How engaging start-ups in research activities can lead to more effective technology and knowledge transfer from public research organisations

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Abstract
The role of public research organisations (PROs) has changed over the decades. They have engaged more in bringing new knowledge towards companies as a way to foster economic progress through technological renewal. The traditional response of PROs has been the creation of technology transfer offices, who have adopted a technology-push approach to bring new technologies to the market and foster (academic) entrepreneurship. This paper, by means of a case study in iMinds (a PRO on digital media and ICT in Belgium), presents a new approach, the so-called 'flipped knowledge transfer approach'. By adopting this more market-driven approach to knowledge transfer, start-ups and SMEs in a region are reinforced and a fertile breeding ground for the creation of a regional cluster of innovation is fostered. This paper analyses the effects of such approach, and discusses the hurdles to implement it in other PRO settings.

Keywords
Academic entrepreneurship; Technology transfer; Incubator; Entrepreneurship program; Public research organisation; Start-ups

1. Introduction

Research institutions, such as universities and other public research organisations (PROs), have been engaging in knowledge transfer outside their boundaries for centuries, mostly using education and publications as channels. More recently, these PROs have been trying to find other, more direct ways to bring new knowledge into applications for business and society, usually facilitated by a technology transfer office (TTO) or industrial liaison office (ILO) (Guston, 1999; Debackere and Veugelers, 2005; Macho-Stadler et al., 2007). In this sense, PROs have been engaging increasingly in more entrepreneurship-related activities: establishing spin-off ventures, setting up investment funds, etc. This additional role has sometimes been described as the third mission of PROs (besides research and education) (Etzkowitz, 1998; Rothaermel et al., 2007; Dale Meyer, 2011).
However, the common approach adopted by these TTOs relates closely to a technology-push or inside-out approach, where new knowledge is most commonly 'pushed' from the research institution towards third parties (e.g. through sale of intellectual property, licensing or creating spin-off ventures to commercialise new technologies) (Birley, 2002; Macho-Stadler et al., 2007). This approach imposes specific challenges and many PROs are struggling to get enough benefits from their knowledge transfer activities, both in the short as well as the long run.
Additionally, SMEs and start-ups face important challenges in getting access to the latest knowledge, state-of-the-art technologies and research results developed at PROs (Gibb, 2000; Nunes et al., 2006). This is due to the fact that SME manage knowledge differently than large companies do (Desouza and Awazu, 2006) and PROs are not well-adapted to interact with SMEs (Gibb, 2000). For most (Western) economies, this becomes a real issue, since SMEs are the engines of economic growth and innovation. Indeed, SMEs typically account for at least 50% of employment generated in

economies and make up over 90% of the total amount of business in any region (FSB, 2014; IFC, 2012; Singh et al., 2010).

The objective of this paper is to provide a conceptually new approach to technology and knowledge transfer from PROs (the 'flipped knowledge transfer' model, which is more demand-driven and less technology-push) and to illustrate this new approach by means of a case study with preliminary results. In this flipped knowledge transfer approach (external) start-ups and SMEs play a key role and knowledge creation is no longer unidirectional, but rather based on co-creation. They can enable fast(er) adoption of new knowledge and technologies and inspire researchers for follow-up research activities. One of this new approach's key advantages lies in the fact that knowledge and research results find a more 'natural' way towards market applications, given the demand-driven nature of the approach. The central research question addressed in this paper is:

> *"(How) can a more demand-driven knowledge transfer approach in PROs be beneficial to SMEs (incl. start-ups) and the PRO itself in bringing new knowledge and technologies faster into application?"*

The structure of this paper is as follows. The next section embeds this paper's topic in various literature streams related to academic entrepreneurship and the Triple Helix, technology and knowledge transfer and some theoretical foundations underlying this strand of research. Afterwards, the third section discusses the main methodological aspects of this paper. In fourth instance, an in-depth case study of a PRO (iMinds) in Belgium will be presented, together with the main results and findings. The last section brings the main implications forward, opens discussion on a more general level on the role of PROs in entrepreneurship and suggests some opportunities for further research in this domain.

2. Literature review

This case study is embedded in four main strands of literature. Firstly, the literature on the European Innovation Paradox will be discussed. Afterwards, the entrepreneurship theory and literature on academic entrepreneurship and the Triple Helix model will be addressed. In third instance, this literature review frames this study in the strand of research on technology and knowledge transfer. The fourth and last strand refers to the involvement of SMEs in clusters of innovation and their importance for regions and countries in economic growth.
The last part of this literature review identifies gaps in this literature and the main research questions addressed by this study.

