

**The relation between key events in the development phase
and the financial structure of NTBFs in the software sector**

**Running title: The relation between key events and financial
structure in NTBFs**

Teresa Hogan*
Dublin City University Business School
Glasnevin, Dublin 9,
Ireland.
E-mail: teresa.hogan@dcu.ie

and

Elaine Hutson
UCD Michael Smurfit School of Business
Blackrock, Co. Dublin, Ireland

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Abstract

This paper finds no systematic relation between product lead time and acquisition of first external funds in new technology-based firms (NTBFs) in the software product sector. Contrary to the stage model's predictions, these firms are just as likely to secure finance in advance of producing their first product beta as they are to receive funds subsequently. Product lead times in this sector are short. Firms produced their first product beta in a median of 12 months and acquire their first external funds a median 3 months later. The timing of these two events, however, is not significantly different. There is a significant difference in the mean time to receipt of consulting revenues and the development of first beta, suggesting that most software product companies use consulting revenues to fund product development

Keywords: Stage model, capital structure, product lead time, NTBF, soft starts.

It is widely agreed that technology-based small and medium-sized enterprises (SMEs) play an important role in the development and diffusion of innovation, and economic growth and employment. As a result, the financing of technology-based firms has become an increasingly important focus of government policy in the European Union. At the centre of concern is the possibility that new technology-based firms (NTBFs) experience severe financing constraints, especially at start-up.

We examine this issue through the lens of the stage model (or life cycle model), which has been the dominant theoretical framework in empirical research on NTBFs. One of the major criticisms of the stage model as applied to NTBFs is that they are not a homogenous group. Several scholars have suggested that in order to provide a framework for more meaningful analysis of the development and growth of firms, the stage model must be tested on specific sectors. We take up this suggestion by looking at the software product sector. In this paper we use data gathered via a large-scale survey to examine the financing of 117 privately held firms in the Irish software sector.

While several studies have tested the general model of the life cycle of technology-based firms (Arbaugh and Sexton, 1993; Hansen and Bird, 1997; Kazanjian and Drazin, 1990), few have tested the stage model in relation to financing events. We examine the timing of key milestones in the start-up phase of the sample firms in relation to the timing of the first injection of external finance. The key milestones include the first product beta, recruitment of first employee or employees, and receipt of first product revenue. We also test Bullock's (1983) hypothesis that technology firms may be 'soft starts' by

examining the extent to which software product firms rely on consulting revenues.

We show that, in contrast to firms in other high technology sectors that face long product lead times and high capital costs, product lead times in the software sector are short (a median of 12 months to the first product beta). Sample firms acquire their first external funds a median 3 months later, although the timing of these two events is not significantly different. In fact, only slightly more than a third of sample firms receive their first external funding before producing their first product beta. As well as short product lead times, the absence of external funding at start-up can be explained by the critical role played by consulting revenues in the financing of the sample firms. Software firms are indeed 'soft starts': we find that the receipt of consulting revenues is the earliest activity recorded by the sample firms – a median of 3 months after formation. The combination of short product lead times and the availability of consulting revenues appear to give software firms considerable flexibility in their choice of financing.

The remainder of the paper is structured as follows. The next section presents an overview of the software sector in Ireland. This is followed by a discussion of the literature on NTBFs and the stage model, and includes the paper's hypotheses. In the fourth section, we discuss the survey methodology and presents summary data on the characteristics of the sample. Our findings are discussed in three sections: capital structure by stage, key events in the formation process, and sequencing of the key events. The final section concludes.

THE SOFTWARE SECTOR IN IRELAND

The software sector is sub-divided into 'products' and 'services'. The term *software products* refers to packaged software, defined 'as commercially available programmes for sale or lease from systems vendors and independent software vendors' (IDC, 2000: 189). Software products are generally produced in large volumes for mass markets, while bespoke software is usually provided on a client-by-client basis. *Software services* usually refers to bespoke software, and the term includes consulting, implementation, support services, operations management and training (IDC, 2000). We define software product firms as those that are primarily involved in the development and commercialisation of their own products; that is, they have developed or were in the process of developing software packages for commercialisation.

The software sector is an important component of Ireland's economic output. In 2000 Ireland and the United States together accounted for more than 55 percent of OECD software exports. Ireland has become the centre of European manufacturing and distribution for many of the world's top software firms, accounting for over 40 percent of all packaged software and 60 percent of all business software sold in Europe (Enterprise Ireland, 2000). It is also the world's largest exporter of software services. Software services exports of \$5.48 billion in 2000 comprised one-third of Ireland's total services exports. Multinationals account for most of the activity in the Irish software sector. This paper, however, is concerned with the indigenous software cluster, which accounts for about 10 percent of the sector's output.

