
University-affiliated Venture Capital funds: funding of University Spin-Off companies

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Abstracts: During the last decade, there has been an increasing focus on commercialisation from universities, often referred to as University Spin-Off companies (USOs). USOs are considered more profitable and survive longer when compared with other start-ups; however, they face major obstacles when seeking funding due to information asymmetry, uncertainty and the nature of their characteristics. The findings of this study indicate that USOs lack financing alternatives at early stages providing sufficient amounts of funding. In terms of bridging the financing gap, University-affiliated Venture Capital funds (UVCs) should be considered as an initiative to improve the financing situations for USOs.

Keywords: technology transfer; USOs; university spin-off companies; capital gap; risk capital; UVCs; university-affiliated venture capital.

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1 Introduction

There has been an increasing focus on the commercialisation of knowledge and technology from universities and publicly funded research institutions during the last decade (Wright and Lockett, 2005). Both national and regional policymakers look to their universities for entrepreneurial activity that can transfer technology and know-how to society. Through their traditional activities in teaching and research, the universities have had an important indirect impact on entrepreneurial activity. This has, for example, been through educating students who provide society with a skilled workforce, and who also develop wealth in the existing industry or pursue entrepreneurial opportunities of their own. As it is common for universities to have research collaboration with industry, this can lead to the discovery of new commercial opportunities. However, in recent years, there has been more focus on the direct and institutional entrepreneurial output from universities (Lockett et al., 2005). This takes the form of patent applications, licensing of technology to industry and University Spin-Off companies (USOs). In this paper, we define USOs as new ventures that are dependent on the licensing or the assignment of the institution's intellectual property for initiation (Lockett et al., 2005). These companies are especially interesting since they can be developed into high-tech companies with global growth potential. In turn, they can directly create wealth and employment opportunities on both regional and national levels.

Some argue that universities may not be able to capture the full value of their technology through a licensing scheme, and that a spin-off company will be more profitable both in terms of the financial returns to the university and the economic value created (Wright and Lockett, 2005). This proposition is interesting, but unfortunately it does not make any attempt to analyse what types of university technologies are attractive and profitable to pursue through a spin-off company. O'Shea et al. (2005) categorise four types of tangible and intangible resources possessed by a firm: institutional, human, financial and commercial. These resources constitute a firm's resource base, which can be developed for a sustained competitive advantage (Barney, 1991). In this paper, we will emphasise the financial resources related to the

USOs, because raising capital is a tremendous obstacle faced by start-up companies. More precisely, these companies have a challenge to cross the equity gap (Landström, 2003). The equity gap can be defined as

“The absence of small amounts of risk capital from institutional sources for companies at the seed, start-up and early-growth stages, which arises because the fixed costs of investment appraisal and monitoring make it uneconomic for venture capital funds to make small investments, and also because of the reluctance of banks to make unsecured lending.” (Van Osnabrugge and Robinson, 2000)

USOs also represent a type of entrepreneurial firms that Knight (1921) has characterised as having a very high level of uncertainty. As a consequence, investors lack sufficient information to be able to calculate risk and define suitable terms for funding. From the specific characteristics of USOs, we also know that these companies tend to be at early stages of development and require large amounts of capital to develop a product ready for sale.

The aim and scope of this paper is to emphasise the need for and the effect of universities funding spin-off companies by establishing a venture capital fund affiliated within the university. There are several empirical examples of universities establishing such funds, but it is an overlooked research field (e.g., Lerner, 2005; Atkinson, 1994). To be able to discuss the use of such funds and contribute to this important research gap, we will explore the following research questions:

Q1: What unique characteristics do USOs have, and how does this affect their capital need?

Q2: What kind of financing sources are available for USOs, and how do the different sources comply with the needs of such companies?

Q3: How should a venture capital fund affiliated within the university be organised to increase commercialisation activities at the university?

