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THE SOFT COMPANY BUSINESS MODEL OF HIGH-TECH GROWTH

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Abstract

Despite the overwhelming emphasis placed upon it in the innovation and entrepreneurship literature, the Silicon Valley model of venture capital investment is not the only way to develop new high-risk technologies in the private sector outside the R&D departments of large firms. A very different business model has contributed to the growth of the Cambridge (UK) cluster, where successful science-based firms funded lengthy phases of exploratory technology development by carrying out R&D for external customers and by building competitive advantage through 'demand pull' incentives and the strategic accumulation of intellectual property. This paper contains an inductive exploratory analysis of the soft company business model and provides illustrative case study evidence of its use in the life sciences sector. While this empirical evidence is specific to the Cambridge context, the findings can be generalized to provide a suitable alternative, or complement across developmental phases, to the standard VC investment model.

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1. Introduction

The problem of generating value from new knowledge has taken center stage in the literature. Despite the increased interest in both the academic and policy domains, however, the creation and exploitation of technological opportunities remain a challenge. Stronger international competition, higher R&D costs and increasing complexity of goods and services seem to have intensified the fundamental uncertainty that characterizes investments in innovation. It has been argued that these factors have motivated the diffusion of more distributed or 'open' models of innovation (Chesbrough, 2003; Coombs, Harvey, & Tether, 2003) and influenced recent shifts in the perceived role of universities (Etzkowitz, 2002; Audretsch & Phillips, 2007; Antonelli, 2008; Perkmann, Tartari, McKelvey, Autio, Broström, D'Este et al. 2013; Deiaco, Hughes, & McKelvey, 2012; Martin, 2012). These have been accompanied on the one hand by the emergence of intermediate markets for technology (Arora, Fosfuri, & Gambardella, 2001) and on the other by the diffusion of specialized institutional channels for the transfer of technological knowledge from the research base to industry (Bozeman, 2000; Feldman, Feller, Bercovitz & Burton, 2002; Debackere & Veugelers, 2005; D'Este & Patel, 2007; Bekkers & Bodas-Freitas, 2008). Expectations are now high not only about the entrepreneurial role of universities, but also about the capacity of venture capital (VC) to support the creation and growth of new technology-based firms.

In recent years venture capital (VC) has conquered the lion's share of scholarly contributions on the financing of innovation as the optimal solution to the financial constraints experienced by young high-tech firms. Relative to more established firms, young (typically also small) companies do not have internal cash flow to finance growth and are at a disadvantage in external capital markets because of classic problems of information asymmetries and adverse selection (Cosh, Cumming, & Hughes, 2009; Hall, 2009). These occur when potential borrowers do not send reliable signals about firm quality or when potential investors are not able to capture and use these signals to make optimal decisions (Jensen & Meckling, 1976; Stiglitz & Weiss, 1981). Asymmetric information induces agency costs that generate a wedge between the cost of external and internal funds and therefore make some projects viable only if they can be funded internally by the firm (Myers & Majluf, 1984; Myers, 2000). Since young companies tend to be unprofitable at the early stages of their life-cycle, they will seek external finance (Berger & Udell, 1998; 2006).

The problem of asymmetric information is especially severe for R&D-intensive companies because these investment opportunities can be evaluated and managed only by specialist suppliers of external capital. VC can be an effective solution for investment in high-

risk and informationally opaque projects: it can provide not only finance, but also investment screening, monitoring and certification skills (Sahlman, 1990; Caselli, Gatti, & Perrini, 2009; Ueda, 2004; Hellman, 1998; Chan, 1983; Megginson & Weiss, 1991; Lerner, 1995; Kaplan & Strömberg, 2001) as well as valuable knowledge of markets and technologies (Cohen & Levin, 1989; Kortum & Lerner, 2000; Cornelli & Yosha, 2003; Denis, 2004).

In spite of these advantages over alternative forms of external capital, VC is not the only possible investment model for knowledge-intensive entrepreneurship (Delmar & Wennberg, 2008; McKelvey & Lassen, 2013) and most importantly does not work in isolation from the broader innovation-finance system where it operates (Mazzucato, 2011). Moreover, it is often unsuitable to the funding of technologies whose characteristics and developmental times do not fit with VC risk-return investment framework.

In this paper we explore a business model of high-tech entrepreneurship which is not built on venture capital but has nevertheless played an important role in the growth of the Cambridge (UK) cluster. It entails the internal financing of lengthy and risky phases of exploratory technology development by carrying out R&D for customers and by building competitive advantage through 'demand pull' incentives and the strategic accumulation of intellectual property. As we will explain, we refer to it as the 'soft-company' model to emphasize its flexibility and adaptability relative to the 'hard' model – typically backed by VC funds – of rapidly developing a scalable product based on a standard offering with a fixed strategy. In the following sections we describe our research setting and strategy; we present the characteristics of the 'soft company' model and then illustrate it through case study evidence. Finally, we discuss the key managerial and policy implications of the model.

2. Research setting and strategy

The Cambridge (UK) area is one of the leading technology clusters in Europe and has also one of the highest concentrations of venture-backed companies in the world. The role of VC in the region has been documented (Library House, 2007) and attention has been drawn to the role of the University of Cambridge (Kirk and Cotton, 2012). However, the role of other mechanisms of local growth has received less attention even though insiders seem to have long been aware that many of the local high-tech companies were adopting a business model based on performing external R&D for customers, rather than developing, marketing and selling standard products (Segal Quince & Partners, 1985). This phenomenon – observable both among specialist R&D service firms and among many other young companies in the manufacturing sector – has arguably been underestimated despite the fact that the provision of

R&D services by leading technology development consultancies has grown over time into a fundamental mechanism to develop new technologies directly and through spin-outs (Probert, Connell, & Mina, 2013).

In this paper we use a qualitative research design to identify, examine and profile the 'soft company' business model of high-tech growth. We adopt an exploratory and inductive approach (Edmondson & McManus, 2007) and apply a case study methodology as required by analyses of organizational and/or institutional phenomena which are unsuitable for purely deductive designs but are instead highly relevant for the generation of new theory (Eisenhardt, 1989). More specifically we employ a multiple case design to strengthen the accuracy and generalizability of results through a replication logic (Eisenhardt and Graebner, 2007; Yin, 2008).