THE STAGE MODEL AND NEW TECHNOLOGY-BASED FIRMS

The stage model paradigm has long been popular in both the practical and theoretical literature on organisational evolution. The model portrays the development of new firms as linear and sequential, consisting of identifiable stages. Its underlying premise is that the firm requires different management and structures in order to respond to the unique challenges posed by the various stages in the firm's evolution. Acceptance of the model in the technology sector is demonstrated by the structuring of venture capital deals into stages or rounds. Nesheim's (2000) widely acclaimed handbook *High-Tech Start Up* breaks down the capital formation process into 14 stages, from the idea phase through to initial public offering (IPO).

The stage model has been used extensively in academic analysis of technology-based start-ups (see, for example, Galbraith, 1982; Hansen and Bird, 1997; Kazanjian, 1988; Kazanjian and Drazin, 1990; Roure and Keeley, 1990). Despite its popularity as a theoretical framework, the stage model as applied to the NTBF has received little empirical validation. The research that has been conducted confirms the hypothesis of Reynolds and Miller (1992) that, rather than occurring sequentially as predicted by the life cycle model, key events (such as first employee hire and first sale) can occur concurrently or in any order in the general population of start-ups. Hansen and Bird (1997), for example, analyse key events to test the validity of the stage model in NTBFs. They suggest that firms are likely to hire their first employee before or during the product development stage. Because development and testing precedes the first sale, the first employee hiring should also precede the first sale. They found, however, that while some of their sample firms followed this sequence as predicted by the stage model, others did not.

While many prior studies of NTBF development have disregarded financing issues, more recent research holds that stages in the firm's development are paralleled by changes in its financial structure and access to finance. In a large-scale study of high-technology firms, Roberts (1991) points out that

The new technology-based firm evolves through a succession of several stages of corporate growth and parallel development in its finance. The time during which a company can be classified in a particular phase varies widely among firms and the dividing line between phases is at best fuzzy. Yet the relative stage of evolution does strongly influence the type and amount both of capital required and especially of capital available (Roberts, 1991: 125).

Roberts (1991) identifies four stages in the financial lifecycle of NTBFs: seed, start-up, early growth, and sustained growth. These are presented in Table 1, which includes the primary sources of financing available and the potential financial problems encountered at each stage.

Insert Table 1 about here.

The Seed Stage

As noted in Kazanjian (1988) and Kazanjian and Drazin (1990), NTBFs differ from the general population of start-ups in that they are characterised by an intensive period of research and development, which, if successful, results in the development of a real asset that is as yet unproven in the marketplace. At this *seed* (or *zero*) stage, the organisation tends to be informally structured and much of the initial research and development may be undertaken on a part-time basis while the founder is still based at a university, research laboratory or commercial organisation. The success of this phase is highly dependent on the human capital

of the founder and is characterised by high levels of uncertainty. In order to develop the product, the founder commits limited personal funds, assumes the risk of failure, and puts in time and effort (so called 'sweat equity'). This phase is funded primarily by the founder's personal savings and those of friends and family.

The Start-Up Stage

The seed stage is followed by prototype development and testing at *start-up*. It is likely that the founders' personal funds will be exhausted during this stage, and some source of outside funding is usually necessary. This is because the NTBFs tend to be characterised by long product lead times. However, amongst NTBFs there will be great variation in capital requirements and product lead times. Oakey (1995) highlights the financial implications of differences in the innovation cycle of NTBFs in different sectors such as software vis á vis biotechnology or electronics. Software firms clearly require less initial funding because product lead times for software products are generally short, and early costs are usually smaller, involving mainly human rather than expensive physical capital (Roberts, 1991 and Oakey, 1995).

There is limited evidence on NTBF financing at start-up. It is likely, however, that external sources play a minor role in NTBFs at start-up, and this may be due to financing constraints. Roberts (1991) reports that:

Initial capital is supplied most frequently by entrepreneurs themselves from their own savings, second by their family and friends, and third by private investors, all these being sources of capital outside of the normal channels (Roberts, 1991:141).

In the UK, Moore (1994) reports that NTBFs raised only 7 percent of initial funding from banks, compared with 24 percent for SMEs in general, suggesting that NTBFs face greater problems in debt markets than their counterparts in other sectors at start-up. If private equity and/or venture capital are unavailable, the NTBF is likely to face serious financial constraints. Undercapitalisation at start-up has been linked to poor growth performance (Lumme, Kauranen, and Autio 1994; Moore, 1994).

As an alternative source of finance, high-technology firms may rely on cash flows from consulting activities. Bullock (1983) suggests that many begin life as 'soft starts'; founders can choose a low-risk service-orientated 'soft' start-up entry strategy and 'harden' over time to become product-orientated ventures. PricewaterhouseCoopers (1999) demonstrates that Bullock's (1983) 'soft start' description is particularly apt for the software sector; many software product companies start out providing bespoke development and consulting services to businesses before going on to develop software products.