As stated above, there is an increasing level of interest in university spin-off activity, and one would expect that this subject would receive a significant amount of academic enquiry. Even though Shane (2004) concludes that research on this topic is virtually non-existent, researchers have shown increased interest in the last few years. Wright et al. (2006) claim that there is a demand for additional research on alternatively financing mechanisms to fund USOs, and that it is necessary to evaluate how such sources can complement or substitute institutional venture capital. In addition, they stress that new research is needed to understand what kind of financial sources are appropriate for these ventures at different stages in their development. This paper contributes by responding to these calls for research. It tries to explain the peculiar financing challenges met by USOs. The paper also evaluates the different sources of funding available, and discusses a direct way universities can bridge a possible financing gap between governmental funding and the private financing market for such companies by establishing their own venture capital fund. Finally, we will draw conclusions and implications from our findings, and give some recommendations for further research.

2 Method

This paper is focusing on the process of universities spinning out new firms. Shane (2004) argues that this requires a phenomenon-oriented method, rather than a disciplinary-oriented one. A phenomenon-oriented approach uses a variety of theoretical frameworks to develop understanding, while a disciplinary-oriented approach requires a particular theoretical framework to test and evaluate the research subject. Shane (2004) argues that using one theoretical framework seems to be premature, since there is a lack of broad deep empirical research on the subject of USOs. This is even more current regarding the financing of such companies. In this study, we use the existing empirical literature on university spin-off activity as a basis for our analysis. As these studies use different theoretical research perspectives, this paper is in line with the phenomenon-oriented approach presented here. In addition, we use the theoretical lens of uncertainty and information asymmetry, which is useful when discussing phenomena related to the financing of early-stage technology-based companies (Shane and Cable, 2002).

We use the existing literature with the purpose of understanding the best practice on the subject, and to adapt this experience and knowledge in other contexts. Research questions Q1 and Q2 are answered deductively by an extensive review of the existing literature and theory. With a literature review, we gain *objective* insight to the problems discussed, but we lack *precision* regarding the context of these observations because of the distance to the empirical data (Ringdal, 2001). To complement this objective and the deductive approach, we have used an inductive approach with empirical examples, which are studied with a qualitative and exploratory method to give policymakers a practical approach to research question Q3, about how to organise a venture capital fund affiliated within the university.

Since a significant amount of the research in this field is conducted on US cases, there are some limitations related to the literature review. One important issue to remember is that many US universities, and especially those known for their spin-off performance, are privately owned. This situation is different in Europe, where more of the universities are funded by the governments. Privately owned universities have tendencies to be more competitive to invest, recruit and retain top-ranked science and engineering faculty and students, and the presence of such expertise has been shown to be positively correlated to spin-off performance (O'Shea et al., 2005). Further, in the context of entrepreneurial developed regions, such as the greater Boston area or Silicon Valley, a strong entrepreneurial community has the capability to select the best entrepreneurial projects and allocate resources to them (Degroof and Roberts, 2004). The scope in this study is universities with less developed entrepreneurial contexts. The reason for this is that we can claim that it is among these universities that there is the greatest lack of risk capital.

3 Theoretical framework

There are several reasons why USOs experience the financial gap. This section will focus on three of these: First, the unique characteristics of USOs are described. Second, the uncertainty and information asymmetry are examined, followed up by describing the

sources of capital available for USOs. Finally, based on the phenomena in the literature review, a model for funding USOs is introduced.

3.1 Unique characteristics of USOs

USOs are quite different from other start-ups in many respects. According to Shane (2004), USOs are more likely to be founded if they exploit technologies having the characteristics given in Table 1, which also shows the relative technology characteristics in established firms.

Table 1 Characteristics of USOs relative to established companies (Shane, 2004)

<i>University Spin-Off company</i>	<i>Established company</i>
Radical	Incremental
Tacit	Explicit
Early stage	Late stage
General-purpose	Specific-purpose
Significant customer value	Moderate customer value
Major technical advance	Minor technical advance
Strong intellectual property protection	Weak intellectual property protection

Shane (2004) has gathered data regarding USOs from MIT from 1980 to 1996. The mean capital raised by these companies was over \$5 million. In comparison, less than 1% of all start-up companies founded in the USA raise more than \$1 million. The large capital need has its explanation in the unique characteristics of USOs given in Table 1. We will look into some of these aspects to explain why this is the case.