In the data collection phase we first had to identify firms that were contracted by third parties to carry out bespoke R&D projects for a period of time in their early developmental path. It was not possible to rely on standard business directories or business classifications because these do not capture the phenomenon under investigation. We therefore identified an intensive sample of relevant firms by cross-checking official reports, FAME (Financial Analysis Made Easy) records and secondary historical sources on the growth of the Cambridge cluster since the late 1970s. This theoretical sampling strategy allowed us to select an initial small sample of companies in different sectors to increase case variability while keeping constant the institutional context (the Cambridge cluster). We undertook semi-structured interviews with the founders or senior managers of these firms and progressively expanded our sample through a chain referral technique based on insiders' knowledge. This led us to the identification of similar local firms which were regarded as competitors or as firms known in the cluster for following or for having followed a similar business model. The fieldwork generated 52 recorded and coded interviews about firms from a range of industry sectors that perform or have performed external R&D for other organizations as part or all of their activity to fund the commercialization of their own technology. The complete list of interviewees is presented in the paper's Appendix.[1] We analysed the case studies to abstract

[1] The interviews took place in 2008 and were completed in March 2009. They were conducted by two members of the team, with one taking the interview lead while the other took detailed notes. We cross-checked these interview data against alternative publicly available sources (the press, company websites and official company records) to triangulate information from at least two different sources. We excluded from the analysis information that could not be verified by triangulation. Full case study histories were drafted and sent to the interviewees for comment and validation in the second half of 2009 (the complete repertoire of case histories is presented in Connell and Probert, 2010). In order to reduce the risk of bias, the third author coded and pooled the data used in this paper. Manual coding was preferred to avoid potential losses of information.

the generalizable features of a 'soft company'. After presenting the emergent theoretical construct, for illustrative purposes we include case study evidence of early applications of this business model in the Cambridge cluster. We then focus on two case studies that exemplify the use of the model as an alternative and complement to VC in the life sciences sector.

3. The 'soft company' business model

We use the concept of 'business model' to refer broadly to the structure, architecture or heuristic logic of decisions that create value for a firm (Chesbrough and Rosenbloom, 2002; Teece, 2010; Chesbrough, 2010; Zott, Amit, & Massa, 2011). More precisely, we focus on the construct of business model in the entrepreneurial context of new ventures and innovation-driven industries (George and Bock, 2010), with special emphasis on the link between opportunity creation, opportunity exploitation and firm funding. The term 'soft company' was first coined in 1983 by Matthew Bullock, at the time a Barclays Bank manager who played a key part in financing some of the early Cambridge technology companies, though it was based as much on research he undertook into the financing of technology companies in the US as on his experience of lending in the UK. We define a *soft company* as *a science or technology based company whose business model is to perform external R&D and which draws on its expertise and/or proprietary technologies to provide bespoke offerings for a range of customers and applications.*

This definition highlights the 'demand pull' approach to technology development common to most soft companies. It contrasts with the 'technology push' approach generally found in 'hard' start-up businesses whose purpose is to engage in the development and commercialization of 'standard' products prior to any customer commitment to purchase them. The term 'soft' indicates how companies adopting this model can remold their offer to meet a wide range of customer needs in different industries, based on their expertise. This model provides much greater flexibility and a wider choice of early customers compared with the rather fixed strategy of 'hard' companies.

At the simplest ('softest') level an individual or group of individuals with specialist technological expertise could sell their time in the form of consultancy projects for customers seeking analysis of specific problems. Early customers might be existing business contacts, or they might result from targeted cold calling or responses to conference papers or articles by founders. In most sectors, though not all, this is an activity with low overheads and requiring very little in the way of up-front investment, including specialized equipment. Marketing expenses are limited to time and travel costs and the only real uncertainty is how long it will

take to win the next contract. Fees can be charged monthly against deliverables or even partly in advance, depending on what the client will accept. In the case of a pure consulting company, as it grows the level of management skills required increases, but remains limited to project management, people management and rudimentary financial management – skills that can pretty much be learned on the job. Success depends on selling 'time' and on delivery of projects to budget.

Sometimes, consulting reports analyzing a customer's problem can lead to more tangible R&D contracts. Companies carrying out these R&D contracts – i.e. delivering demonstrators, prototypes or 'ready to use' physical deliverables – usually incur both higher costs and higher risks: higher costs, because of the cost of equipment required (although this can sometimes be borrowed in the early days, bought second-hand, or even charged to the customer); and more risky, because of the difficulty in predicting how long it will take to develop the technology or indeed whether the desired outcome can be produced at all. Otherwise, external R&D is not too different to the kind of consultancy that produces reports. And if the project involves developing a new product, it is the client who has to worry about market risks and competitors. The terms of trade under which contract R&D companies operate vary. The simplest is monthly invoicing based on time and materials used, just like a legal firm or management consultancy. But up-front payments to purchase materials and equipment are common, and payments are sometimes linked to milestones such as completion of key stages of the project. Contract R&D companies try to avoid quoting fixed prices in advance, as this means they have to bear the risk of overruns – common in most innovation companies. One way of getting around this is to undertake projects in successive phases of increasing size, so that key uncertainties and risks can be investigated first and quotations (or, better still, 'indicative costs') for later stages refined.

In some sectors a company providing external R&D to clients develops technology to the level of demonstrator or prototype, with the client then taking over responsibility for converting it into the final product and organizing manufacturing. Where the final deliverable is software, a single machine, or chemical or biological samples, the contract will typically extend to delivering the final version. Managing this type of activities is somewhat similar to paper-based consulting businesses. Financial success depends on keeping people busy and not overrunning on projects. However, managing technical risk now assumes much greater importance, especially as companies grow and founders become less directly involved in key projects. As a result, managing technology risk is one of the key strengths of successful suppliers of external R&D. Together with the capacity for innovation which their flexibility

and entrepreneurial approach brings, this particular way of performing R&D can make them much more effective at innovation than the established laboratories of the large firms for which they work.

This is a viable start-up model in many sectors, from software to electronics to drug discovery. It can also emerge from the pure paper-based consultancy model described earlier, provided founders have the necessary skills. External R&D performers may work around a fairly standard service (e.g. electronics design, chemistry synthesis), although in this case the scope for moving up the value chain is generally limited. Or they may work around an area of expertise in short supply (microprocessors in the 1970s, wireless telecommunications in the 1990s) that offers higher fees and better long-term potential.

Frequently, a highly innovative engineer or scientist is a key driver. And sometimes, soft companies are based around a proprietary technology platform with multiple applications, offering the potential for projects with multiple customers – although here some up-front investment is typically required so that IP can be created and then retained, at least for some applications. Companies undertaking external R&D frequently have the opportunity to move into small volume manufacture on behalf of individual clients, for example because a customer wants half a dozen machines or a continuing supply of chemical reagents. The new management skills that must be acquired or developed – in costing, production management and after-sales service – help support the transition later to the 'hard company' model if the choice is made to develop proprietary products for wider marketing.

The creation and exploitation of intellectual property around a different application of a technology developed under contract moves the firm into more speculative R&D activity. The IP can be exploited in various ways, but it is important to manage ownership and commercialization rights carefully, since the intention is to establish a robust IP package for licensing out or assignment to a new venture. In contrast to soft companies, most businesses established to develop new products on a speculative basis require significant amounts of cash to move from the early phases of development into bringing out a product and scaling up production, sales and marketing. This level of investment is normally only available from venture capital investors, and, for those companies that are successful, growth can be very rapid. For venture capitalists the steepness of this curve is crucial, because it indicates the potential multiple to be made when they sell the business on the basis of future sales prospects (The faster the growth, the bigger the multiple to sales acquirers will be prepared to pay).