The Early Growth and Sustained Growth Stages

The 'early growth' stage marks the end of product development, and at this stage the firm begins to establish a foothold in the market. The risk of failure recedes as sales revenues increase and retained profits become an increasingly important source of finance. By the time the NTBF reaches the 'sustained growth stage' it will have diversified in terms of products and markets. The firm's investment decisions and financing requirements will not differ substantially from those of other successful large companies.

Critiques of the Stage Model

While Roberts' model is potentially useful for explaining NTBF financing, the well-known criticisms of the stage model apply. The model implicitly assumes that all firms pass uniformly through these predetermined stages (Gibb and Davies, 1991; O'Farrell and Hitchens, 1987). Many firms do not survive beyond the first stage, and few of the survivors achieve the sustained growth phase. In relation to sequencing of the stages, Storey (1994) questions the validity of the assumption that the movement from one stage to another is driven by the emergence of problems or crises. Other researchers view new firm development as a stochastic rather than as a linear sequence as the stage model implies (Gersick, 1994; Katz, 1993; Reynolds and Miller, 1992). In a rare empirical test of the stage model for SMEs, Reynolds and Miller (1992) examined the sequencing of four events: principals' commitment, first hire, first financing, and first sales. They found little support for a linear and sequential formation process.

Hypotheses

The stage model predicts that NTBFs are primarily self-financing at the start-up phase in their evolution. Product lead times, however, may affect the firm's ability to finance this phase internally. The longer the product lead time, the more likely firms will require external financing (Oakey, 1995; Roberts, 1991). In the software sector, product lead times are generally shorter than in other high technology sectors, and capital requirements are relatively low (Oakey, 1995). This suggests that the software product firm may be able to produce its first product beta without having to first secure external funds. The central hypothesis of this paper is that software product firms will be primarily self-financing at start-up.

H1: Beta development will precede the first injection of external funds in software product firms.

Bullock (1983) suggests that NTBFs, particularly in the software sector, are 'soft starts' that engage in consulting activities and evolve over time to become product companies. Bullock notes that the 'soft start' is particularly applicable to the software industry because the advent of low-cost computing has greatly extended the range and complexity of the consultancy services that new firms in the sector can offer. Low-cost computing

...has blurred the soft/service - hard/manufacturing distinction that was common in earlier years and has allowed the steady growth of hard service companies, such as software houses (Bullock, 1983: 17).

Hypothesis 2 posits that software product firms use consulting revenues to finance the product development phase; that is, that they engage in consulting activities prior to beta development.

H2: Software product firms are 'soft starts,' and engage in consulting activities prior to producing their first product betas.

Software development is heavily dependent on human capital input, and capital costs are relatively low. According to the stage model for the technology sector, firms are likely to hire their first employee(s) before or during product development and testing, so that the first hire precedes the first sale (Hansen and Bird, 1993). This gives rise to hypothesis 3:

H3: First hire will precede first beta in software product firms.

SAMPLE, SURVEY AND DATA

NTBFs are a sub-class of high technology firms. Little's (1977) definition of NTBFs is widely accepted: they are less than 25 years old, their product or service must be based on the exploitation of an invention or technological innovation, and they must be independent. Little's (1977) intention was to exclude large and/or well-established high-technology firms, so that NTBFs can be viewed as a distinct sub-sector of high technology firms. However, as pointed out by Storey and Tether (1998: 934), "in some instances it is unclear whether the word 'new' applies to the firm or to the technology or both." In a recent review, the term 'technology-based new firm' (TBNF) was adopted, perhaps in an attempt to clarify this point (Autio, 2000). In this study, the word 'new' refers to both technology intensity and firm age; our software firms are less than 25 years old. In terms of firm size and legal status, consistent with the EU SME definition, we include firms that have less than 250 employees and are legally independent, insofar as they are not subsidiaries of multinational firms.

The population of independent Irish software product firms was identified using a wide variety of information sources, including lists provided by the Irish Software Association and the National Informatics Directorate, lists of occupants of innovation parks, lists of participants in a national technology entrepreneurship award program, and firms cited in specialist journals. At the end of 2001 the population of independent software product SMEs in Ireland was 257.

The survey design is based on self-administered questionnaires using the tailored design method (Dillman, 1976 and 2000). The survey was administered by mail

and addressed to named CEOs. A covering letter requested that the surveys be completed by the founder, or by the lead founder if the company had been founded by a team. Respondents were given the choice of completing either a paper or web-based questionnaire. The first follow-up contact was also by mail, and the second by telephone. The final contact was via e-mail, and it contained a hyperlink to the electronic version of the questionnaire. Completed questionnaires were received during April and May 2002. The number of valid returns was 117 out of a population of 257, giving a response rate of just under 46 percent. This is a robust response rate relative to SME survey response rates in general, as reported by Curran and Blackburn (2001).