2.1. The European Innovation Paradox

The 'Green Paper on Innovation' (European Commission, 1995) has brought up the issue of the so-called European (Innovation) Paradox. According to a number of studies (Tijssen and van Wijk, 1999; Klofsten and Jones-Evans, 2000; Brooksbank and Thomas, 2001; Clarysse et al., 2002; Goldfarb and Henrekson, 2003), Europe has been lagging behind some other regions around the globe (mainly the United States of America) when it comes to transferring research results to the market (successful applications in products and services for commercial and/or societal benefit). These poor results have amongst others been attributed to the more competitive American academic environment (mainly in terms of remuneration, promotion and job mobility) and legislative system (Goldfarb and Henrekson 2003) and to the more pronounced distinction between teachers and researchers in Europe and the relatively pre-determined pathway to obtain academic positions and promotions that hamper productive commercialisation (Giacometti 2001; Goldfarb and Henrekson 2003). Other studies have pointed to strong public sector science base in the EU coupled to rather poor R&D

activities in EU firms (Tijssen and van Wijk, 1999). On the other hand, a number of studies have challenged the existence of this European Innovation Paradox (see e.g. Dosi et al., 2006).
Many (European) PROs have responded to this Innovation Paradox by installing a TTO with a mission to stimulate, coordinate and support commercialisation of science and research results. A study of De Cleyn et al. (2010) indicated that many TTOs in Europe have been established in the late nineties. These TTOs are (potentially) important actors in the Triple Helix, bringing public actors, industry and business, and science and academia together.

2.2. Academic entrepreneurship and the Triple Helix

The European Innovation Paradox, together with a number of additional changes in society, has forced PROs to rethink their roles and contributions towards business and society.
As touched upon earlier, one of the responses has been the creation of a TTO in many PROs around Europe (and elsewhere) and an intensifying attention for and support of academic entrepreneurship within these PROs. TTOs play an active role in commercialising PRO research outcomes by identifying, protecting, marketing and licencing intellectual property developed by researchers (Djokovic and Souitaris, 2008). However, in analysing the impact of such TTO activity, studies focused more on the effectiveness of technological diffusion that used licencing as commercialisation mechanism rather than through spin-offs (Siegel et al., 2003a). Studies focusing on the impact of spin-off activity and TTOs engagement with start-ups and SMEs have been conducted less frequently. The main outcomes of the by Lockett and Wright (2005) and Powers and McDougall (2005) relate to the importance of TTO size and experience in explaining spin-off activity at PROs.
The increased engagement of PROs in promoting and supporting entrepreneurial activities has not only been triggered by an internal reflex. PROs have become increasingly aware of the context in which they operate, as opposed to the classic image as 'ivory tower' (Thursby and Thursby, 2002; Etzkowitz et al., 2000) in which new knowledge was produced and disseminated through scientific publications and education (Rogers et al., 2001). PROs are important organisations embedded in a local and global ecosystem, in which various actors play different role and interactions have become even more a necessity than ever before. Scholarly research has conducted research on these interactions under the umbrella coined as "Triple Helix model", which describes the interactions between academia, business and governments (Etzkowitz, 1998; Leydesdorff, 2000; Etzkowitz and Klofsten, 2005). Although academic entrepreneurship has existed for centuries, it has only recently been put on a prominent spot in policy agendas and PROs' scope (Etzkowitz, 1998; Dale Meyer, 2011). PROs can play an important role in the dynamics of a region, given their ability to create knowledge, attract firms to settle in their environment and foster job creation via spin-off establishment (Jones-Evans et al., 1999). Additionally, PRO inventions are an important source of knowledge spillovers (Di Gregorio and Shane, 2003), potentially providing benefits for many stakeholders in a region.

2.3. Technology and knowledge transfer

As briefly touched upon earlier in this paper, this study builds on prior studies that envisaged understanding the models, implications and success factors of technology and knowledge transfer programs and organisations in PROs as well as in corporate environments. TTOs play an important role in supporting the translation from academic knowledge into applications. With the help of TTOs, PROs potentially impact and contribute to local and global economies at various levels: they develop new technologies and knowledge that can help solve issues and respond to needs in business and society (Etzkowitz et al., 2000; Henderson et al., 1998), they can introduce new innovations and – e.g. through spin-off ventures – create new business that create new employment (Jones-Evans et al., 1999; Gunasekara, 2006), they create new knowledge that is beneficial to a wide myriad of

stakeholders (other researchers, students, policy makers, companies, …) (Gunasekara, 2006) and they can even become critical for an entire industry to fuel it with new inventions, such as the pharmaceutical industry that has (at least partially) become dependent on academic research to conduct basic research that can initiate the discovery of new drugs (Festel et al., 2011; Santos, 2003).

