path while others do not – and it also raises the question as to whether it is meaningful to study high-tech firms as a distinct category of internationalisers at all.

A second problem is that the 'born global' model is a partial theory of internationalisation, which focuses primarily on the timing and speed of international sales. A more holistic perspective that considers other dimensions – such as market selection, sequencing of entry mode choices and other international activities beyond sales – is rare. One exception is Jones (1999; 2001), who focuses on a wide range of both inward and outward activities, and on different activities in the value chain rather than just sales. In her 2001 study, she found that while exporting and importing were the most common form of cross-border activity, production and research linkages were also important. Research linkages are of potential importance for high-tech firms, so one

implication of Jones's (2001) findings is that any study of the internationalisation process needs to shift from a focus on the timing of first international sales.

A final problem with the 'born global' debate is that it has been framed in opposition to the original Uppsala Model proposed in 1977, but this model has since been developed and refined in later contributions. Two important refinements to the model have been made since 1977. The first is that Johanson and Vahlne (1990; 1992; 2003) have 'tied' their model to a business network perspective (Johanson & Vahlne, 2006, p. 166), according to which internationalisation is a process of building relationships: firms do not commit to a faceless market, but to other firms, in the process learning from, with and about their business partners. Once internationalisation is conceived as a process of 'relationship' commitment rather than 'market' commitment, it follows, then, that 'the concept of a "country market" is no longer seen as a valid unit of analysis' (Johanson & Vahlne, 2006, p. 166). The second alteration is to emphasise that experiential learning does not just alter a firm's decision-maker's perception of risk, reducing uncertainty, but also alters their perception of opportunities, allowing them to identify and co-create opportunities that would not have been open to them without their international involvement. This entrepreneurial process of opportunity development – of identifying, reframing and creating new knowledge with business partners – is, they argue, the driver of internationalisation, while uncertainty reduction 'puts a check on the process' (Johanson & Vahlne 2006, p. 168). In the course of revisiting the model, they also clarify that it does not constitute the establishment chain or psychic distance – rather, these were the empirical phenomena that they observed, which they then explained in terms of 'the

interplay between knowledge development and increasing foreign market commitments' (Johanson & Vahlne, 2006, p. 166).

These revisions to the Uppsala Model address key criticisms in high-tech studies: that it does not account for the role of social and business networks or entrepeneurship, or that the 'establishment chain' and psychic distance do not hold for born globals. These extensions to the model also provide for a holistic perspective on internationalisation, potentially accounting for a wide range of possible foreign market commitments and of inward-outward connections. This 'later' Uppsala Model will therefore be used as a framework for analysing the internationalisation of high-tech SMEs. It would be expected that the insight that experiential learning is a process involving not just uncertainty reduction but also opportunity development – combining knowledge and resources to attain new markets and knowledge (Hdjikhani, Ghauri & Johanson, 2005, p. 11) would be of relevance to explaining knowledge-intensive, high-tech firms. The question still remains, however, as to how knowledge and commitment develops in high-tech SMEs. How does their high-tech nature affect this process? We now turn to our empirical study of biopharmaceutical SMEs in order to investigate the internationalisation of high-tech firms in depth.

Methodology

The empirical research reported here is part of a larger and ongoing study into the internationalisation of the Australian biopharmaceutical sector. For the purpose of this

paper, we present findings from an in-depth retrospective longitudinal case study of two biopharmaceutical firms. Case studies have been widely used in the existing born global and international entrepreneurship literature (see Coviello & Jones, 2004 for a review), as they allow the researcher to 'undertake complex and rather context specific issues' (Rialp et al., 2005, p. 155). Our research aims suit the strengths of a case study, as we are seeking to understand the evolution of the firm through time and to understand the context of a specific industry sector. We have chosen the biopharmaceutical sector of the biotechnology industry as it relies on highly advanced and complex technological innovations, yet has not been intensively studied in previous research on high-tech internationalisation – despite the fact that it is expected not to conform to a straightforward 'born global' model. Thus, it was expected that the biopharmaceutical industry would provide a research setting where the 'process of interest is "transparently observable"' (Eisenhardt, 1989).

The case firms, BresaGen and GroPep, were chosen as they both had a track record of internationalisation over an extensive period of time, since 1982 and 1988 respectively. They both seemed to have a typical profile of an Australian biopharmaceutical company, in that they were a spin-off from public institutions. They were comparable yet contrasting: they had similar origins and both were the subject of friendly takeovers in 2006, yet GroPep was more successful than BresaGen, which suffered a period of voluntary administration. They were also selected as extensive access to company informants was possible.

Two types of sources were relied upon for data collection. The first source consisted of publicly available records for both firms, which amount to thousands of

pages spanning over a 20-year period, and which include each firm's prospectus, annual reports, patent records, legal registrations, coverage in the daily press, and industry publications. The second source is in-depth interviews with key company and industry participants. Eight interviews have been conducted with current or former staff or associates of GroPep, 12 from BresaGen, and two informants who were connected to both firms but not employed by them. Interviewees have ranged from the ex- and current CEO of each firms, the chief research scientist, business development managers, patent holders of in-licensed technology, legal counsel and company marketing and science representatives. Care was taken to include interviewees from different time periods of the firm's operations and who were involved in their firm's internationalisation decisions.