Table 2 summarises the data on firm age (Panels A and B) and size by number of employees (Panel C). Panel A shows that the youngest firm is 5 months old and the oldest is 27 years. Two firms are more than 25 years old, and thus they fall beyond Little's (1977) age criterion. However, as they fulfilled all of Little's other criteria we have decided to include them.

The under-representation of the smallest and youngest firms is a key issue in small business research. Overall, young firms are well represented in our sample. The average firm is just under 6 years (5 years and 10 months), and the median age is 4¼ years. Panel B of Table 2 delineates the sample into 4 age categories. Experts in the Irish software sector estimate that approximately 30 start-ups were formed in this sector in 2001 (HotOrigins, 2002). Fifteen of our sample firms are less than 2 years old, indicating that new firms are well represented.

Insert Table 2 here

Panel C of Table 2 shows the size distribution for the dataset of 115 firms using the European Union classification system for SMEs. In 2002, the sample firms employed a total of 3,005 people, giving an average of 26 employees per firm. Micro and small firms are well represented: 37 percent of firms had less than 10 employees, 48 percent had between 10 and 49 employees and 5 percent had between 100 and 249 employees.

Table 3 presents the data on start-up costs.¹ The vast majority – 59 percent – had very small start-up costs with less than €127,000 in capital. A small proportion (almost 10 percent) started with very large investments of over €1,270,000.

Insert Table 3 here.

The survey also requested details of financing sources, separated into internal (savings, consulting revenues and retained earnings) versus external (bank debt, venture capital, private investors and government grants). Respondents were asked to identify their firm's formation date and to supply dates for key events in the formation process relative to the formation date. These events are development of the first product beta, recruitment of the first employee(s), receipt of the first revenues from consulting activities and receipt of the first revenues from product sales, and first external funding. To enable greater precision than in prior studies that have used annual data, we requested this information to the nearest month.

¹ Start-up cost figures were requested in Irish punts because the questionnaire was sent out just after the full introduction of the Euro in early 2002. The figures have been converted into euro at the €/£ exchange rate of 1.27.

THE CAPITAL STRUCTURE OF SOFTWARE PRODUCT FIRMS BY STAGE

The stages are defined as follows: start-up (less than 2 years), commercialisation (2-4 years), growth (5-9 years) and maturity (more than 10 years). The time bands for the start-up, commercialisation and growth stages for software product firms are based on estimates provided the National Software Directorate (1997), and the description of the four stages is based on Roberts (1991), with one exception – Roberts (1991) does not include a mature stage in his model. The description of the mature phase comes from traditional financing stage models as outlined by Weston and Brigham (1970) and the time band is taken from Berger and Udell (1998).

Table 4 provides summary capital structure information at each stage for the 96 firms in the sample that provided detailed funding information. The average figures for the full sample show a 50/50 divide between internal and external sources of finance. A mere 4 percent of financing is provided by banks, and the remaining outside finance (46 percent of the total financing requirement) is private equity and government grants. An important and novel finding is that the largest individual source of internal finance for the firms overall is consulting revenues, providing almost 20 percent of total financing. This is closely followed by retained profits (17 percent) and savings (14 percent). These findings are largely consistent with prior research on capital structure in NTBFs. In the US, Roberts (1991) found that bank finance did not feature at all as a funding source for high-technology start-ups, and private outside equity comprised 21 percent of total funding. However, the proportion of private equity in Irish software firms, at 39 percent, is much higher than for UK-based NTBFs reported by Moore (1994), who found that venture capitalists provide only 10 percent of funding.

Insert Table 4 about here.

Financing clearly differs depending on the firm's age. External sources are more important for firms aged 2 to 10 years, and are less in evidence for firms 10 years old or more, for which retained earnings comprises almost half of financing requirements (46 percent) as reliance on outside finance declines to only one-quarter of the total. Consistent with hypothesis 1, it is clear that the NTBFs in our sample are primarily self-financing at start-up. Assuming 'start-up' is defined as firms less than two years old,² 73 percent of financing for the 12 firms aged less than 2 years is sourced internally. Most of this funding is from personal savings of the founders (43 percent), and a substantial component is provided by cash flows from consulting services (27 percent of total funding). This is consistent with hypothesis 2 and Bullock (1983) that software product companies are 'soft starts' and rely in their early years on revenues from consulting activities.

External funding is at its highest for firms at the commercialisation stage of their evolution – those between 2 and 4 years old. Sixty-eight percent of finance is sourced externally, largely from venture capitalists (38 percent) and private investors (18.5 percent). The reduction in internal sources and the increasing reliance on external sources during the commercialisation is consistent with the stage model; as savings have been run down and sales have not yet taken off (and firms have therefore not yet had the opportunity to build up retained profits), funds for commercialisation expenses must be sourced from outside the firm. Another interesting feature of firms at the commercialisation stage is that funds from consulting revenues are at their lowest (13.5 percent of total funding).