3.1.1 Radical technologies

When a technology has disruptive properties in that sense that it can alter the way the market is organised, or how products and services are created, it is more likely that it can be the basis for a spin-off company. This is what Schumpeter (1934) described as creative destruction. Existing firms do not want to license such technologies because it cannibalises their existing assets (Utterback, 1994). Nelson and Winter (1982) describe this phenomenon as path dependency. Since it will be too expensive for most of the existing industry to completely alter their production or distribution methods, radical technologies are often not licensed by existing industry.

3.1.2 Tacit knowledge

With tacit knowledge, the concepts and ideas of a technology are largely held in the minds and beliefs of the researchers, and this knowledge can be difficult to communicate to others (Polanyi, 1974). Obviously, this makes licensing more difficult since these companies are dependent on close collaboration with the inventors to be able to extract the desired value. When a spin-off is based on tacit knowledge, the company must engage in scientific research develop a proof of the concept, develop a prototype, and further product development to be able to concretise the invention into a commercial product.

This business idea will generally take longer time to develop than a more explicit license in an established firm and, therefore, will require more capital.

3.1.3 Early-stage and general-purpose

When a technology is developed within a university, it is generally so unproven that it cannot be easily licensed to established firms, and universities may not have other choices than forming a USO (Powers and McDougall, 2005). The vast uncertainties of the value of such early-stage technologies imply that potential industry licensees would rather wait until the technology is further developed (Shane, 2004), both through proof of concept and proof of technology. USOs also tend to exploit basic technologies, which have possible application areas in many markets and possibly many industries as well (Nelsen, 1991). One reason is that established companies avoid such technologies, since their existing operations are focused on creating products or services within one specific market or industry. General-purpose technologies are a good basis for USOs since it makes the founders capable of changing the market application if the first application that is chosen turns out sour (Tornatzky et al., 1995). When a company is based on early-stage inventions that are of general purpose, the company must use time to develop the basic technology into possible commercial application, and perform market analysis to identify a customer need. Shane (2004) calls this stage the ‘minus two stage’ and the process of getting to a commercial product is generally long and will obviously need a considerable amount of financing when compared with other start-ups.

3.2 Financing of USOs: information asymmetry and uncertainty

Information asymmetry and uncertainty are two major obstacles that occur when an early-stage venture seeks funding. These are fundamental theoretical issues in any investment decision, but are especially important to explain the financing process of USOs.

3.2.1 Information asymmetry

Information asymmetry creates at least four challenges in the financing of early-stage companies. First, entrepreneurs do not want to disclose too much information about their concept, since this is the basis for their competitive advantage. This means that investors must make their decisions with less information than the entrepreneur possesses (Shane and Cable, 2002). Regarding the financing of USOs, this issue becomes even more complicated. Since most USO technologies probably are unfamiliar with the investment community, it may be difficult for the entrepreneur to even communicate why and how the concept can be transformed into real value (Wright et al., 2006). Second, because the entrepreneurs have superior information that the investors lack, the entrepreneurs can act with opportunistic behaviour. The entrepreneur can thus extract the needed resources that a fully informed investor would not provide (Shane and Cable, 2002). Third, by using this information advantage, the entrepreneur can limit the investor’s ability to monitor that the investment is used wisely and thus puts the investor’s resources at more risk than necessary (Shane, 2004). This may also be particularly perceptible in the context of USOs, since the intellectual property such companies possess must go through several development phases that are unknown

or unfamiliar to the investor before it can become a commercial product. Finally, the information asymmetry problem can lead to adverse selection by the investors, since it may be difficult to distinguish between competent entrepreneurs with valuable concepts from the less talented entrepreneurs with limited concepts (Sahlman, 1990).

Theoretically, these issues could make investors unwilling to provide the resources necessary to exploit the opportunity. A high degree of information asymmetry between the inventors and the risk capital will increase the price of that capital, or even worse, that capital will not be available.