In the case of a soft company, however, the cash flow curve is far flatter (Figure 1) because there are fewer start-up costs involved and customer revenues can be generated

quickly. Some soft start-ups effectively never become cash negative at all. On the other hand, the growth rate once profitable is much slower. Hard product companies need backers prepared to shoulder the risk in order to make the progress necessary to stand a chance of getting to market first. Because of the need to capture market share and gain strength ahead of competitors, speed of execution is critical. As a result a full management team is required, with experience in marketing, sales and distribution management, supply chain management, technical service and possibly production. Financial management and, of course, the job of the CEO are commensurately more demanding. As a result, many of these skills need to be recruited into a hard start-up. There is little time to learn on the job.

Insert Figure 1 about here

The risks associated with hard start-ups are very high, in terms not only of getting the technology to work but also of managing the complexities of putting it into production and getting it out into the marketplace – but so are the potential returns. However, there are rarely second prizes, and investors in hard start-ups that fail can expect to lose everything.Another key difference between incubating product firms within a soft business environment and a completely product-focused hard start-up firm. For the latter, the gap between first customer engagement and demand at last taking off can be surprisingly long, especially in specialist equipment markets. During this period the hard start-up continues to incur costs rather than revenues and, if venture capital-backed, the founders and management team will suffer strong pressure from investors, heavy dilution and possibly closure. But a soft company environment can enable people to be shifted onto customer-funded projects in other areas during gaps in customer interest in the technology or while the evidence, budgets and political support that is required to make any innovative purchase in most large organisations is being accumulated. This greatly reduces investment costs (possibly even maintaining profitability) and allows the patient accumulation of expertise and market understanding, putting the firm in a far stronger position to fine tune its product and exploit the opportunity once demand finally begins to take off.

4. Early 'soft company' examples of the Cambridge Phenomenon

The tendency for new science and engineering-based firms to spring up in and around Cambridge over the last 30-40 years has been well recorded.[2] The specific features of the Cambridge environment that made it so conducive to technology start-ups – the liberal attitude in the University towards intellectual property exploitation, labor market dynamics, the foundation of the city's first Science Park on the recommendation of the 1969 Mott Report[3] – were reinforced by changes in the wider industrial environment.

In particular, in the electronics industry the concept of generating revenue from knowledge-intensive services as an initial start-up strategy was beginning to emerge in the 1960s and 1970s, when microprocessors and the falling costs of computing generally opened up myriad new applications in existing industries which small firms could help develop. The Cambridge Computer Group, a 'club' for small IT companies formed at the end of the 1970s, and the strong personal connections between the University's computer lab and (among others) the Acorn 'family' of firms reflect these circumstances. In other industries, such as the life sciences, the soft start-up model emerged later, when technological developments allowed firms in the biotechnology field to create new research tools and platforms they could offer to large incumbent pharmaceutical firms as a stepping stone towards their own 'hard' product/IP offerings.

Electronics, including computing, telecommunications and software, and the life sciences have been important new fields of expertise in the region. A number of firms and research establishments that played a central role in the Cambridge Phenomenon followed a soft business model. Among the earliest examples were Cambridge Consultants, founded in the early 1960s by a group of recent Cambridge graduates, and the MinTech Atlas Centre, a government-funded research institute for computer graphics in engineering design which was set up in the late 1960s as part of the Wilson Government's investment in the 'white heat of technology'. Both of these organizations remain important in the Cambridge region even today – demonstrating the potential for longevity in the soft business model, as well as its adaptability to changing circumstances.

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[2] Segal Quince & Partners (1985), Segal Quince Wicksteed (2000), Herriot & Minshall (2006), Kirk & Cotton (2012).

[3] The Mott Report was the outcome of a special Cambridge University Committee set up under the Chairmanship of Sir Nevill Mott (then Cavendish Professor of Experimental Physics). The Committee had to consider an appropriate response from Cambridge to the Government's view that universities should expand their interaction with industry. The Report, published in 1969, recommended an expansion of facilities to facilitate exchanges between the Cambridge scientific community and industry.

The MinTech Centre, renamed CAD Centre in the early 1970s when computer-aided design was coming to the fore, was an intermediate R&D organization, that is to say a partly government-funded R&D center with a medium-term focus and emphasis on getting new technologies into the market, rather than on publications or teaching. The CAD Centre was largely funded by government with some private sector contracts and, despite some criticism of its operations in the 1980s, has turned out to be enormously important in building Cambridge's CAD (computer-aided design) software cluster. During the 1970s it spun out a series of CAD companies, each pursuing a soft start-up strategy.

CAD Centre itself went through privatization in the 1980s, followed by a management buyout and stock exchange listing in the 1990s. Today, as AVEVA, it is an important player in the world market for software tools to design complex, large-scale industrial process facilities. AVEVA has travelled a long way from the early days when it was simply a "melting pot with government money, equipment and lots of bright people thrown into it" (Interview source: Dick Newell, former CADCentre engineer and founder of CIS and Smallworld), with different industry groups delivering on a few customer contracts (such as an electronic photo-fit system for the police) and working up their own research agendas loosely based around the perceived requirements of the industry.

Other early firms that initially followed the soft model and were crucial to the development of the high tech cluster around Cambridge include Cambridge Processing Unit (CPU), which was the precursor to Acorn Computers and ARM; Chiroscience (in biotechnology); and Symbionics (wireless telecommunications).

CPU was founded by Hermann Hauser after his PhD and a short period as a post-doc at the Cavendish Laboratory, and Chris Curry who had been working for Clive Sinclair's computer company. The firm started in December 1978 with £100 of capital and with the initial aim of carrying out development contracts for companies wishing to incorporate microprocessors into their products. But the idea of selling computers had been growing in Hauser's mind for some time, and he had already helped with one of Sinclair's products. CPU rapidly won a contract with Ace Coin Equipment in Wales to develop a microprocessor-based controller for its fruit machines, and the profits on this enabled CPU to develop its first computer, the System One, helped by the enthusiasm and creativity of its designers, Steve Furber and Sophie Wilson, who were then still university undergraduates. A new company, Acorn Computers Ltd, was set up to market the System One to computer enthusiasts. By adopting the mail-order model, which was then prevalent for home electronics and computer kits, it was possible to finance working capital through an overdraft with National

Westminster Bank, secured against cheques received from customers. The transition to a product-based company was swift and a series of kit-based computers followed, leading to the Acorn Atom which was launched in March 1980 and aimed for the first time at a more mainstream consumer market. An improved design called the Proton was also in preparation. In 1981, when the BBC was looking for a home computer to use in its pioneering computer literacy TV series, Acorn was able to rapidly submit a new design, drawing partly on the Proton, and win the contract.