² Several studies have defined 'start-up' in this way, the most recent being Cassar (2004).

This would probably be because the firm's human resources are mobilised into the commercialisation effort, and consulting activities must therefore be curtailed.

KEY EVENTS IN THE FORMATION PROCESS

Table 5 reports the timing of the following key events³ in the start-up process of software product firms: development of first product beta, recruitment of the first employee(s), receipt of the first revenues from consulting activities, receipt of the first revenues from product sales, and first external funding. The timing is calculated from the month of formation. Column 6 reports the number of firms that attained the five milestones described above, and column 7 is the number of firms that had not reached the particular milestone. There are considerable differences in the proportion of firms reporting attainment across the five events. At the time of the survey, all but four firms for which data are available had recruited their first employee, and all but six had produced their first product beta. The number of firms reporting attainment for the remaining three events is much lower. Twenty-three firms (or 19.7 percent) had not received their first consulting revenues; 18 (15.3 percent) had not received revenue from product sales, and 24 (20.5 percent) had not acquired external funding.

Insert Table 5 about here.

The mean and median number of months from start-up to the attainment of each milestone appear in columns [1] and [2] of Table 5. All of the means exceed the medians, indicating right-skewness in the data. This is confirmed by the

³ One extreme score, relating to time to first beta, was removed from the analysis. This company was formed in 1975 but did not produce its first beta until 1999 and provided no information on other founding events.

histograms of the time to milestones in Figure 1. The discussion of the summary statistics will therefore concentrate on medians rather than means, and the statistical testing will be non-parametric.

The median time to first product beta was 12 months, which was well after the firms hired their first employee (4 months), and earned their first consulting revenues (3 months). First product revenues were earned a median of two months after product beta in month 14, and first external funding was obtained one month later – a median of 15 months after start-up.

Figure 1 shows considerable variation in the distribution of these milestones over the sample firms. Most firms achieved all five milestones during the first year of operation. Eighty-eight firms (76 percent) had hired at least one employee by the end of their first year, and 31 (27 percent) had employed staff immediately on or before the formation date. A substantial proportion (66 percent) had received their first consulting revenues during the initial 12 months of operation, and 19 had received these revenues before or at the time of start-up. Smaller counts are recorded during the first year for first product revenue and first external financing (36 percent for each), and 58 firms (50 percent) produced their first product beta during their first year of operation.

Insert Figure 1 about here.

SEQUENCING OF THE KEY EVENTS

The test statistics for the sequencing of the key events are presented in Table 6. As the data are not normally distributed, the Wilcoxon rank sum test is used to test for timing differences. In addition to reporting results on tests for

Hypotheses H1, H2 and H3, the table reports the findings for one other sequence: beta versus product revenues. As product revenues can be generated only after the first product beta is available, this comparison is included as a check on the consistency of the survey responses.

Insert Table 6 about here.

H1: Beta Before External Funding

Hypothesis H1 suggests that software product firms should be able to produce their product betas without needing to access external finance. At first glance, the findings in Table 5 tend to support hypothesis H1, as the sample firms produced their first product beta a median of 12 months after formation and they received their first external funding three months later. The histograms in Figure 1, however, show that the distribution patterns for the two milestones are very similar, and the Wilcoxon test reported in Table 6 confirms that the times taken to reach these two milestones are not significantly different ($p = 0.44$). H1 therefore is not supported by the data.

Table 7 presents more detail on the sequencing of these two important events. Monthly observations were available for both events for 92 firms. Annual data for 17 firms was included, because in these cases the reported milestones occurred in different years. The table shows that the sample software product firms were just as likely to secure finance in advance of producing their first beta as they were to receive funds subsequently. Thirty-six percent of firms produced their first product betas before receiving funding (row [B]) and 37 percent received funding in advance (row [C]). Four firms secured funding and produced their first betas concurrently (row [A]).

Insert Table 7 about here.

Table 7 also reports the findings for 27 firms that did not attain one or both of these events. For the 20 firms that had produced a product beta but had not received external funding (row [D]), it is possible that they intend to seek external funding in the future. However, it is also possible that these firms intend to remain entirely self-funded. An examination of the age structure of this group reveals that four are less than two years old, six are between two and four years, and 11 are more than five years old. The 'less than two years old' group may well intend to seek external funding in the future, but this is a less plausible explanation for the absence of external funding amongst the older firms. All but four of the 11 firms in the 'more than five years old' age group had produced their first product beta within two years of formation, and all but one had produced their first product beta within three years. It is therefore likely that this group of mature firms demonstrate a different pattern to the general population of software firms, in that they would appear to eschew outside funding, preferring to finance their development from internal sources.