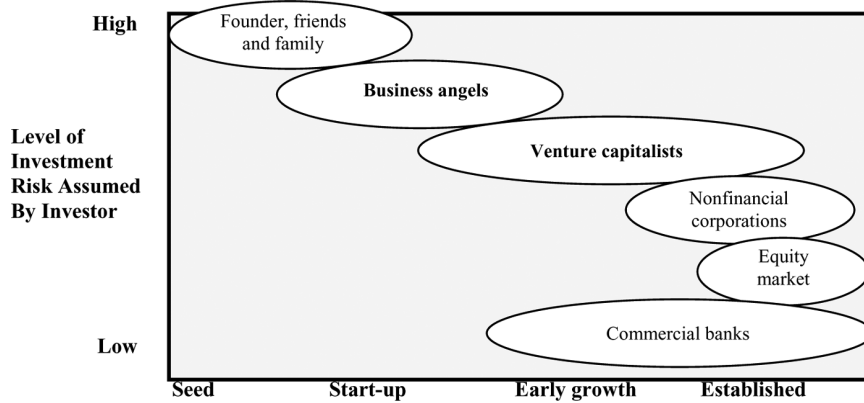
3.2.2 Uncertainty

There is some confusion concerning the difference between risk and uncertainty, and some use these terms as if they were synonyms (Alvarez, 2007). Knight (1921) distinguishes risk and uncertainty on the basis of whether or not a rational probability distribution of a fixed possible outcome is known to the decision-makers. With risky decisions, all possible outcomes and the possibility of each of them are known. With uncertain decisions, neither the number of possible outcomes nor the probability distribution is known. It is obvious that USOs are exploiting new, untried market opportunities with new technologies operated under higher conditions of uncertainty, than the average start-up. Various sources of funding have different preferences regarding the risk of their investments. A challenge for USOs is, therefore, to transform their ventures where the opportunity is characterised by levels of uncertainty to the level where investors can evaluate the opportunity with their rational risk assessments. The process where USOs transform their early-stage technologies into commercial products can be conceptualised as a way of transforming their entrepreneurial opportunity from high levels of uncertainty to levels of risk appropriated to different funding sources (see Figure 2). Commercially focused universities and research institutions have experienced that these two contrasts are making it difficult for USOs to attract the necessary private funding (Lerner, 2005; Moray and Clarysse, 2005; BVCA, 2005).

3.3 Sources of capital for USOs

Van Osnabrugge and Robinson (2000) define a model for the main providers of external financing to entrepreneurial firms (Figure 1). In this model, the most likely sources of outside finance are identified, even though not every firm uses every funding source obviously. The amount of funding usually increases with each progressive stage of financing, and as the firm becomes more mature and grows in size, the inherent risk decreases and the problems of securing finance normally decrease (Wetzel and Wilson, 1985; Van Osnabrugge and Robinson, 2000). Van Osnabrugge and Robinson (2000) further indicate the clear presence of the equity gap, as earlier defined, for business ventures seeking external finance at the early stages.

In this section, we will review sources of risk capital that could be available for USOs. Owing to the scope of this paper, we will focus on the sources that are available at the early stages, namely governmental funding, informal venture capital and institutional venture capital. The purpose of this review is to analyse pros and cons of why these actors, on the one hand, are adequate investors for USOs, and on the other hand, why they are not necessarily prepared to handle the uniqueness of the USOs.

Figure 1 Stage of development of entrepreneurial firm

Source: Van Osnabrugge and Robinson (2000)

3.3.1 Government funding

Shane (2004) identifies four main reasons describing why public sector financing can fill the financing gap and allow USOs to develop to a stage at which private sector financing is available. First, in the initial critical period, government funding can allow the founders to explore the technology and to develop products or services that are appropriate for a valuable market application. Such a development may result in proof of principle or prototypes, which can be vital in the further financing process. Second, government grants and contracts allow USOs based on new technology without any identified commercial use to perform thorough market research and essential evaluation of customer needs. Third, government financing facilitates the acquisition of private sector financing. Government grants can be used to lower the investment cost and reduce the risk for private investors. Finally, government funding provides a way to manage the high level of uncertainty inherent in developing products or services from university technologies. Lerner (2002) identifies several limitations of public programs. If government financing is going to address funding problems, programs will be needed to overcome information asymmetries and identify the most promising firms. Further, governmental funding is normally not seen as 'knowledge money'. That is, governmental finance does not have knowledge added, e.g., technology knowledge, commercialisation knowledge, market knowledge or finance knowledge. This is in contrast to formal and informal venture capital.