Winning against much larger and better known companies, this contract, though not bringing funding directly from the BBC, enabled Acorn to build a business which by 1984 had grown to annual revenues of £93 million without raising a penny in venture capital. The BBC contract, coupled with Acorn's status as a nominated supplier to the Department of Industry's Micros for Schools scheme, remains one of the most powerful illustrations of how contracts from public sector customers can help stimulate the development of our high tech industrial base. Acorn's computers were far ahead of their time in terms of file server use and networking capability, and remained an important innovative force for many years. Although Acorn had to be rescued by Olivetti in 1985 when it over-ordered from suppliers and hit cash flow problems, as lead customer it funded the in-house team and the technology that eventually became ARM plc.[4]

After Olivetti rescued Acorn, Hermann Hauser became Vice President of Research at Olivetti in Ivrea, in charge of DOR (Direzione Olivetti Ricerca) with seven labs worldwide. One of those labs, Olivetti Research Labs, was created in Cambridge under the leadership of Andy Hopper (who had driven the computer networking development at Acorn). ORL and its later incarnations, though not an independent soft company, had many of the same characteristics as an innovative intermediate R&D institute funded by corporate sponsors. It went on to incubate a variety of technologies and teams, notably the spin-out Virata (DSL semiconductors) in 1993, but also Cambridge Broadband (intelligent packet microwave), Real VNC (remote control software) and Ubisense (real time location systems). In each case, early technology development was effectively funded and/or trialed by the parent company.

Biochemist Chris Evans founded Enzymatix in 1987 with corporate investment from the Berisford Group, owner of British Sugar, to build on his experience working for Genzyme in the US and for its subsidiary in the UK. The business model was to sell both enzyme-based

[4] ARM is arguably one of the biggest success stories in the Cambridge high tech cluster, even though few would recognize it as a company with 'soft' origins.

diagnostics products and technology problem-solving services. Although mostly financed by Berisford, the venture also had some contracts. In 1992, when Berisford wanted to dispose of its interest, Enzymatix' technology was parceled up into five pieces, each with its own revenue stream, and spun off in different directions.

Chris Evans, together with Andy Richards and Peter Keen, formed Chiroscience from Enzymatix' chiral technology activities. Chiroscience pursued an elegant soft start strategy and went on to become one of the UK's first successful biotechnology companies. In the first year alone it earned £1 million from fee-for-service chemistry and collaborative activity with major pharmaceutical players including Wellcome, Abbot and Menarini. Revenues from fee-for-service chemistry helped to fund the drug discovery activity, supplemented by £3 million raised in the first year from venture capitalists, for whom this revenue-generating activity transformed perceptions of the risk profile. Although fee-for-service revenues covered only around 25% of first year expenditure, it generated far more in terms of contacts, network-building and company credibility.

The soft start worked perfectly, because it allowed the flexible resourcing of work programs between customer projects and in-house developments. It also enabled Chiroscience to grow an IP position and on the back of it to develop a business model that was more oriented towards proprietary pharmaceutical research. In due course the chemistry business was separated into a wholly-owned subsidiary, Chirotech, both to resolve potential conflicts of interest between chemistry contracts for pharmaceutical company clients and Chiroscience's own drug discovery work, and to overcome resource allocation issues. Chirotech was sold in 1998-9– by which time it employed 47 people and had revenues of £30 million – but it continued to operate on Cambridge Science Park until 2008.

Chiroscience itself went through various transformations; having started off as a service business it became a single isomer racemic switch company, then a drug discovery company. It later bought a genomics company and eventually merged with Celltech in 1999, having achieved annual sales of £41 million and employment of some 330 people. Although the Chiroscience name then disappeared, over 120 scientists continued its research activity on Granta Park outside Cambridge until the site was closed down in 2008. The founders have gone their separate ways, but remain active in the Cambridge life sciences sector by funding and/or managing other biotechnology start-ups.

In the case of Symbionics, a typical soft-start consulting project model based purely on fees-for-service evolved after 2-3 years into investments in pre-development designs of mobile telecommunications chips that could be out-licensed. Rather than focusing simply on

collecting royalty payments, however, the company pioneered the highly successful idea of IP licensing, not as an end in itself, but as a means of leveraging into larger product development contracts to create derivative designs and IP for individual customers – a model subsequently much copied by other high tech firms. Symbionics was founded in late 1987 by a team of five people from PA Technology Centre's Telecoms Group.

The founders wanted to use their experience in contract R&D to build a more scalable and valuable business. Symbionics achieved its position firstly by recognizing that as a small start-up it needed to focus on a specific technology, second by having a start-up team with all the requisite functional skills in addition to their technical capabilities, third by settling on a business model that played to Symbionics' strengths without having to involve external investors, and fourth by working closely with its customers. Technologically it stayed ahead of the curve by deliberately getting involved early in European industry discussions on DECT mobile telecommunications technology standardization. By participating in the meetings (where tiny Symbionics in those days was the only consultancy attending alongside all the major mobile telecoms operators and manufacturers) it could not only align its technology development to the standardization process, but also influence that process according to the directions its own development activity was taking. From its core ASIC design expertise it developed skills in software design and radio design, enabling it to undertake the design of complete products (except for industrial design, which was mostly dictated by the customer), but chose not to move into product engineering. It moved into other technologies also, including wireless LAN (which was ahead of its time and found no market) and digital video broadcasting, which became a very successful activity.

Throughout the ten years of its independent existence, Symbionics' business model remained that of a product development consultancy leveraging proprietary IP. Recognizing the different skills that would be required to integrate forwards into manufacturing, the only standardized product it ever made was separated out into a subsidiary, Symbionics Instruments, which produced highly specialized, very low volume chip-testing equipment.

Symbionics had grown to 140 people with revenues of £12 million when it was taken over in March 1998 by Cadence, which wanted to establish a contract development business as a complement to selling its IC chip design tools. Its growth over this period was totally self-financed, without recourse to venture capital. Although Cadence closed what had been the Symbionics site in 2002 in the wake of the dotcom bust, new firms comprising teams of ex-Symbionics engineers sprang up to capitalize on its expertise, among them Nujira, Fen Technology, Commsonic, Change Management Consultancy, Cellmetric, Qualtra, Cambridge

RF, and Sheffield-based Jennic. Symbionics Instruments, which had spun out of Symbionics in 1997, was taken over in 2001 by Tektronix (the North American manufacturer of oscilloscopes and test equipment) and continues to operate as Tektronix Cambridge from its offices in Histon.

Each of the companies discussed above was founded by talented scientists and engineers who developed distinctive customer-focused – and customer funded – business models to overcome the heavy capital demands of developing proprietary technology. Start-up funding often came from traditional 'bootstrapping' practices, drawing also on personal savings and raising money from family and friends. Where they moved rapidly towards developing proprietary IP and products, this was supplemented not only by customer consultancy work but in some cases by relationships with the local branches of some of the high street banks. The more astute managers of these banks recognized that firms with the potential to generate revenue streams from consultancy projects or contract R&D work had lower working capital requirements and presented a lesser financial risk than firms seeking bank loans against purely speculative product development. As a result they were able to split out a class of technology firms to whom they could offer overdraft facilities with or without the personal collateral of the founders. Contract R&D debtors with blue chip customers were seen as an asset which could be used as security, enabling these firms to finance growth more easily.