Three firms had received funding but had yet to produce their first product beta (row [E] of Table 7). These firms could probably be categorised as having received funding prior to producing their first beta, unless of course the product development phase proves fruitless. Finally, three firms had neither secured external funding nor produced their product betas (row [F]).

H2: Consulting Revenues Before Beta

Hypothesis H2 posits that 'soft start' implies that firms would undertake consulting activities before their first product betas are available. Table 5 shows

that the receipt of consulting revenues is the earliest activity recorded by software firms, occurring a median three months after formation. Only 23 firms report receiving no consulting revenues. In contrast, the median time to first product beta is 12 months. The Wilcoxon test (Table 6) confirms that consulting revenues are obtained before first product beta ($p = .00$). This result strongly supports H2 - that software product firms begin life as 'soft starts,' supporting Bullock's (1983) model of the evolution of NTBFs.

H3: First Hire before Product Beta

Hypothesis H3 posits that the first hire will precede the development of first product beta. Table 5 shows that sample firms hired their first employee(s) a median of four months after formation, with first product beta 8 months later. The Wilcoxon test presented in Table 6 confirms that employees are hired significantly earlier than the appearance of the first product beta ($p = .00$).

Along with consulting activities, hiring employees is one of the earliest events in the life of Irish software product firms. Although the median time to first hire is one month later than the median time to first consulting revenues, a Wilcoxon test shows that the difference in the timing of these two events is not significant ($p = 0.94$). This finding is not surprising because these two events would be highly interconnected. As firms increase their consulting activities, revenues increase, facilitating the hiring of additional staff. Equally, the hiring of staff increases the pressure on firms to generate income to cover salary costs, which in turn drives the pursuit of consulting contracts.

Product Revenues Versus Beta: A Consistency Check

Table 5 shows that first product revenues (median 14 months after formation) follow hard on the heels of the first product beta (12 months), as would be expected. Despite these events occurring so close to each other, the last row of Table 6 reports that the timing of first product beta significantly precedes first product revenues. Figure 2 shows the number of companies reporting both first product beta and first product revenues, cumulated by months. Fifty-eight firms had produced a product beta and 42 had earned product revenues within in the first year after they started, and most had achieved both objectives by year 5. The two lines on Figure 2 remain approximately equidistant, which is indicative of consistency in the survey responses.

Insert Figure 2 about here.

CONCLUSION

The financing of NTBFs continues to be an important issue for both practitioners and academics, and the stage model remains a central framework of analysis. In this study, we presented a model of financing in software product firms that provides a snapshot of financing at 4 different stages: start-up (less than 2 years), commercialisation (2 - 4 years), growth (5 - 9 years) and maturity (more than 10 years). The analysis revealed significant differences in the sources of funding used by firms at each stage, providing strong support for the stage model. In common with other NTBFs and SMEs in general, financing at start-up and at maturity in software product firms is dominated by internal sources, which account for on average 72.5 percent of funds used by start-ups and 76 percent of funds employed by mature firms.

To test the applicability of the stage model in software product firms specifically, we sought to determine how key developments in their start-up stage are linked to financing. This analysis revealed a number of particularly interesting findings.

First, the evidence suggests that while software product firms produce their first product betas prior to securing their first external funds, the difference in the timing of these two events is not significant statistically. In addition, the analysis of their sequencing demonstrates that firms are just as likely to receive external funding before producing their first betas as they are to receive funding subsequently. Consistent with prior research that has questioned the stage model's implication that there is a uniform pattern of start-up in SMEs general (Reynolds and Miller, 1992), our disaggregate analysis reveals that there is no uniform pattern that drives funding at start-up. This weakness in the stage model is often ignored by both academics and practitioners. Few would deny the utility of a framework that identifies the typical stages in a process, but in reality not all firms pass uniformly through these predetermined stages. Our research indicates that even within a specific sector there will be different start-up configurations. In addition, external conditions such as the availability and cost of funding will also have an impact on the process. In particular, the supply of early stage venture capital to NTBFs is highly susceptible to changes in market conditions.

Second, product lead-times are short in the software product sector. It takes software product firms only 12 months to develop their first product beta. This contrasts with product lead times of up to 5 years in biotechnology and pharmaceutical NTBFs (Oakey, 1995). Since they are shorter, lead-times do not appear to dictate financing at start-up in the software sector. The implication for

researchers is that there are dangers in treating NTBFs as a homogenous group. Our analysis has shown the potential to augment the explanatory power of the stage model by 'grounding' it in a sector-specific analysis rather than relying on generalisations for the entire population of NTBFs.