The results of the data analysis follow. Analysis commenced with a detailed chronology of each case firm being complied, which is not included in the paper due to space restrictions. Care was taken to include information about each firm's pre-inception period, the careers and social networks of key individuals and the development of each major innovation of the firm. Domestic and international linkages were identified and international activities were coded according to their type (e.g. sourcing, in- or out-licensing, R&D agreement). Both interviews and documents were important in tracing the main foreign market commitments: typically, the facts of agreements could be found in documents, whereas the 'how and why' of the deals were provided by interviewees. Occasionally sources would conflict, most commonly because several people claimed credit for initiating an agreement. Any differences were cross-checked and reconciled if possible, or otherwise the different explanations were recorded. Case descriptions were also sent to key informants for factual verification. Condensed summaries of the coding,

in the form of a brief description of each foreign market commitment, are presented in Tables 2 and 3, and form the basis for the next section.

Case evidence

The two firms under study, GroPep and BresaGen, have similar origins as spinouts from the same university in Australia, the University of Adelaide – indeed, some of the key scientists were involved in both firms in their early stages and BresaGen was the initial owner of GroPep's first parcel of intellectual property. Incorporated in 1982, BresaGen was one of the first commercial spinouts owned by the university and was among the earliest wave of biotechnology firms founded in Australia. It listed on the Australian stock exchange in 1999 and over its period of operation accumulated a diverse product and patent portfolio. The firm experienced some major changes in technological and strategic direction and in 2004 went into voluntary administration, although it was able to relist in the following year. The cross-border activities of BresaGen from its first commercial agreements until its takeover by a US firm in 2006 are shown in Table 2, together with its domestic agreements.

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Table 2 about here

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GroPep was set up as an independent entity in 1988 as the commercial vehicle for a collaborative research program between University of Adelaide scientists and their colleagues at another research institute, CSIRO. The firm listed in 2000 and was largely profitable during its history, apart from a difficult period following a domestic acquisition in 2002. GroPep's cross-border activities, listed in Table 3 along with its key domestic agreements, commenced with the licensing of intellectual property to Genentech that was the catalyst for forming the new venture, and concluded with its friendly takeover by a Danish firm in 2006.

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Table 3 about here

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Uncertainty reduction and learning

The internationalisation efforts of both BresaGen and GroPep were focused to a large extent on the USA, with other developed markets in Europe, such as the UK, and Japan also of importance. Of the 27 inward or outward activities identified during Bresagen's development until 2006, 18 involved agreements with US collaborators, licensees, distributors or financiers; as well, all the firm's FDI activity, in the form of a greenfield investment and two mergers and acquisitions, took place in the USA (Table 2). In the case of GroPep, 12 out of the 18 inward or outward activities up until 2006 involved US partners (Table 3).

While the USA is culturally close to Australia, its dominance was, as could be expected, largely not the result of the firms' decision-makers seeking to reduce 'market' uncertainty by selecting a foreign market with low cultural or psychic distance from their own. For a start, cultural distance was perhaps of less relevance in an industry that was bound by a strong, unifying professional culture: key figures had all received similar scientific training, had often spent time in laboratories abroad, attended the same conferences and published in the same journals, and were known to each other either by reputation or on a personal basis. Of more relevance were other institutional factors: above all, the structure of national innovation systems, with the USA the industry leader in technological, regulatory and financial terms. Key patents and innovative capabilities were developed in the USA; the US Food and Drug Administration (FDA) was the regulatory gatekeeper to the largest pharmaceutical market in the world and a powerful influence on other regulatory authorities; and the US venture capital market was the world's most sophisticated at a very early stage in the industry's development. The dominant position of the USA in the industry was reflected in the personal careers and networks of the key decision-makers in both case firms. For example, the founder of GroPep had been a postdoctoral researcher in the USA and the managing director of BresaGen had spent a large proportion of his career there. This increased their familiarity with key players in the US biotech industry.

Beyond these cultural and national differences, it can be seen that the market uncertainty faced by both case firms took particular forms due to industry factors. The case firms were mainly selling intangible intellectual property and niche industrial products and services: they were seeking partners to exploit and further develop their

innovations. Potential partners were in the form of research institutes, other specialised biotechnology firms and established pharmaceutical companies. Many of these potential partners were already known to the firms' managers: key players in the industry were linked through common scientific interests. In the 1980s and early 1990s, the industry was yet to enter into a period of consolidation and was more fragmented and dispersed than today; nor had the larger companies developed systematic mechanisms for 'talent scouting' promising technology. In this context, personal contacts were important means for identifying potential partners, reducing search costs and market uncertainty (at least 21 of BresaGen's agreements were facilitated through personal connections and 15 of GroPep's). However, market uncertainty remained even when a promising partnership had been negotiated and a deal signed, with plans for cooperation possibly disrupted when one of the partners changed corporate direction. For example, Smith & Nephew decided that the research collaboration with GroPep (#15, Table 3) did not fit its core business, although it then helped facilitate a deal with an alternative partner, Nestlé (#16, Table 3).