3.3.2 Informal venture capital and business angels

Informal venture capital is capital investments made by private individuals, using their own money directly in private companies with which they have no family connections (Mason and Harrison, 2000). These are also commonly called Business Angels, and they play a critical role in the financing of early-stage entrepreneurial firms, and often contribute with both their financial wealth and entrepreneurial experience (Landström, 1992). According to Mason and Harrison (2000), Business Angels have a critical position in the financing spectrum, bridging the gap between the entrepreneur's internal funds and later-stage financing sources. Erikson and Sørheim (2005) identify a subclass of informal

investors, 'Technology Angels', which may be an especially suitable investor for USOs. They are more actively involved in their portfolio companies, and in some cases become co-founders. This should be very compelling for USOs since investors can use their business experience and know-how to help to reduce the market uncertainty faced by USOs (Sørheim and Landström, 2001).

Business Angels are generally more focused on companies in their seed and start-up phases and often invest before a market application is known (Shane, 2004). Informal investors thus seem to be well aligned to the financing need of USOs regarding the time horizon and technical and market development that such companies must engage in. Informal investors are often more patient than venture capitalists, and have a lower expectation of the return on investment, and will therefore probably be a more accessible source of funding for USOs (Van Osnabrugge and Robinson, 2000). However, Shane (2004) also has examples of Business Angels who regretted financing a USO, because of a noncoterminous time horizon.

3.3.3 Institutional venture capital

The substantial capital requirement for many high-tech USOs is one reason for why the VC industry is considered an attractive source of funding. Shane (2004) claims that USOs pursuing a large market with strong patent protection are favoured. Also, general-purpose technologies that can be applied in a variety of different markets, and entrepreneurial qualities of the founders are considered highly valuable.

There is a significant cultural difference between academia and private sector businesses specialising in commercialisation and innovation (Wright et al., 2006). Founders of USOs often lack experience and the attributes required (Siegel et al., 2003; Wright et al., 2006). Value-creating services from a VC investor can, therefore, be of significant importance for the founders and the success of the venture. Manigart and Sapienza (2000) state that VCs are more involved in high-tech firms than in other ventures, and that the time and effort VCs spend in providing value-building services pay off beyond the value of financing, selecting and monitoring these ventures.

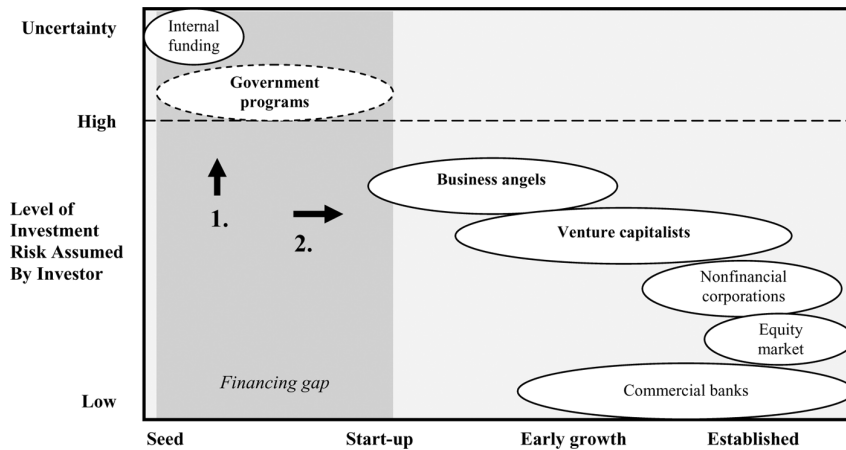
External equity backing by large corporations or financial intermediaries such as VC firms is considered an important indicator of performance (Lockett et al., 2005). Such backing can be viewed as a signal of quality as such ventures have successfully passed the scrutiny of professional investors, who assess their ability to generate significant future returns (Lockett et al., 2005). USOs can benefit from such an acknowledgement when seeking the next round of funding or in the process of building relationships with partners and customers.

The VC industry has adopted screening and evaluation processes to reduce uncertainty and address the various problems arising from asymmetric information between the entrepreneur and the investor (Wright et al., 2006). These processes are developed primarily for commercialisation in the private sector, and introduce at least three specific problems for USOs in the process of securing venture capital. First, risk measurements are more difficult to perform with higher level of uncertainty. Second, early-stage technology may be difficult to communicate and are poorly understood in the venture capital industry. Finally, commercialisation through technology transfer is relatively new to many universities.