> *"Soft companies were 'bankable' in a way that hard companies were not: they typically had customers committed to purchase before they did the work; these customers were often high quality, undoubted names, who would pay if the company delivered the project; the project was often based on their previous research expertise. All these factors served to reduce the risk of lending provided we monitored their performance closely. We did a lot of good business on this basis."*
>
> Matthew Bullock, former Head of High Technology Finance Team, Barclays Bank

By not involving venture capital at all or, as in the case of Chiroscience, not relying on it fully to fund early growth, firms were able to remain in greater control of their destiny and adapt their business model to suit changing circumstances; they were also able to remain locally based for many years rather than being obliged by an acquirer to relocate operations overseas. With firms staying in the area, the region retained its entrepreneurs, scientists, engineers, and specialized technology expertise, even if operations were subsequently run down, and key players re-emerged as serial entrepreneurs, investors or advisors. New

entrepreneurial businesses were able to spring up based on that expertise, perhaps funded by local angel investors who had already made money in the Cambridge high tech cluster.

5. THE SOFT COMPANY MODEL IN THE LIFE SCIENCES

5.1 Background

Since drug discovery is a capital- and IP-intensive industry with very high barriers to entry, significant regulatory development costs, and very long timescales, the general perception is that the whole of life sciences is dominated by venture capital.[5] In actual fact, contrary to the US, it is far from the case that mainstream VC funds have funded all the top UK publicly-listed biotech firms. The business model generally assumed – that start-ups are based on scientific research undertaken in a university and are financed through several funding rounds by a VC before being IPOed or sold – is not particularly prevalent.

The biotechnology 'revolution' of the 1970s ushered in an era of technology proliferation and new firm creation focused either immediately on drug discovery or on the development of platform technologies and research tools to aid the drug discovery process. Whereas the former normally require significant amounts of venture funding, the latter type can earn early revenues by contracting their services to pharmaceutical and other biotechnology companies in the drug discovery business. 'Soft' business models began to emerge in biotech when scientists left major pharmaceutical firms – which are widely recognized as inefficient in the research process – and began to sell their specific expertise back on a research contract basis. These new ventures typically need two or three highly experienced people who can provide scientific leadership at a very senior level to generate credibility with customers, combined with some entrepreneurial understanding.

There are numerous examples where the closure or acquisition of pharmaceutical and biotech company research sites in the East of England region has presented opportunities for soft start-ups in the life sciences as teams of scientists depart. Since 2000 several Big Pharma companies have shut down UK research laboratories in the quest to rationalize facilities and/or therapeutic areas: Aventis (formerly Rhone- Poulenc) in Dagenham, Bayer, Merck (Harlow), GSK (also Harlow) and Roche (Welwyn). The US firm Millennium Pharmaceuticals acquired Cambridge Discovery Chemistry in 2000 and built a new research

[5] For an excellent discussion of the long-term industrial dynamics of the UK biotech sector, see Hopkins, Crane, Nightingale, & Baden-Fuller (2013).

facility in Cambridge to house a substantially expanded team. However, it was forced almost immediately by poor results in the US to close down its UK operations in 2003. From the wreckage emerged both Sareum, which brought out the technology it had developed using X-ray crystallography for structure-based drug discovery, and Pharmorphix, which specialized in polymorphism (the relationship between a compound's pharmaceutical activity and the physical form of the chemical). Both were founded by small teams (of 3 people and 4 people, respectively) who had already worked together for many years at Cambridge Discovery Chemistry, and both firms provided services to the pharmaceutical community. Pharmorphix remained a purely soft model focused on R&D services, quickly became profitable, and was sold to Sigma Aldrich within three years. However, Sareum opted for an AIM listing, raising capital to supplement revenue from fees- for-service to fund its proprietary oncology drugs program.[6]

Argenta Discovery is another instance of redundant scientists leaving established pharmaceutical companies to set up on their own. In this case a team of chemists from Aventis later joined up with a respiratory disease group from Bayer. More than a decade earlier Cambridge Antibody Technology (CAT) had followed a somewhat similar path after David Chiswell left Amersham International with a team of 10 antibody researchers when its central research laboratory was shut down in 1989. CAT was a trailblazer in the biotechnology world (as Chiroscience had been in a different field) for another reason: it was the first UK company to structure partnership deals with major pharmaceutical companies in the form of escalating milestones as successive technological hurdles were passed. This mechanism provides a means for a small biotechnology company to get drug candidates into the clinic without raising significant financial investment and to use the revenues earned to take other proprietary technologies further in the development process. This business model has now become standard practice, but until then UK biotech firms had followed the US West Coast business model, believing they could finance themselves better, and achieve a higher return, by raising large amounts of venture capital to fund development. CAT showed that, even in the expensive drug discovery world, a revenue-generating platform technology model backed by a strong patent position could finance at least the initial stages of the transition to a product company – and that the interaction with Big Pharma during the contract-based work was invaluable in helping such firms gain access for subsequent partnering opportunities. But

[6] This combination proved difficult to manage and in August 2008 Sareum sold its services activity to BioFocus, based on Chesterford Business Park.

by the end of the 1990s, gaining access to Big Pharma had become much less of a 'hard sell' because of the desperate shortage of drugs in the development pipeline.

5.2 Case Study (1): Argenta

Argenta Discovery is a highly successful demonstration of the co-existence of soft and hard activities in the drug discovery sector. After the merger of Rhone-Poulenc with Hoechst to form Aventis in 1999, the firm's UK drug discovery group based in Dagenham was closed down and the staff made redundant. In 2000 a group of 20 scientists, together with some academic scientific advisers from Imperial College, raised some £6m of venture capital to found Argenta.

They acquired a large amount of laboratory equipment from the Rhone-Poulenc research lab at a knock-down price to equip the new company, and in addition negotiated a 3-year contract to supply drug discovery services to their former employer – a revenue stream that attracted the interest and support of the VCs. With this and other contracts Argenta was able to operate close to breakeven right from the start. Although a 70/30 mix between contract and proprietary research was planned, in practice only modest proprietary work was done until 2004, when the VCs pushed through a merger with Etiologics. This was another soft start company, based around 15 scientists, led by Dr Mary Fitzgerald, who specialized in chronic obstructive pulmonary disease (COPD). They had been made redundant after Bayer shut down its respiratory disease therapeutics group a couple of years earlier. The Etiologics scientists, like Argenta's, had been able to acquire their equipment for a very nominal sum; they also had a tightly focused pharmacology-based research agenda, but offered R&D services around models of respiratory disease to bring in some contract revenue.

Etiologics' CEO, Chris Ashton, had been brought in by its VC investors to lend entrepreneurial experience and credibility to the firm's scientific pedigree, and when the two companies merged he became the CEO of the new Argenta.