However, uncertainty for the case firms did not just take the form of 'market' uncertainty: it was compounded by extraordinarily high technological uncertainty. Lead-times were lengthy, promising drug discoveries were more likely to fail than not, and the innovation process was non-linear and difficult to predict. For example, GroPep established a pharmaceutical drug development business in 1998 to develop drug candidates through Phase I and II clinical trials, with the aim of then on-licensing them to larger multinational companies with the capabilities to take them to larger scale Phase III trials. However, by 2005 work on 6 of the 8 products had been discontinued due to

inconclusive or negative results (e.g. #18, Table 3). The technology was also difficult to value because its veracity could be hard to confirm even for those with the required scientific training. This was the case with BresaGen's outlicensing agreement in 2000 with British Biotech (#22, Table 2), who found that they were unable to replicate earlier published data. Even if a research program yielded promising results, it could be trumped by a competitor elsewhere in the world or blocked by unfavourable or uncertain legislation (as occurred with BresaGen's xenotransplantation project, e.g. #20, Table 2).

This high level of uncertainty had a number of effects on the firms' internationalisation patterns. First, the non-linear nature of technological innovation was reflected in the punctuated succession of deals that were signed. Agreements were potentially not renewed or new ones were signed, depending on research results. Second, the high degree of risk provided an impetus for collaboration. Collaboration was necessary to share risk and underwrite exorbitant development costs, with both GroPep and BresaGen very dependent on milestone payments to continue their research programs. Collaboration was also important in cases where another organization was developing similar technology, leading to a situation where both firms were in danger of violating each other's patents and blocking each other's freedom to operate (this dilemma was faced by GroPep, which was however able to in-license the required technology and therefore save several years of development, #22, Table 3). Third, the high degree of uncertainty led to a reliance on personal trust and reputation in many cases: given the outcome of a research program would possibly not be known for many years, agreements were at least partly based on an assessment of the quality of the research team involved. Market learning – in the form of experiential knowledge about the suitability of potential

partners and their objectives – did therefore go some way in assisting firms to manage the high degree of technological uncertainty.

Rapid and early internationalisation?

At first glance, GroPep and possibly even BresaGen might be termed 'born global' in the sense of early and rapid internationalisation. GroPep's first deal was an international licensing agreement in 1988, the same year it was incorporated (#1, Table 3). This was not a coincidence, as the licensee, Genentech, insisted on contracting with a single commercial entity rather than the consortium of public institutions whose scientists held the patents. Its first international product sales – reagents for use by research and teaching laboratories – occurred in 1991, three years after incorporation. The market for reagents was overwhelmingly international, as was their later cell culture business. BresaGen was initially established with the modest aim of import replacement, only seeking out international licensing agreements from 1985 onwards (#3, 6, 7, Table 2), following the discovery and patenting of a new product with global potential.

However, measuring the firm's inception from the point of legal incorporation is somewhat misleading in this situation, where a very long product development cycle (R&D and commercialisation) preceded any commercial activity. Both firms were the commercial face of long-standing scientific ventures that only took the step of registering a company once they had a product or patent ready to trade. These commercial entities remained shell companies for many years. GroPep was initially nothing more than a trading name – an administrative convenience for a group of researchers spread across

two different public institutions. At this stage the firm had no full-time employees and was not seeking to make a profit. In 1991, the firm became the commercial arm of a research centre, so it was funded by the centre (largely through grants from government and the partners in the research centre), did not have to carry the expense of its own research labs and did not even have a full-time managing director until 1999. The company therefore only became an independent entity following its IPO in 2000. For its part, BresaGen (originally called Bresa) was attached to a university department and, like GroPep, was able to call on university resources. Initially it had one employee, did not have to pay occupancy or R&D costs, and its first full-time managing director was appointed only in 1987. Because the organizational and technological development of both case firms was so protracted, the acquisition of market knowledge preceded full-scale commercial activities. Commercial activities were scaled up only slowly, with a consequently modest advance in terms of internationalisation.

At the same time, GroPep's and BresaGen's domestic linkages – 23 for BreaGen (46% of the total, Table 2) and 9 of the total for GroPep (33% of the total, Table 3) – should not be discounted. GroPep itself was the result of a cross-institutional collaboration, and it derived much of its strength from the fact that the core partners endured over time. As well as sourcing R&D and marketing partners domestically, the company was overwhelmingly dependent on domestic sources of finance. During the period of the research centre's operation, funding was largely from public sources; and even when the company listed on the stock exchange, its major shareholders were overwhelmingly local. Moreover, domestic credibility and recognition was a critical step towards the international standing that would attract overseas partners. BresaGen

similarly relied heavily on domestic sources of financing and also sourced much of its intellectual property from domestic institutions.

Choice and sequence of foreign market commitments

Tables 2 and 3 specify the different types of foreign market commitments that the case firms undertook during their history. The agreements consisted of, or combined one or more of, the following: R&D collaboration, licensing, marketing, active pharmaceutical agreement supply, contract manufacturing or development, and different forms of investment (FDI, minority, greenfield, mergers and acquisitions). Of Bresagen's 27 international activities (inward or outward), 7 were investment related, 6 for R&D, 7 licensing or licensing/marketing, 4 marketing or marketing/manufacturing, 2 contract development and one an active pharmaceutical ingredient (API) supply agreement (although the latter such agreements are highly confidential so it is probable that more such agreements were signed but not reported). Of GroPep's, 10 were R&D collaborations, 2 marketing, 2 licensing, 2 for contract development or manufacture, one was investment related and one an API supply agreement (the latter's details were publicly speculated on but not publicly confirmed by the company). Unlike GroPep, BresaGen was active in pursuing FDI opportunities at a later stage in its internationalisation, but this was driven at least in part by the fact that its stem cell program could not proceed in Australia due to restrictive legislation.