3.4 A summary of the early-stage financing opportunities for USOs

Based on the theory review, we introduce a holistic model that describes the unique characteristics of USOs, the concept of uncertainty and risk, and available early-stage finance (Figure 2). The model is adopted by Van Osnabrugge and Robinson (2000), and its intention is to demonstrate why the financing gap is even more present in terms of funding USOs.

Figure 2 Stage of development for USOs



First, the high levels of uncertainty require more financial efforts in the seed stage. USOs often must undertake additional technical development after founding and these additional efforts require a great deal of time and postpone the USOs progress to the next progressive stage. Further, product development is often underestimated, both regarding time and money. Second, obstacles identified by the lack of knowledge and information asymmetry make investors more expectant to invest and postpone the point in time in which informal and institutional venture capital is available. Wright et al. (2006) states that private investors generally want to invest in USOs that have reached the later stages of development. This can be critical for these ventures since their characteristics imply that they have a major capital need, but in their current stage of development they are unattractive for private sources. Therefore, we argue that the financing gap for USOs is also a knowledge gap, as the theory on information asymmetry and uncertainty implies.

In terms of bridging the financing gap, it seems reasonable to conclude that government funding is an important and very necessary initiative (Shane, 2004). However, it appears to be widely recognised that the available amounts of seed capital financing, and more precise, pre-seed capital, is insufficient. Especially for capital-intensive high-tech USOs, such programs will generally be inadequate. At the same time, several limitations in public programs have been documented in recent literature. Public-private partnership funds seem to fit closest with the financing characteristics of USOs in early stages, but because of the private ownership, these funds will attempt to maximise economic profit and consequently invest in later-stage projects (Rasmussen et al., 2006). The private financing market is a likely source of equity investments for USOs but because of high levels of uncertainty and problems regarding information asymmetries, such financing is generally not available at the seed stage.

The basic problem regarding the financing of USOs thus seems to be the lack of larger investments at early stages. We argue that funding alternatives that attempt to fill this gap must be driven by other primary goals than short-term profit maximisation. Otherwise, investments will be focused on later-stage ventures. A classification according to this assumption is illustrated in Table 2.

Table 2 Classification of financing sources for USOs

Profit as main motivation	Yes	Informal venture capital (Business angels)	Institutional venture capital
	No	Government funding	UVC?
		Low	High
Amount invested in each round			

4 University-affiliated Venture Capital funds (UVCs)

As indicated in Table 2, a quite novel approach to overcome the challenges USOs face in acquiring private equity financing is for public-owned universities and publicly funded research institutions to establish an internal venture capital fund. We call these University-affiliated Venture Capital funds (UVCs). We claim that UVCs are an alternative that should be considered to effectuate spin-off performance and frequency of such organisations. Moray and Clarysse (2005) claim that UVCs are providing the necessary capital to prepare prototype products and conduct market analysis and thus provide the financial resources needed to convert uncertainty into levels of risk. There are some empirical examples of universities that have established a UVC to address the capital need of emerging technologies (Lerner, 2005; Moray and Clarysse, 2005; Rasmussen et al., 2006).

4.1 Lessons learned from established UVCs

4.1.1 UK

The UK has implemented a national scheme to assist USOs in the successful transformation from research to the commercial arena. The initiative was organised as a competition in 1999 and £60 million has been awarded to 19 new seed funds covering 57 institutions. The concept was called The University Challenge Seed Funds (UCF) and the background was that many universities experienced a funding gap for bringing research discoveries to the commercial market. The seed funds was independently driven and not under the control of the appurtenant universities. A report issued by the British venture capital association, BVCA (2005), concludes that the UCF arrangements have been successful in promoting USOs to the stage where institutional venture capital can take the companies further. The same report notes that UCFs together with R&D grants from the government were the most important sources of funding in the seed phase for USOs. Even though most experience seems to be positive, the report also states that too much of the UCF funds had been allocated to the later stages of USOs, and not in the proof of concept stage as originally intended.