Future research might involve a disaggregate analysis of stages other than the start-up phase. The commercialisation stage, for example, is of particular interest because it is unique to NTBFs; SMEs in general serve established markets. We have shown that software firms are particularly reliant on external funds during the commercialisation stage. A disaggregate analysis could attempt to identify the key drivers of the funding requirement during commercialisation of NTBFs in different sectors, which would assist in an understanding of whether and to what extent firms might be financially constrained at this critical time in their evolution. Obviously, the analysis would be bound by the external environment of the day, and in particular conditions in technology and financial markets. However, such an analysis might provide more relevant guidelines to practitioners than those proposed by the general model, once it is recognised that observed practices and strategies may have a limited shelf life.

A third important finding is that software product firms make extensive use of consulting activities as a source of finance. The vast majority of our sample software product firms are 'soft starts', in that they undertake consulting activities to finance product development. The receipt of consulting revenues is on average the first activity recorded by software firms, and only 23 firms in the sample received no revenues from consulting activities. This is good news for potential future software entrepreneurs. The ability to conduct consulting activities clearly gives software firms considerable financial flexibility in their early

years. It also suggests that as founders can substitute human capital for financial capital, team-based start-ups might be a good strategic choice.

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Table 1. The financial life cycle of the new technology-based firm

Stage	Source of finance	Potential problems
Seed		
<ul style="list-style-type: none"> Concentrated R&D resulting in product idea First test for commercial viability 	<ul style="list-style-type: none"> 3Fs: Founders, Family and Friends Research Grants/Equity 	<ul style="list-style-type: none"> Undercapitalisation
Start-up		
	As above plus:	
<ul style="list-style-type: none"> Prototype development design and redesign Targeting reference customers 	<ul style="list-style-type: none"> overdrafts, bank loans leasing private investors venture capital seed funds 	<ul style="list-style-type: none"> Undercapitalisation Finance gap Loss of control
Early Growth		
	As above plus:	As above plus:
<ul style="list-style-type: none"> foothold in the market sales growth move towards profitability large commercialisation costs 	<ul style="list-style-type: none"> retained profits trade credit longer-term finance from financial institutions supplier/buyers new market issue 	<ul style="list-style-type: none"> Maintaining ROI
Sustained Growth		
	As above	Maintaining ROI

Notes. This table is derived from Roberts (1991). In addition, potential problems encountered at each stage are flagged.

Table 2. Age and size distribution of the sample firms

Panel A: average age (months)

Mean	70
Median	51
Minimum	5
Maximum	324

Panel B: number of firms by age

Years	Number of firms	Proportion of sample (%)	Proportion of sample cumulative (%)
<2	15	12.8	12.8
2 - 5	54	46.2	59.0
6 - 10	26	22.2	81.2
> 10	22	18.8	100.0
Total	117	100.0	

Panel C: number of firms by size of workforce

Size class	Employees	Number of firms	Proportion of sample (%)
Micro	0	5	4
	1 - 9	38	33
Small	10 - 49	55	48
	50 - 99	11	10
Medium	100 - 249	6	5

Table 3. Start-up costs

Cost bands	[1] Number of firms	[2] Proportion of sample (%)	[3] Proportion of sample cumulative (%)
< €63,500	53	46.1	46.1
€ 63,500 – €126,999	15	13.0	59.1
€127,000 – €316,999	16	13.9	73.0
€317,000 – €634,999	11	9.6	82.6
€635,000 – €1,269,999	9	7.8	90.4
€1,270,000 +	11	9.6	100
Total	115		

Table 4. Sources of finance in different age categories

Age Band (years)	Number of firms	Internal Sources of Financing %				External Sources of Financing %				
		Savings	Consulting revenues	Retained profits	Total internal	Bank loans	Venture capital	Private investors	Govt. grants	Total external
<2	12	43.0	27.0	2.5	72.5	0.0	13.0	10.0	4.5	27.5
2-4	46	10.0	13.5	8.5	32.0	3.0	38.0	18.5	8.5	68.0
5-9	20	9.5	28.0	18.0	55.5	6.5	28.0	3.0	7.0	44.5
10 +	18	10.0	20.0	46.0	76.0	5.0	11.0	5.0	3.0	24.0
Total	96	14.0	19.0	17.0	50.0	4.0	28.0	11.0	7.0	50.0

Notes. This table reports the averages for each source of finance, as a percentage of total financing, for the 96 firms that provided financing information.

Table 5. Timing of key events in the start-up stage (monthly analysis)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]
	Mean	Median	Min.	Max.	Total attaining milestone	Milestone not (yet) attained	Missing
Time to first:							
a. Beta	17	12	0	88	108	6	2
b. Employee	8	4	0	135	110	4	2
c. Consulting revenue	6	3	0	33	90	23	3
d. Product revenues	19	14	0	91	96	18	2
e. External funding	21	15	0	156	89	23	4

Notes: Column [6], 'milestone not yet attained': firms were asked to tick a 'not applicable' box if their business had not yet reached the particular milestone.