An explanation for the firms' choice of agreements lies first of all in the product innovation process. If the technology was at the early, discovery stage or was still

proceeding through clinical trials, an R&D collaboration would be set up. If intellectual property existed, licensing would be involved; if a saleable product was ready for market, a marketing and/or manufacturing agreement could be signed. Some agreements could be renewed and last for many years, with one party provided the option to acquire licensing and marketing rights at a later stage if a saleable invention were to result from the research collaboration. If the technology was successful, the sequence from research collaboration to licensing to manufacturing and marketing could be followed. However, because of the high failure rate, many collaborations would either be abandoned or amended, reappearing at a later stage in a different form. Seemingly unconnected agreements were in fact linked through similar technology: for example, BresaGen's activities in xenotransplantation, which were wound up due to a regulatory environment hostile towards genetically modified food, were used to provide the basis for the firm's later focus on human stem cell research. The firms were also trying to balance diverse product portfolios at different stages of development: ultimately, GroPep proved successful in producing a revenue stream from its industrial products, while BresaGen struggled to generate cash following its sale of its reagents business in 1995, only finding a more constant revenue stream from contract development (#41-49, Table 2) following its period in voluntary administration.

At the same time, the exact nature of the agreement signed with an international party was also influenced by other factors: the relative bargaining power of the parties, which often put the case firms at a disadvantage; resource constraints, with the firms driven to potentially unfavourable agreements due to high cash burn rates; competitive threats; and personal connections and networks. Thus, the nature and sequencing of

international activities were dependent on the firm's innovation path, but was not pre-determined by it. Equally, each firm's series of international agreements then had a feedback effect on their technological development, with research programs that received milestone payments, intellectual property or expertise from a collaborative partner more likely to continue than those unable to attract collaborators. Thus, the case firms' internationalisation record could very much be characterized as one of dynamic opportunity development: of combining technological resources across borders to develop pharmaceutical innovations and applications.

Conclusion

Our case analysis of the internationalisation process of two biopharmaceutical firms has proceeded by using the 'later' Uppsala model as a framework. As the model would suggest, it was more meaningful to analyse relationship commitment than market commitment, as firms were choosing partners rather than choosing national markets – although country borders were not insignificant, due to the influence of national innovation systems and changes in legislation on partner selection. A holistic perspective was important, as research collaboration and licensing were more common than the sale of finished products. When expanding internationally, the firms needed to balance uncertainty with the exploration and exploitation of their technological potential. The firms proceeded incrementally, held back as much by the slow progress of technological innovation as by resource constraints. Thus, while their internationalisation appeared to

follow a ‘born global’ pattern, this is because lengthy innovation lead times meant that much of the foundation for their early cross-border activities had been laid before the firms were legally incorporated.

Our analysis has also led us to clarify important influences on the firms’ internationalisation, notably technological uncertainty and technological development. While uncertainty in the Uppsala Model is generally associated with uncertainty surrounding foreign markets (what we have termed here ‘market uncertainty’), the two case firms also had to contend with a high degree of ‘technological uncertainty’ that affected their internationalisation process. Ultimately, the firms and their partners were trading the unknown: they were not able to predict what the final outcome of their R&D programs would be. At the same time as technological uncertainty shaped and constrained their choices, the process of technological development was a strong influence on the pace and direction of internationalisation – and, at the same time, the firms’ internationalisation decisions had a feedback effect on their innovation pathways. Thus, while the key mechanisms of knowledge development and market commitment can be observed in the internationalisation of both case firms, they evolved in distinct ways due to the nature of the technology involved.

The in-depth, intensive nature of our comparative case study, which enabled us to trace the firms’ key market commitments over a 20-year period, has allowed us to examine the nature of market commitment and knowledge development in considerable detail. However, it does not allow us to generalise to other biotechnology firms (especially firms that were not spinouts or that specialize in medical devices rather than drug development), let alone to other high-tech industries. But the conclusion we can

reach from our data is that the high-tech nature of these firms did affect their internationalisation behaviour. Thus, the case firms were a 'special case' of internationalisation, but one that can be explained within the framework of the 'later' Uppsala Model. It would therefore be worth exploring in further research whether technological uncertainty and technological development affects the behaviour of other high-tech firms. Given the highly advanced, even speculative nature of the technology involved and the lengthy innovation times, the biopharmaceutical industry may well constitute an extreme case, and if so, high-tech firms' internationalisation patterns will vary according to the degree of innovativeness that their technology entails. This study has therefore raised additional questions and offered new concepts for a future research agenda into the internationalisation of high-tech firms.