4.1.2 Belgium

Moray and Clarysse's (2005) study of Inter University Micro Electronics Centre (IMEC), a Belgian top-tier research centre, also gives insight into the possible challenges of UVCs. They are describing a situation in the early 1990s, where the European venture capital industry and financial markets financing technologies in the (pre)-seed stage is rather immature. In this decade, the main financial partners are large corporate firms, and the universities from the associated labs bringing in a part of the capital. In 2000, IMEC decided to launch an Incubation Fund. This decision is based on the increasing difficulty in securing VC for early stage, high potential projects that have not yet made a working prototype or drafted a long-term business plan. The shareholders in IMEC's Incubation Fund had expectations of financial returns similar to a traditional venture capital fund, which cannot be expected from a UVC. In addition, the fund was structured in a way that allowed investments only to cover 60% of the requested funding amount. The remainder should be funded by other sources, such as formal or informal venture capital. These co-investments by other sources proved to be impossible to acquire, both because of the poor state of the venture capital industry at the time, and for the reasons mentioned earlier in this paper. The result was that the fund instead restructured, and that IMEC itself funded in pre-seed and seed stages of its USOs. Maray and Clarysse (2005) suggest that universities must be careful with the performance expectations of a UVC.

Before the implementation of the Incubation Fund, IMEC also invested in a local venture capital fund with the expectation that these VCs would invest in USOs from IMEC. In retrospect, IMEC learnt that the pre-seed and seed phase is generally of little interest for the VCs who did not invest in a single one of IMEC's USOs. Even though the intention from the VCs is to contribute capital to USOs, this is difficult in practice since the VCs must fund companies that can provide the greatest financial return within the lifetime of their fund.

Table 3 Recommendations and consequences for UVS initiatives

<i>Recommendations</i>	<i>Consequences</i>
The establishment of a UVC initiative should be to correct a specific market failure in the funding of high-tech USOs	Not every university should have a UVC
The UVC initiative should focus on other primary goals than short-term profit maximisation	UVSs need to have a long-term strategy relying on both the strengths of the research conducted at the university, and the expertise in the environments
The UVC initiative should base evaluation activities and screening criteria on lessons learned from the venture capital industry and from the academic research in this area	Build a professional organisation which is measuring its activity based on best practice and benchmarking
The UVC initiative should have a limited technological focus	Focused mandate from the UVC owner(s) and focused knowledge building within this technological area

Table 3 Recommendations and consequences for UVS initiatives (continued)

<i>Recommendations</i>	<i>Consequences</i>
The UVC initiative should be organised with a professional management with substantial business development capabilities	Be ready to fight for the best management available in business, and be willing to take the costs this requires. At the same time be crystal clear about what the management will be measured on, and the consequences of not reaching the goals
The UVC initiative should be prepared to offer follow-on investments selectively when the market is unwilling and adopt a long-term commitment to a firm despite the inevitable vicissitudes of the business	In an ideal world, the fund should be larger. In practice, only half of the fund can be invested, and the other half should be used for follow-up investments
The UVC initiative should strive to establish close links both to the informal and the institutional VC community	The success of the UVC is related to deal flow, value development and exit. This recommendation is related to exit, and to prepare both the USO to be 'investment ready' and inform the investors about what prospects the UVC has in the pipeline. This will reduce the risk

4.1.3 USA

Boston University is another example of a university that has had a UVC running for some time. This fund has a strict industry concentration on information technology and life sciences. These two industries are also shown by Degroof and Roberts (2004) to be the majority of the technological origin of USOs in the USA. Boston University also has a co-investment policy and requires another investor, usually an institutional venture capital fund, to take the lead investment role. However, the entrepreneurial environment in the greater Boston area is well developed, and we therefore suggest that such a fund may have a different position than UVCs in other environments. The strict industry focus and co-investment policy make this fund looking more like a traditional VC. Because of the attractive exit possibilities, information technology and biotechnology are industries where institutional venture capital is generally more willing to enter at an earlier stage than other technologies (Shane, 2004). If it co-invests with a professional top-tier venture capital firm, the university is more likely to get a fair share of the economic value created by this company. Similar kind of fund structures can also be seen at Harvard and Stanford University, which have related characteristics to Boston University and very active entrepreneurial environments.