By 2004 Argenta thus possessed well equipped laboratories (which it continued to supplement at very low cost as other facilities closed down), an experienced CEO, considerable drug discovery skills and expertise, a profitable contract research activity based around a small number of high value deals with high quality organizations, and a highly focused therapeutics program in respiratory disease. In due course this led to collaborative agreements with Big Pharma to take Argenta's proprietary programs forward into clinical trials. With annual contract revenue varying between £6.5 million and £8.5 million per year, by 2007 the company had earned around £50 million, against a total of £17 million invested

by VCs: “The whole point is to run a contract research business that is profitable enough to make a contribution to R&D costs… Every time we get £1 million of contract revenue, it’s money we haven’t had to raise from VCs. That’s why this model works”, points out Ashton. Argenta is able to bill clients quarterly in advance (compared with the normal monthly-in-arrears billing pattern) for contract business because of the differentiation its combination of chemistry and biology allows and the peer-to-peer respect from Big Pharma for the expertise of the ex-Bayer and ex-Aventis scientists in the respiratory disease area. Argenta calculates that its fully-loaded cost per scientist is only one-third of the real costs incurred by Big Pharma’s in-house teams. The contract business brings both delivery focus and the track record needed to impress potential partners of its proprietary respiratory programmes with the quality of its chemistry, biology and pharmacology. This ensures that any proposition gets a serious hearing.

In 2007 Argenta signed an agreement with AstraZeneca for $21 million up front plus downstream milestone payments for one of its proprietary programs. This was a transformational deal for the company, giving it significant cash reserves to progress its other proprietary programs over the next 3-4 years whilst continuing its contract R&D business. “We created IP that AstraZeneca wanted access to; in addition to the licensing deal there is a collaboration agreement where we work together to finish the program, create more molecules to back up the original work, and get additional milestone payments as the potential drugs go successfully through each phase of clinical development.” (Asthon Interview, 2009).

By 2008 the company employed 152 people, its annual revenues were £18 million, there were six drugs at the clinical or pre-clinical stage, and £18 million of cash was sitting on the balance sheet. The company was acquired in 2010 by Belgian biotech firm Galapagos and changed hands again in 2014: it is now owned by the US pre-clinical CRO Charles River Labs.

5.3 Case study (2): Cambridge Antibody Technology

Cambridge Antibody Technology is a classic example of a soft start company. Its founding chief executive was David Chiswell, who had been made redundant from his job as a research department head at Amersham International when it closed its central research laboratory in 1989. Chiswell was responsible for looking at molecular biology futures at Amersham and had already been doing some lab research on humanizing antibodies. Greg Winter, a leading academic expert in the field at the Medical Research Council Laboratory of Molecular Biology in Cambridge, was one of Chiswell’s consultants. He held several patents for single

domain antibodies and much of the base IP to the MRC's antibody gene library and when Chiswell sought his advice on setting up a company the two of them decided to team up together.

The initial team of four was largely funded from the Amersham redundancy pay and for some months the only lab work was in a borrowed "tray" in Greg Winter's lab at the LMB. Chiswell tried for 6 months to raise venture capital, but "antibody engineering" was not something in which VCs were interested at the time. Instead CAT received some start-up funding from an Australian company, Peptech101, which already had a relationship with Greg Winter and had previously tried to recruit him to head up its research. A Smart award of £45,000 in April 1990 enabled the team to be expanded to five and there was another Smart award later. However revenue funding from R&D contracts became increasingly important and by 1993, when CAT employed 15 people, the company was operating profitably. In the first couple of years CAT relied heavily on the laboratory resources of the MRC and was able to draw in a rather informal way on the expertise of LMB scientists. It filed a patent on phage display of proteins in mid-1990 and got itself noticed in the scientific world with an important paper in the journal Nature at the end of that year. While advancing the phage display science, Chiswell approached Pharmacia to suggest making research kits based on CAT's technology. The terms of that first deal – for what was essentially CAT's first product – was worth one or two hundred thousand pounds in 1991 alone, in the form of an up-front payment and a research and development agreement to design and assemble the kits. David Chiswell noted this was "a fantastic deal for us, because it was more than we could spend", generating most of CAT's revenue that year and the next.

Having moved the basic technology forward to demonstrate it could actually isolate useful proteins, in late 1992 CAT began working on deals with pharmaceutical firms to produce antibodies against specified targets using the proprietary technology it had accumulated and developed, at first for a small up-front fee and expenses plus milestones and eventually royalties. The first deal was with BASF in 1993, to produce an anti-TNF antibody, two additional specified targets and 2-3 as yet unspecified targets over a three-year period, in return for £100,000 upfront, £1 million when CAT delivered a candidate antibody, £1 million when BASF developed it to the next stage, and so on. CAT put six of its twenty staff to work on that project. There was very little precedent at that time for a deal structure in which CAT covered its costs but only made profits if it successfully produced suitable antibodies. "We could never get a profitable FTE return unless we took on some of the risk of achieving what the client wanted." But this was a managed risk, staged over intermediate milestones, each of

relatively low risk but carrying a significant premium. The first milestone was usually to produce a relatively small number (~5-6) of antibodies that bound to the target, but with a low specificity hurdle; over the next 3-4 milestones (which could be less than six months apart) the deal might specify 1-2 antibodies with a higher affinity, then one that would be neutralized, and then one candidate that to be useful in the clinic would need a given affinity and given specificity. Although CAT's first deals with Big Pharma were struck under uncertainty over whether its technology could deliver, success gave it confidence and over the following 3-4 years the up-front access fee on each deal rose from a few thousand pounds to £5 million.

Work on proprietary products commenced in 1995, a year in which CAT struggled for finance (owing to its expansion to over 20 people plus the high cost of clinical work). £3 million of additional equity had been raised in 1993, but VC funds still showed no interest in antibodies. However, major contract deals that year with Genentech, Lilly and Pfizer put the company in a position to raise £12.75 million in a pre- IPO round in 1996 and do an IPO in 1997. Until 1996, two thirds of the total £12.25 million of funding raised had come from customer revenues; CAT more or less broke even from 1993 to 1995, by when it employed 32 people.

The pre-IPO and IPO rounds allowed CAT to invest more in its own programs and increase head count rapidly – to £27m and 200 respectively by 2001. From then onwards the mixed model continued on a roughly 50/50 basis: if CAT started to run out of money for clinical work it did more contract deals, although the obligation to meet deadlines on contracts always risked sucking resources away from the proprietary work. By 2006, when CAT was acquired by AstraZeneca for £702m[7], it had 3-4 development programs that were entirely its own, another 2-3 programs partnered on a 50/50 basis, and a further 7-8 funded by other companies, all at various stages of clinical development. Hence it was a mixed portfolio, demonstrating CAT's move up the value chain and a gradual 'hardening' of its business model.

CAT was taken over during a 'buyout frenzy', when AstraZeneca's offer of £13 against a share price of £7 gave the board no choice but to accept. It acquired a firm that had grown over the course of 14 years to 284 employees and revenues of £294 million.

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[7] Company Press Release, Tuesday, 22 August 2006 http://www.astrazeneca.com/Media/Press-releases/Article/20060822--AstraZeneca-UK-Limited-Completes-Acquisition-of-Cambr.