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Table 1: Key studies on internationalising high-tech firms

Author(s)/date	High-tech sector studied	Key findings
Almor and Hashai (2004)	Telecommunications, electronics, software, pharmaceuticals, biotechnology, medical	Knowledge intensive small and medium-sized multinationals are likely to internalise R&D and marketing activities while externalising production
Andersson and Wictor (2003)	Medical and IT*	The individual entrepreneur is the main factor explaining the Born Global phenomenon
Autio, Sapienza and Almeida (2000)	Electronics	The earlier the firm internationalised and the greater their knowledge intensity, the more rapid was their international growth; however, imitability was positively related to international growth
Burgel and Murray (2000)	ICT, engineering, life sciences and technology, other	Experiential knowledge was of limited value in explaining firms' entry mode choices, which were rather choices determined by product- and firm-specific factors
Coviello and Munro (1997)	Software	The internationalisation of SMEs can best be understood by integrating models of incremental internationalisation with the network approach
Crick and Jones (2000)	Not specified	Support for a contingency view of internationalisation: stimuli for internationalisation are moderated by influences related to firm, market and industry factors, as well as decision-maker characteristics
Crick and Spence (2005)	Not specified	The internationalisation of high-tech firms is not a systematic and linear pattern, but rather a complex path not just involving planned decision-making, but also networks and serendipity
Evangelista (2005)	Software	International new venture creation comprises four elements: founder characteristics, external environment, the new venture organisation and the founding process
Gabrielsson and Kirpalani (2004)	Various	Networks, the internet, and using MNCs as systems integrators or distributors are viable channel alternatives for born globals
Hashai and Almor (2004)	Telecommunications, electronics, software, pharmaceuticals, biotechnology, medical	While the surveyed firms internationalised rapidly, they also exhibited a gradually increasing commitment to foreign markets
Jones (1999)	Plastics, biotechnology, advanced surgical instruments, advanced electronics instruments	Identify four patterns of internationalisation: reluctant developer/export specialists, conventional developers, rapid developers and international entrepreneurs
Jones (2001)	Plastics, biotechnology, advanced surgical instruments, advanced electronics instruments	While importing/exporting are the most common form of cross-border activity, production and research links were also found to be important
Larimo (2003)	Biotechnology*	The born global firm behaves according to an evolutionary framework
Moen, Gavlen and Endresen (2004)	Software	A variety of entry forms were used, often involving complex partnerships, with a firm's network relations determinant in deciding market entry modes and even which markets to enter
Preece, Miles and Baetz (1998)	Not specified	Found differences between the international intensity and global diversity of early-stage technology-based firms, with these firms likely to be instant internationals but not global in scope
Sharma and	ICT	The internationalisation process of born globals is driven by the

Blomstermo (2003)		knowledge gained through their network ties
Spence, 2003	Electronics and precision instruments	International strategy formation among high-tech SMEs may be opportunity seeking rather than planned
Stray, Bridgewater and Murray (2001)	Not specified	Identify three distinct groups of small technology-based firms, with the group that expands more rapidly into international markets achieving the highest success
Yli-Renko et al. (2002)	Electronics	The knowledge intensity of a firm's resources may play an enabling role in the internationalisation process
Zahra, Ireland and Hitt (2000)	Total of 12 industries surveyed	International expansion has a positive effect on technological learning
Zahra, Matherne and Carleton (2003)	Software	Technological networks and reputation were found to be significant predictors of the speed and degree of sales internationalisation, and the interaction of networks and reputation were also positively associated with sales internationalisation