The reason why UVC is a successful strategy in these kinds of environments is the strong entrepreneurial infrastructure that has the capability of using well-developed and intricate social networks to find and select the best entrepreneurial projects and allocate the appropriated resources to them (Degroof and Roberts, 2004). In weaker entrepreneurial infrastructures, the universities may need to have a more proactive approach, by being highly selective and provide greater support functions to their USOs (Degroof and Roberts, 2004). This and other issues will be discussed in the final part.

5 Discussion and implications

5.1 Premises for the use of UVCs

It is important to realise that UVCs seem to be applicable only in some contexts. We have learned that the spin-out frequency is correlated to the scientific quality at the university and research institutions. If this relationship is to be armoured, we would argue that UVCs are more applicable in universities and research institutions that have a strong scientific focus. Furthermore, faculty size and funding of the engineering departments are also predictors of university spin-off activity (O'Shea et al., 2005). Therefore, UVCs are more applicable in relative large universities with a substantial engineering budget. In addition, biotechnology and life sciences are proven to be the most promising technologies to establish USOs (Shane, 2004). However, it is important to remember that environmental factors are of major importance regarding the commercialisation possibilities for ventures based on such technologies. The last statement can also be reflected on by using the example of Boston. The reason why the Boston University UVS has biotechnology and information technology as its focus is probably the potential financial returns these kinds of technologies can give in the local environment. The environment in the Boston area can be described as perfect, because the VC industry is so large, so specialised and so knowledge-based, that it constitutes a seamless finance line, from pre-seed to IPO.

However, the owner of a UVS must consider whether the fund should be strictly focused on the return on investments, or if the fund goals are to bridge a financing gap for USOs in a more socio-economic approach. Another issue is whether the environment is capable of adapting the USOs that are produced by the university. There are not many universities that are in a position like in Boston or in Silicon Valley. Thus, it can be claimed that USOs are even more important in situations where a robust entrepreneurial environment is lacking.

Another aspect is that establishing a UVC management can be very costly, especially if the management is highly skilled and if the university has to compete with VC firms for their services. This gives some implications for what kind of universities and research institutions that should pursue this. Degroof and Roberts (2004) argue that such substantial support functions can only be justified if there is enough 'deal flow' from the university's own research. It could be added that there should be enough exit-possibilities as well, meaning entrepreneurial environment. If this is not the case, universities and research institutions should evaluate a partnership and pooling of resources with other academic institutions.

5.2 Recommendations and consequences for UVC initiatives

In terms of bridging the financing gap, we claim that various UVC initiatives are alternatives that should be evaluated to improve conditions for the commercialisation of university research. Extracted from the previous sections, we are proposing the following recommendations as guidelines for how such initiatives can be organised:

The paper has discussed the financial challenges met by USOs and has proposed that UVCs can be a direct way that universities can bridge the financing gap. Through the characteristics that have been identified to categorise USOs, we have shown that such ventures have a large capital demand in the early phase of the development of the

company. Government programs are of major importance in the financing process of these companies, but we have indicated that USOs face a financing gap before private equity investments are available. Business Angels with technological experience and background have been shown to be an important contributor of both capital and competence, but these investors can probably only cover part of the capital required. In most European countries, institutional venture capital is not a likely source of funding for most USOs at early stages, with the unique exception of biotechnology companies. However, venture capital will become a vital source of funding when USOs reach a stage where their growth potential matches the strict requirements of venture capital funds.

5.3 Limitations and areas for further research

The authors suggest that more empirical studies are necessary to gain a deeper understanding about the important variables to consider when universities discuss technology transfer, and especially the financial options that this paper has focused on. A collective case study at different universities is a possible methodical approach that could gain significant insight into best practice on UVCs, and which environmental factors seem to be important to consider accordingly. One obvious and difficult question that is not within the scope of this paper is what investment criteria UVCs should have. Much attention has been given to the investment criteria and process for venture capitalists (e.g., Fried and Hisrich, 1994; MacMillan et al., 1985), and how these criteria are designed to minimise adverse selection. Our results show that experience and capabilities within a UVC management is of major importance in order for the initiative to succeed. Further research is needed to address appropriate organisation models and staff compositions. This study has mainly looked at the financing of USOs from the university's and investor's point of view. Additional research should be conducted from the academic entrepreneur's point of view to gain additional insight in what kind of value-added services they give highest priority to, besides financing.

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