6. Discussion

Many biotech firms have found that trying to combine contract and proprietary drug discovery work is a difficult juggling act. The dilemma for firms with a fee-for-service business – where the principal aim is revenue – combined with an IP-based business (whose goal is to invest in its own pharmaceutical product development), is whether to invest the revenue generated in marketing and in growing the revenue-based business or whether to put it into the risky drug discovery side. The challenge, then, is to strike the correct balance between immediate revenues and creating long term value. Also important is to avoid a cultural divide between 'money earners' and 'money spenders' (the latter being the 'glamorous' or 'real' business of in-house research). This is most easily achieved by intentionally switching people between contract and proprietary programs from time to time. Since contracts are typically several months rather than several years long, opportunities to work on different things in different project teams stimulate both interest and learning. Further, contract work instils a delivery discipline that could be lost if the two sides were separated: monitoring on a daily basis to ensure weekly or monthly targets for customers are met introduces a different style of working to the more cosseted research environment often encountered when customer pressures are small or non-existent and timescales are long.

According to Chris Ashton at Argenta, the contract R&D model in life sciences requires strong financial discipline and realistic ambitions: rather than doubling its headcount following the merger with Etiologics "we capped the size of the service business and concentrated on getting the right price for the service so that it was profitable", especially against a background of price attrition at the less complex end of the contract chemistry market.

Whereas Chiroscience solved the balance problem successfully by moving contract work to a separate subsidiary, Chirotech, others have had less success with the model. Royston-based Pharmagene, a supplier of human tissue samples for use in drug research which was also attempting to develop a treatment for cystic fibrosis, was taken over by US firm Asterand in 2005 when its proprietary drug development programme faltered. BioFocus, a chemistry-based company rather like Argenta, was unable to remain independent on the fee-for-service model but continues to offer chemistry services under the auspices of Galapagos NV. At Daniolabs, which aimed to develop assays based on zebra fish, early revenues were generated on contracts to conduct sophisticated disease modelling and safety pharmacology services, but finding the balance as it built up a technology base and an IP position was a constant struggle. It succeeded in winning many small pilot contracts but never managed to

capture the larger follow-on contracts that would make ends meet. Eventually the company was sold to a UK competitor, Vastox (now Summit plc), which continues to offer zebra fish-based services combined with its own drug development program. The balance is particularly difficult to manage in public companies due to the conflicting interests between shareholders who have invested because of the revenue stream and those who have invested for the longer term but higher risk drug discovery potential.

The soft model was rather unpopular among life sciences venture capitalists for a long period in the 1990s, even though revenue-generating activities could be seen as partially de-risking the proprietary technology proposition. But a renewed interest in platform technologies may now be altering that negative perception. Investors in the past have sometimes forced the sale of profitable service-based assets that they do not recognize as a valuable component of the business, because they regard fee-for-service activity as slowing down the growth potential. Venture capital-backed drug discovery firms have often faced the problem of UK VCs preferring trade sales – often on the basis of unsolicited bids from Big Pharma – when data on their proprietary research programs start to come through. This suggests that concern by VCs over the need to finance further rounds of investment (or, alternatively, their fear of dilution) effectively imposes a natural size limit on UK drug discovery firms.

One of the reasons why the softer model of biotech start-up has functioned relatively well at least in the East of England region is the involvement of ex-PA Technology scientists. PA established a strong biotechnology group in the 1980s but, unlike academic bio-scientists and people with a background in the large pharmaceutical companies, its members developed their business skills in an environment in which they lived and died by how much work they could sell. They created a valuable pool of expertise and, in times when there was little venture capital available, some important biotech companies in the region employed such individuals in business development roles to access and set up contracts with client companies. Andy Richards, who rounded out scientific skills developed at ICI with several years picking up commercial capabilities as a consultant at PA, is an example of an experienced life sciences business development director (and, more recently, angel investor). Having been instrumental in the growth of Chiroscience until its acquisition by Celltech, he has since been involved in several other biotech start-ups that operate some form of the soft business model.

Adopters of this business model in the life sciences sector point to its impact on development and training at all levels of the company: scientists collaborate and interact with

their peers in other organizations and all the time have exposure to activities that they would not necessarily experience in a different style of company. Progress through a career at a company like Argenta Discovery is based on the ability to collaborate and communicate. It exposes managers to tough negotiators in major client organizations on a regular basis in a way that proprietary research company managers do not until the moment comes to commercialize a drug. At this point the learning curve is arguably too steep.

7. Conclusion

A soft business model can bring great benefits to companies at different stages in their development. *As a start-up model*, it requires limited capital investment or equipment; is relatively easy to manage; provides a means of accessing a wide range of client companies; and enables an unrestricted product strategy through which both start-up and clients can explore new techniques and solutions in a relatively risk-free manner. *As a growth model*, it allows the gradual build-up of capabilities and market understanding; exploits the creative talents of scientists and engineers; facilitates progressively larger projects as resources increase; permits more or less self-funded growth; generates cash for some degree of investment in IP; and enables technically oriented managers to learn on the job. *As a platform for transition into product*: it provides a mechanism for on-going intelligence gathering about emerging customer needs; can turn modest investments in IP into additional revenue streams, e.g. through licensing; and can enable standard products to emerge in a variety of ways, e.g. through consortium-funded technology developments or as a result of 'orphan' projects discontinued by clients. *As a mechanism for exploring applications of platform technologies*, it enables different commercial applications of science or engineering breakthroughs to be explored with a variety of potential customers; and helps address the problem of funding lengthy development and manufacturing scale-up timeframes.

Although the management demands raised by the soft model are multiple, they are relatively uncomplicated compared with the financial, production, market and people management challenges immediately encountered by product-based companies. A soft business model enables firms to conduct 'real world' market research, test and refine their technology proposition, build credibility with customers, and develop a robust and competent team of people. These factors are crucial to the longevity of a firm. If a soft company decides to transition into a product business, venture capital financing will nevertheless often play a key role. Though the further the transition can be taken with internal funds, the larger the equity stake the original owners are likely to retain until exit is reached.

There are also systemic benefits to the adoption of this business model which are observable in the East of England region. The soft model firms we interviewed that continue to operate as separate entities directly employed around 3,525 people and generated over £435 million in revenues. These figures represent the bare minimum contributions of soft model firms to the regional economy, since (i) they exclude the earlier contributions of firms that followed a soft business model but are no longer in independent existence, and (ii) we believe many other firms in the region than those we interviewed also follow some version of the model.

Since soft companies tend to grow relatively slowly and do not engage in high volume manufacturing, their product-based spin-out companies tend to be bigger contributors to the local economy than they are. Cambridge Consultants has created over a dozen spin- out firms, including Domino Printing and Cambridge Silicon Radio, that together employ over 3,500 people – well over 10 times its own current headcount; Acorn Computers, a hard company whose founders pursued a soft start approach, nurtured internally the team that established ARM; and ORL/AT&T Labs and its alumni created numerous new businesses in the region.