**Study also includes firms from non-high-tech sectors*

Table 2: BresaGen's domestic and foreign market commitments

Deal #	Started	With Whom	Nature	Content
1	1985	Bethesda Research Laboratories, USA	Licensing and marketing agreement	Distribution and marketing of Photobiotin on the East Coast of America.
2	1985	Metro Meat Holdings Pty Ltd and Reprotec, Australia	Joint Venture	Metro Meats would provide capital in return for IP rights to the transgenic technology and Metro Farms was to build a piggery, 60 km north of Adelaide for the capital value of AUD$2.1 million as well as provide the capital for the manufacturing facilities to produce pGH. In return for the capital, Metro Farms was to have exclusive rights on a worldwide basis to manufacture and sell all products arising from this technology.
3	1985	Vector Laboratories, USA	Licensing and marketing agreement	Distribution and marketing of Photobiotin on the West Coast of America.
4	1985-1986	Bunge Meat Industries Australia	R&D collaboration	Bunge Meat were producing pigs for field trials but were unwilling to conduct further field trials because they were concerned about a consumer backlash. The project was put on hold.
5	1986	Alfa Laval, Sweden	R&D collaboration	Access to and sharing of research facilities
6	1987	Pharmacia	Licensing and marketing agreement	Distribution and marketing of Photobiotin in Europe.
7	1987	Toyobo (subsidiary of Mitsubishi Corp)	Licensing and marketing agreement	Distribution and marketing of Photobiotin in Japan.
8	1988	Metro Meat Holdings Pty Ltd (subsidiary of Metro Farms Pty Ltd) and Bresatec	Joint venture	Metro Meat would pay approximately AUD$2M into the joint venture between 1988 and 1990 for the R&D that was mostly undertaken at Metro Meat's piggeries in South Australia. In March 1991, Bresatec purchased Metro Meat's share in the joint venture when the Adsteam Group was experiencing financial difficulties
9	1988-1992	Pig Improvement Company, UK	R &D collaboration	An agreement to continue the research into transgenesis
10	1989	Cambooya Hambro-Grantham	Investment funding	Each company purchased approximately 20% of Bresatec shares for a consideration of AUD$1 million.
11	1991	American Cyanamid Co.	Investment funding	Bresatec granted Cyanamid two options exercisable within 12 months, with Cyanamid exercising the second option in March 1992 of purchasing shares in Bresatec.
12	1991	Macquarie Bank Ltd (MBL) Aust and Bresatec Ltd	Joint venture for R&D	Funding of approximately $9 million to provide research and development to overcome current problems with the transgenic technology and find a commercially valuable breeding stock.
13	1992	MS3 (a subsidiary of MBL) and Bresatec Investments (a subsidiary of Bresatec)	Joint venture for R&D	Setting up of a syndicate, with MS3's equity in the Syndicate amounting to $27,645,750 and Bresatec Investments' amounted to $279,250 comprising equity capital of $169,250 and debt funding of $110,000 from its parent company Bresatec. MBL was appointed to manage the Syndicate.
14	1993	Medvet Science Pty Ltd, Aust	Licensing agreement	Product (E21R) was to be developed and taken to Phase 1 clinical trials by BresaGen under exclusive licence from Medvet Science Pty Ltd
15	1994-1997	Rutgers University Texas AMU Louisiana State University	R&D collaboration	Clinical development for BresaGen's veterinary drug, EquiGen
16	1995	Bresatec Pty Ltd – later known as Geneworks Pty Ltd	Spinoff investment	The reagents business segment was spun off, trading as Bresatec Pty Ltd. In 1999, and with the same ABN number, Bresatec Pty Ltd changed its name to Geneworks Pty Ltd.
17	1997	Biotechnology Investments Limited The Rothschild Bioscience Unit: Luminis Pty Ltd Hambro-Grantham	Investment funding	BIL made an investment in BresaGen of $2.5 million, Rothschild $4 million, Luminis - $0.5 million, Hambro-Grantham Capital $0.5million and Cambooya $0.5 million

Deal #	Started	With Whom	Nature	Content
		Capital Ltd Cambooya Pty Ltd		
18	1998	Undisclosed Agents in Malaysia and Dubai	Marketing and distribution agreements	Appointment of distributors
19	1999	Alza Corporation, USA	R&D collaboration	Under the agreement, the parties would develop a product incorporating EquiGen in Alza's injectable sustained release delivery system and BresaGen would test the product in a clinical trial in horses. If preliminary work was successful, it was expected to take between 18 months and two years to develop a new generation slow release EquiGen product
20	1999	Baxter Healthcare, USA, Nextran Inc. USA St Vincent's Hospital Melbourne and BresaGen Xenograft Marketing (a joint venture between BresaGen and St. Vincent's Hospital)	R&D collaboration	The agreement provided research funding that would support continued xenotransplantation research specifically in the area of pig cloning technology. BresaGen was the subcontractor to St. Vincent's for the generation of transgenic pigs, and for developing gene knockout and cloning technology. As this was an extension of the existing agreement, Baxter/Nextran would continue to retain exclusive Intellectual Property commercialisation rights for xenotransplant applications of the research, and the other parties would retain rights in all other areas
21	1999	University of Adelaide and Dr Peter Rathjen	Licensing agreement	In-licensing of IP for stem cells
22	2000	British Biotech Plc.	Licensing and marketing agreement and contract development	British Biotech was granted an exclusive worldwide licence to commercialise E21R for all indications and would reimburse BresaGen for the cost of clinical trial supplies. Under the terms of the agreement, British Biotech would make an equity investment of US$1 million make payments totalling US$7 million that include an up-front payment and milestone payments conditional on the successful development and approval of E21R for AML.
23	2000	Cytogenesis Inc., USA	Acquisition	BresaGen acquired Cytogenesis and incorporated it into BresaGen Inc.
24	2001	BresaGen Inc, USA	Establishment of a wholly owned subsidiary	BresaGen Inc. was established in Georgia, largely devoted to stem cell research. Some staff transferred from BresaGen Ltd, led by the chief scientific officer. John Smeaton was CEO of both companies but based himself in the US at BresaGen Inc.
25	2001	CSL Australia	Marketing agreement	To distribute and sell BresaGen's veterinary product, EquiGen, throughout the US.
26	2001	Image-Guided Neurologics (IGN) and BresaGen Inc., USA	Manufacturing and marketing agreement	Under the terms of the agreement, IGN was to develop the catheter for BresaGen, which has an exclusive license to commercialise the device. BresaGen would test the catheter in pre-clinical sponsored research.
27	2001	Stanford Uni, USA	R&D collaboration	A sponsored agreement to develop a proprietary cell delivery system as part of a cure for Parkinson's disease. Under the terms of the agreement Stanford faculty members in radiology, would carry out BresaGen-sponsored research to develop an image-guided cell delivery device with the capacity for monitoring cell metabolism following transplant of cells into the brain of patients with Parkinson's disease.
28	2002	Plurion Inc., USA	Acquisition of	Acquisition of IP to enable commercialisation of ESC based