Table 6. Test Statistics for differences in the median time to attainment of key events in the formation process

	[1] Median months apart	[2] z-score	[3] p-value
H1: Beta before external funding	3	-.77	.44
H2: Consulting revenues before beta	9	-5.10	.00
H3: First hire before beta	8	-5.79	.00
Product revenues after beta	2	-5.41	.00

Notes: this table reports the results of one-tailed Wilcoxon rank sum tests for the named comparisons.

Table 7. The sequencing of first beta and first external funding

	Number of firms	%
A. Beta and external funding concurrently	4	3.7
B. Beta before funding	39	35.8
C. Funding before beta	40	36.6
D. Beta with no external funding	20	18.3
E. External funding with no beta	3	2.8
F. No beta and no external funding	3	2.8
Total	109	100

Figure 1. Histograms for timing of key milestones

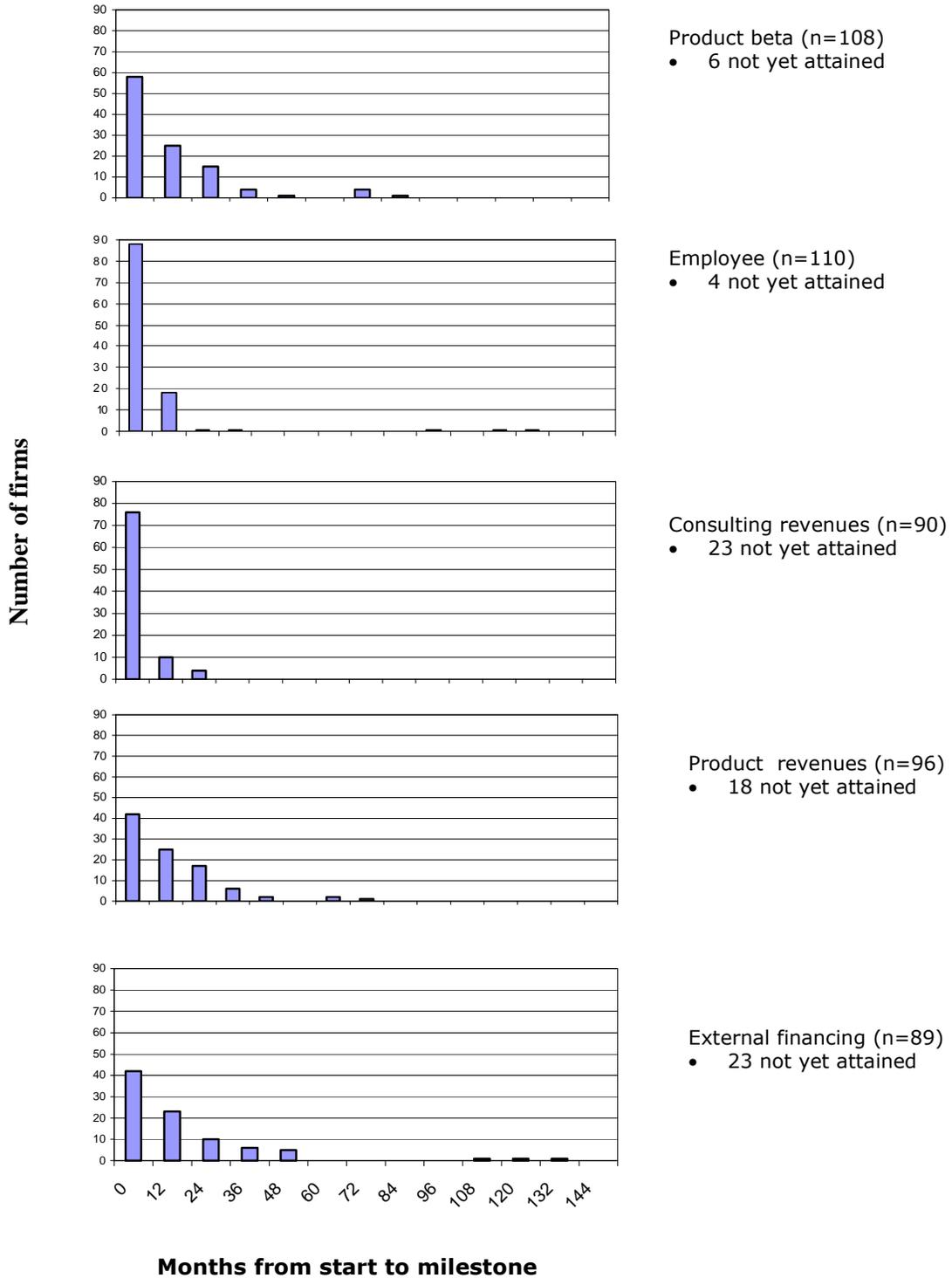


Figure 2. Number of companies producing beta and receiving product revenues by the month: cumulative total