Soft model firms also generate significant indirect economic benefits as an important source of complementary expertise for local 'hard' start-ups and in the form of value-added through technology conceived to enhance clients' productivity. We point also to the important continuing contributions of ex soft-start entrepreneurs who have become advisors to the local technology community, and important early-stage investors. By enabling them to retain control of their businesses as they grow and minimize founder dilution, the soft start up model has played a key role in building the business angel community. This contrasts with the VC-backed, hard start-up model under which the rewards even to successful founders and managers are often much less than generally imagined, resulting from the punitive dilution that goes with successive venture capital rounds. Furthermore, soft firms have greater potential for longevity and continued location in the region than VC-backed firms, bringing continuing benefits to the community through the trickle-through of expertise and expenditure. Even if sold to a larger firm the acquirer of a soft company is likely to remain dependent on the expertise of its technologists and less likely to rationalize operations.

The needs of technology-oriented SMEs that do not pursue the Silicon Valley model may have been poorly served by innovation policy. Only by thoroughly understanding the business models pursued by science and technology firms in practice, and designing policies that support and reinforce these endogenous processes, can we expect to have successful national and regional policies. One of the key challenges for government policy is to help fill

any ‘funding gaps’ arising because of market failure or for other reasons. The phrase is usually used to describe the difficulty that companies face in raising small amounts of equity investment – typically up to £0.5 million. However, there is a more important funding gap when it comes to commercializing research in universities and large corporate laboratories.

The most important commercial opportunities generated by research organizations are typically platform technologies with multiple applications, which usually require a good deal of further development and testing with potential users before they can provide the basis for a VC-backable business. If new materials, devices or process technology is involved, scaling up manufacture to commercial volume can take many years. This exploratory stage of development must be undertaken within a commercial or quasi-commercial, mission-driven environment, even though it cannot readily be financed by venture capital as the timescales are too long and the risks and uncertainties too high. The venture capital model is much more appropriate to a ‘hard’ company requiring funding to scale an already well-defined business idea or develop and market new applications of proven technologies. This funding gap can be at least partially filled by R&D contracts with lead customers to finance the development of demonstrators, either alone or alongside venture capital.

Some companies pursuing an entirely ‘soft’ model have been able to fund experimental technology development wholly from customer contracts, leading eventually to the development of a scalable product or ‘hard’ business. This evidence calls for the design of innovation policies that strike the right balance between supply push and demand pull approaches to entrepreneurial growth in the UK, including the use of public sector innovation contracts for SMEs and broader procurement-based innovation programs.

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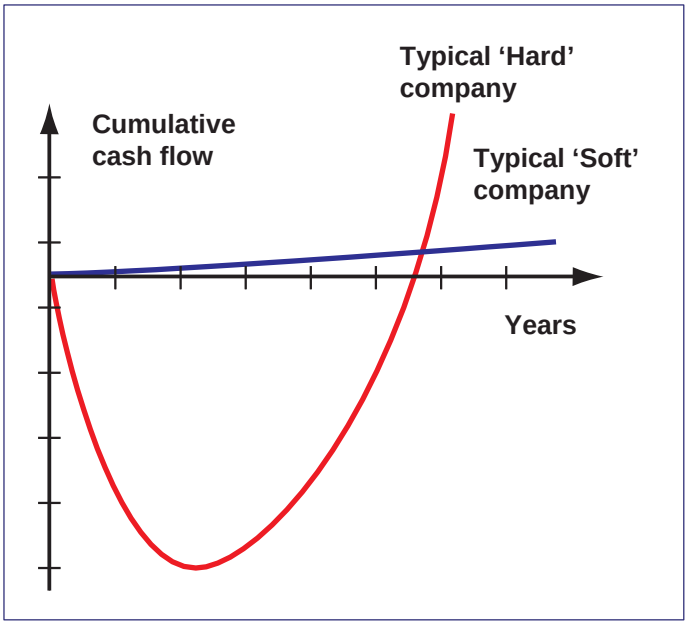
FIGURE 1

Typical Cash Flow Profiles for Successful 'Hard' and 'Soft' Companies



TYPICAL CASH PROFILES		
	Max Cash Negative	*Time to Cumulative Profitability*
Soft Company	Up to a few hundred thousand pounds	6-18 months
Hard Company	Ten million pounds plus	5-10 years

APPENDIX – List of Interviewees (companies no longer operative in brackets)

42 Technology	Howard Biddle	CEO
(Acorn)	Hermann Hauser	Founder
AIC	Matthew Jones	Head of Projects & Innovation
Argenta Discovery Autonomy	Chris Ashton, Colin Knox	CEO, Finance Director
Beru F1 Systems	Mike Lynch	Founder
CADCentre	John Bailey Dick Newell	Managing Director
(Cambridge Antibody Technology)	David Chiswell	Senior Engineer
Cambridge Consultants	Paul Auton	Founder
Cambridge Consultants	Ray Edgson	Former CEO
Cambridge Design Partnership	Mike Beadman, Mike Cane	CTO/Ventures Director
Cambridge Magnetic Refrigeration	Kurt Hasselwimmer	Founders
(Chiroscience)	Andy Richards	Founder
CIP Technologies	Michael Robertson	Founder and Business Angel
Knowledge Solutions	Adrian Palmer-Geaves	VP Research Programmes
Lotus Engineering	Clive Card	Founder
Marshall of Cambridge	Michael Marshall	Project Manager, Research
(Olivetti Research Labs)	Andy Hopper	Chairman
Owlstone	Billy Boyle	Director
PA Technology Centre	Ian Rhodes	Founder
PA Technology Centre	Paul Ruskin	Member of PA's Management
(Pi Research)	Tony Purnell	Group Member of PA's
Plextek	Colin Smithers	Management Group Founder
Real Time Content	Martin Russ	Founder
Sagentia	Alistair Brown	CTO
Sagentia	Gordon Edge	CEO
Scion-Sprays	Gavin Farmer, Jeff Allen	Founder
Sentec	Mark England	Managing Director, Director
Serentis	Peter Keen	CEO
Sonar Link	H-K Yeo	Finance Director
(Symbionics)	Henk Koopmans	Founder
Syrinix	Paul Linford	
Syrris	Nick Tait	Founder
Team Consulting	Jerry Turner	Finance Director
The Automation Partnership	Richard Archer	CEO
TTP Group	Gerald Avison	Founder
TWI	Bob John	Founder
Babraham Bioscience Technologies	David Hardman, Derek	CEO
Beacon Innovation Centre/Orbis Energy	Jones	CEO, Chief Business Officer
BioPark Welwyn	John Balch	Director
Centre for Sustainable Engineering	Steven Read	
Colworth Park	Phil Shephard	
Health Enterprise East	Sally Ann Forsyth	
Herts BIC	Phil Seabright	
Hethel Engineering Centre	Phil Lines	
Norwich Research Park	Damian Hindmarsh, Simon Coward	
St John's Innovation Centre	Robin Daniels	Chief Executive
(Barclays Bank)	Walter Herriot	Chief Executive, Norwich and
Coller Capital	Matthew Bullock	Peterborough Building Society
New Venture Partners (BT Brightstar)	Stuart Davies	
Cambridge Network	Chris Winter	Partner
East of England International	Peter Hewkin	Chief Executive