Deal #	Started	With Whom	Nature	Content
			key intellectual property by BresaGen Inc.	treatments. BresaGen agreed to buy the patent rights from Plurion in return for a 30 percent stake in BresaGen. As part of the transaction, two of Plurion's directors joined BresaGen's board.
29	2002	South Australia State Government	Loan agreement and establishment of ProtEcol Services	Funds to finance the construction of a new building and production facility. 10 year loan term and security was charged over the land and building. An offshoot of this construction was the ability to set up a separate business unit within the Protein Pharmaceuticals Division known as ProtEcol(TM) Services, offering process development and manufacture of recombinant peptides and proteins.
30	2002	University of Minnesota, USA	Marketing agreement	The University of Minnesota licensed its intracranial catheter to BresaGen to market.
31	2003	Australian Cancer Technology	Contract manufacture	BresaGen would manufacture and supply ingredients to AustCancer to complete their Phase 2 clinical trials for their anti-cancer vaccine, Pentrix™.
32	2003	CyThera, USA	Spin-off and merger with BresaGen Inc.	BresaGen Ltd funded the move and the aim was to create one of the leading human stem cell therapy research companies in the world. The new entity would pursue diabetes research and would benefit from rationalised operating costs as well as building on synergies of stem cell biology research within the two companies. The merger included BresaGen's Cell Therapy division that operated at the University of Georgia, and combined BresaGen's work on degenerative diseases of the central nervous system with CyThera's work on stem cell treatments for diabetes. A leading life sciences US venture capital firm, Sanderling Ventures, committed $US1.5 million to the newly merged entity and assisted the new company with raising an additional $US3.5 million in funding. The expanded company had a post funding valuation of $US16.0 million and BresaGen Ltd owned approximately 30% of the new company.
33	2003	Generipharm Inc., USA	Establishment of wholly owned subsidiary with financial support from Caymus Partners	BresaGen Ltd established a wholly owned US incorporated subsidiary called Generipharm Corporation. BresaGen pursued Caymus Partners to help raise finance. BresaGen Ltd intended to transfer its protein pharmaceutical business into Generipharm Inc. on the successful completion of the Caymus Partners led financing. At the same time, the company announced the acquisition of the Xeriject drug delivery platform. The US company AlgoRx Pharmaceuticals Inc., a specialty pharmaceutical company, assigned the XeriJect technology to Generipharm for $US100,000 and AlgoRx retained the rights to the technology for pain applications. Dr Steve Prestrelski, a key inventor of the technology and a world-leading expert in protein formulation and delivery, was instrumental in the transfer of the technology to Generipharm and continued to support the development. At that time, the company estimated that the technology should reach the market with its first drug application by 2008.
34	2003	NexGen Technologies Inc., USA and BresaGen Ltd	Licensing agreement	In and on-licensing: BresaGen assigned to NexGen its exclusive intellectual property licenses from the University of Virginia, University of Minnesota, Virginia Commonwealth University and Stanford University related to catheters. NexGen in return provided BresaGen with a non-exclusive license to use the FDA-approved neurological cell therapy catheter with its own products, such as a treatment for Parkinson's Disease.
35	2003	Restoragen Inc., USA	Licensing agreement	Licensing agreement for a suite of seven patent applications covering production methods for recombinant proteins and peptides.
36	2005	Confidential Middle East Company	Active Pharmaceutical Ingredient Supply Agreement	Contract to develop and register a biopharmaceutical product. The contract included a combination of upfront and milestone payments and was anticipated to be initiated in approximately 4 weeks and progress over a 12- to 18-month period
37	2005	Opsona Therapeutics Ltd, Ireland	Contract development	BresaGen made progress in the process development of the pre-clinical immunomodulator, OPN-201. Over a 6-month period, BresaGen conducted feasibility studies and process development for the eventual large-scale cGMP manufacture of recombinant OPN-201.
38	2005	Pepgen Corporation, USA	Contract development	BresaGen would progress the development of Pepgen's auto-immune, inflammatory and viral therapies.
39	2005	Psiron Ltd, Australia	Contract development	Process development contract in the mammalian cell-derived therapeutics area. Staged rollout involving the construction of a pilot-plant, housed within BresaGen's premises at Thebarton.
40	2006	BV BioCorp, India	Marketing	Registration and distribution of two biopharmaceutical products in

Deal #	Started	With Whom	Nature	Content
			agreement	India. Under the terms of the agreement, BV BioCorp would register and market BresaGen's G-CSF and an undisclosed product in India, Sri Lanka, Bangladesh, and Nepal, however the commercial details of the transaction remained confidential.
41	2006	Caldeon Pty Ltd	Contract development	Process development and materials supply for various stages of product development.
42	2006	CBio, Aust	Contract development	Process development and materials supply for various stages of product development.
43	2006	Domantis Ltd	Contract development	Contract for producing domain antibodies by examining the feasibility of producing domain antibodies efficiently in e coli
44	2006	Hunter Immunology, Aust	Contract development	Process development and materials supply for various stages of product development.
45	2006	Imugene	Contract development	Process development and materials supply for various stages of product development.
46	2006	PDCO	Contract development	Process development and materials supply for various stages of product development.
47	2006	QRx	Contract development	Process development and materials supply for various stages of product development.
48	2006	The University of Sydney, Aust	Contract development	Process development and materials supply for various stages of product development.
49	2006	Tissue Therapies Ltd	Contract development	Process development and materials supply for various stages of product development.
50	2006	Hospira Inc., USA via Hospira Holdings (SA) Pty Ltd.	Acquisition of BresaGen Ltd.	Successful buyout of BresaGen Ltd by Hospira Inc. (the hospital business unit of Abbott Inc.). The deal was valued at A$20.4 million. BresaGen Ltd held a 30% stake in CyThera.

Table 3: GroPep's domestic and foreign market commitments

Deal #	Started		Nature	Content
1	1988-1998	Genentech, USA	R&D and licensing agreement	Pharmaceutical uses of growth factor analogues, Genentech provided up-front payments
2	1992-1995	Mead Johnson, USA	R&D collaboration	Whey growth factors for gut disease and polytrauma
3	1992-1995	HyClone Labs, USA	Marketing agreement	HyClone to distribute reagents in US
4	1993-1995	CSL, Aust	Marketing agreement	CSL to distribute reagents in Australia
5	1993-1998	Cephalon, USA	R&D and licensing agreement	Pharma applications of growth factor analogues
6	1994-1996	MedVet Sciences, Aust	R&D collaboration	Co-developing IP and lease of MedVet's facilities; synergistic effects of growth factors and insulin. Patent filed in joint names.
7	1994-1996	Northfield Labs, Aust	R&D collaboration	Northfield conducted clinical trials while GroPep supplied Northfield with bovine colustrum
8	1994-1998	Bonlac Foods, Aust	R&D collaboration, manufacturing and marketing agreement	GroPep to conduct clinical trials, following regulatory approval Bonlac would manufacture and market product
9	1995 – ongoing	JRH Biosciences, USA (div. of CSL)	Worldwide marketing agreement	Commercialisation of growth factors in industrial cell culture
10	1995 – ongoing	Bunge Meat Industries, Aust	R&D collaboration	Co-developing IP and patent filing for methods to select livestock
11	1995-1997	Embrex, USA, US Department of Agriculture	R&D collaboration	Co-developing joint patent regarding growth factor administration to poultry *in ovo*
12	1995-1999	Diagnostics Systems Labs (USA)	R&D collaboration and marketing agreement	Growth factor diagnostic products; GroPep the importer and distributor for Diagnostic Systems Labs in Australia
13	1996-1999	FH Faulding, Aust & Innovative Technologies, UK	R&D collaboration	Incorporation of whey growth factor mixtures into wound dressings
14	1997-1999	Alizyme, UK	Contract development	Alizyme's IP for the treatment of gut diseases contracted to CHRI
15	1997-2000	Smith & Nephew, UK	R&D collaboration and licensing agreement	GroPep licensed whey growth factors for treatment of chronic wounds to Smith & Nephew
16	1998-2002	Nestlé, Switzerland	R&D collaboration and licensing agreement	R&D program of preclinical trials but includes the right for Nestlé to enter into a licence for the eventual marketing by Nestlé of nutritional and certain oral pharmaceutical compositions covered by GroPep's milk growth factor intellectual property.
17	Late 1990s	International Diabetes Institute, Aust	Contract development	IDI and GroPep to conduct clinical trials of IGF-I as a topical treatment for diabetic neuropathy.
18	Late 1990s-2003	Mayo Medical Ventures, USA	R&D collaboration	Co-develop IP owned by Mayo for treatment of osteoporosis. Beneficial rights for GroPep to develop products resulting from further research by Mayo.
19	Pre 1998	Immunex, USA	API agreement	Enbrel developed – comprised of LR^3.

Deal #	Started		Nature	Content
20	2000	Alpharma Inc., USA	R&D collaboration	GroPep developed new manufacturing process, the resultant product would be manufactured and marketed by Alpharma
21	2001	PrimeGRO Pty Ltd, Aust	Licensing agreement	GroPep's veterinary technology outlicensed to PrimeGro
22	2001	OSI Inc., USA ARI, Aust	Licensing agreement	GroPep in-licensed OSI's IP, and OSI supplied clinical grade drug substance for the further development of technology owned by ARI
23	2002	TGR Biosciences Pty Ltd, Aust	Licensing agreement	GroPep outlicensed 6 patent families to TGR
24	2002	Biotech Australia	Investment	Purchase of facility and IP for $11 million, divided into $7 million for the CMO assets including land, buildings, plant and equipment and $4 million for the IP portfolio
25	2003	Campina, Netherlands	Licensing agreement	GroPep out-licensed its rights to WGFE technology to manufacture and sell nonpharmaceutical oral products
26	2003	Program for Appropriate Technology in Health, USA	Contract manufacture	PATH sponsored clinical trials for a vaccine, with GoPep owing the IP and supplying it for clinical trials
27	2006	Novozymes A/S, Denmark	Acquisition of GroPep Ltd.	The new name of the company became Novozymes GroPep Ltd. The company became a wholly owned subsidiary of Novozymes. Total cost approximately A$97 million.