On a more general level, Teece (2003) has tried to understand the resource cost of transferring technological know-how from multinational firms (see also Teece, 1998). Indeed, knowledge has become a key raw material for many economies (Teece, 1998). Even despite the rapid increase in the use and possibilities of digital technologies, transferring knowledge from one actor to another remains challenging (Inkpen and Tsang, 2005; Argote and Ingram, 2000). Several other studies have focused on technology and knowledge transfer from PROs (e.g. Lee, 1996; Siegel et al., 2003b; Heinzl et al., 2013; Ho et al., 2014). In this sense, a recent study by Clarysse et al. (2014) has identified a gap between knowledge and business ecosystem, which is currently not bridged by any initiative. The flipped knowledge transfer approach may be a tool that helps to (partially) bridge this gap.

From a more financial lens, Bray and Lee (2000) have analysed the effect from technology and knowledge transfer on PROs. Their study concludes that PROs may benefit more from taking equity in their spin-offs than from licensing deals. In general, equity participations generate equal return over licensing contracts, but equity positions have the advantage of occasionally hitting the 'jackpot', which overall makes that taking equity in spin-offs maximizes the financial return that PROs can realise from their intellectual property (Bray and Lee, 2000).

In a broader perspective, recent studies have also analysed the impact of technology transfer activities in upcoming economies such as China and its implications for global markets (Gross, 2013; Kafouros and Wang, 2014). According to these studies, China will undoubtedly become the world's largest customer when it comes to technology and knowledge transfer activities in the coming decades (Gross, 2013; Miesing et al., 2014). However, the country is unlikely to achieve global leadership when it comes to new knowledge production in the coming decade (Gross, 2013; Miesing et al., 2014).

2.4. Clusters of innovation and economic growth

Last, but not least, this paper is embedded into the research strand on (global) clusters of innovation. Over the decades, it has become clear that start-ups are a major force in creating and driving new innovations to the market, thereby creating economic vitality for regions (Engel, 2014). Attracting such start-ups and creating a fertile breeding ground for them however requires a mix of ingredients that can only be provided at a regional scale, surpassing local capacities. AnnaLee Saxenian's seminal work investigated the differences between the Boston and Silicon Valley approaches and eventually predicted the latter's dominance (Saxenian, 1994). Her work has spurred more research in this domain and, as various regions around the globe have experimented with creating successful innovation hubs or clusters, cluster thinking has come to dominate the discussion and content of regional economic development policy (Engel, 2014; Howells, 2005).

Clusters provide advantages to the local actors (Doeringer and Terkla, 1995): physical proximity enables economies of scale and scope (Fujita, Krugman, & Venables, 2001; Krugman, 1991), provides easier access to information (including the latest insights in academic knowledge and newly developed technologies in PROs), proximity to specialised suppliers and customers and reduced transaction costs, among other advantages (Porter, 1998; Porter, 2000). In real 'clusters of innovation' intense concentrations in specific industries emerge, resulting from an ongoing process of new start-up creation and fast commercialisation and adoption of new technologies (Engel, 2014; Engel and del-Palacio, 2009). These clusters of innovation are characterised by mobile assets (e.g. money, people, and information, including know-how and intellectual property (IP)) (Freeman and Engel, 2007; Bresnahan et al., 2001). Additionally, an entire service industry develops around these new start-ups and maturing businesses (Engel, 2014).

The concept of clusters of innovation is highly related to the Triple Helix model, where interactions between academia, industry and government play a central role. Indeed, many clusters of innovation, including the textbook example of Silicon Valley, have at some point been initiated or accelerated by some form of government intervention. In order to fuel the creation of a cluster of innovation, several authors have argued that especially the interactions between industry and academia are of critical importance (Liou and Liou, 2009; Huggins, 2008). In this sense, PROs and their TTOs play a crucial role in unlocking new knowledge and research outcomes for start-ups and other actors in a regional cluster.

2.5. Research goals and hypotheses

Given the increasing importance of cluster thinking and the role academic research plays in this context, knowledge and technology transfer have been demonstrated to play a prominent role in creation new technology-based ventures. The process of transferring knowledge and technologies from PROs to industrial actors (and broader society) has been understood more extensively in more recent years (see e.g. Inkpen and Tsang, 2005; Argote and Ingram, 2000). However, current practices and scholar studies have focused on the more traditional way of bringing this knowledge and technologies into application, i.e. from a rather technology-push orientation (Siegel et al., 2003a). PROs adopting this approach have traditionally been transferring new knowledge and technologies through licenses on intellectual property rights towards third parties and/or through the creation of spin-off ventures (Siegel et al., 2003a; Birley, 2002). This approach has proven successful in a number of domains, including biotechnology, pharmaceuticals and micro-electronics (Zucker et al., 2002; Owen-Smith and Powell, 2001). However, in a number of other technology domains, especially in those where patents as main mechanism to protect intellectual property, the success of this strategy is less rich (Markman et al., 2005).
This paper seeks to present a case study of a PRO in Flanders, the northern part of Belgium, which has adopted a new approach when it comes to knowledge and technology transfer activities. This approach has been coined 'flipped knowledge transfer', given its more demand-driven nature. In this approach, start-ups established by individuals external to the PRO play a critical role in forming the lynchpin between the entrepreneurial world and academic research. The core attribute of this study is defined as:

> *'Flipped knowledge transfer' refers to a demand-driven approach of knowledge and technology transfer activities at PROs, where the main driver to adopt new knowledge comes from start-ups external to the PRO that actively seek for academic knowledge that can be adopted to reinforce their products or applications.*

At the crossroads of the different domains touched upon by the literature review (i.e. the role of PROs in creating clusters of innovation and in overcoming the European Innovation Paradox through knowledge and technology transfer), this study seeks to challenge following underlying hypotheses:

H1: The flipped knowledge transfer approach has a number of attributes which makes it more appropriate to bring academic knowledge into application compared to the 'classic' technology transfer approach.

H2: In the mid to long run, the flipped knowledge transfer approach potentially yields bigger (financial) rewards for PROs than the 'classic' technology transfer approach.

H3: Any PRO can adopt strategies to embrace the concept of flipped knowledge transfer.

This flipped knowledge transfer approach can be highly relevant for a number of reasons. Firstly, new product life cycles and technology cycles are getting shorter (Kessler and Chakrabarti, 2003; Christensen, 1997; LaBahn et al., 1996). This evolution forces companies to adopt new knowledge and technologies at faster pace to keep up with the latest technologies and keep ahead of competition. Secondly, and related to the first reason, the shortening half lifetime of knowledge makes knowledge become obsolete at fast(er) pace (Hershock, 2011). This should moves companies *and* PROs to interact more frequently to keep up-to-date with the latest developments. Additionally, policy makers and public opinion have become increasingly demanding towards PROs to create mechanisms to provide direct added value and (positive) impact with their research outcomes on society and business (Markman et al., 2005; Shane, 2005). This flipped knowledge transfer approach may provide a tool to address these needs and issues.
In the same line of reasoning, there is mismatch in time between the availability of research results and the moment that SMEs decide to build applications based on this knowledge to pursue new business opportunities (Caputo et al., 2002; Kaufmann and Tödtling, 2002). Furthermore, the actual dissemination of research results uses channels that are difficult to access for innovation driven enterprises. Scientific publications and conference proceedings are often behind payment walls and are written in a language for researchers to understand and build upon. Part of this problem is solved by the open access policy of the EU but there is still a lot of work to describe research results in a way that is comprehensible for business actors and that allows them to identify future applications in their own space. The suggested approach can help bridge this time gap.

3. Case study results and findings

The current section presents the results of the case study. From a methodological perspective, this case study has been preceded by an elaborate literature review on the subject (a more detailed literature review paper is in the making). Using the outcomes of this literature review, the scene for this case study has been set following the guidelines of Yin (2014). Afterwards, data have been collected and coded by multiple researchers from different institutions to ensure robust data interpretations and avoid issues with self-reported data (Gonyea, 2005).
The case study starts with an in-depth presentation of the case study itself. Afterwards, the main results and outcomes are discussed at two levels: first, the main results of the case study itself will be presented, followed by a more general discussion of outcomes and benefits of a more open approach to academic entrepreneurship and knowledge transfer.

3.1. The case of iMinds, a PRO in Belgium

This study describes and analyses the flipped knowledge transfer approach through an in-depth case study. The subject of the case study is iMinds, a public research organisation (PRO) in Flanders (Northern part of Belgium). iMinds has been established in 2004 by the government of the Flemish Region, under its original name of IBBT (Interdisciplinary Institute for Broadband Technology). The organisation, funded by the Flemish Region, was given the task to develop demand-driven research

and solutions for the digital media and ICT sector and foster the business and societal application and adoption of newly developed technologies, knowledge, products and services. Applying knowledge and newly created technologies to addressing societal and business challenges in this sense is part of iMinds' core mission.
iMinds as an organisation somehow acts as network integrator for research and entrepreneurship in digital media and ICT in Flanders. In this role, iMinds collaborates with universities and university colleges and other actors in the ecosystem supporting entrepreneurship (including SMEs, large companies, TTOs, incubators, pitching events, financers and others). From a research side, iMinds has strategic partnerships with all five universities in Flanders (Vrije Universiteit Brussel, Ghent University, Hasselt University, KU Leuven and University of Antwerp). Through these partnerships, iMinds has direct access to and involvement with the vast majority of (ICT-related) researchers in Flanders. In this sense, iMinds acts as lynchpin in a Triple Helix ecosystem for the Flemish digital media and ICT community, integrating various actors and stakeholders.

The activities of iMinds are centred on two pillars: [1] collaborative and demand-driven research, in close cooperation with Flemish, Belgian and international companies, government organisations and other societal actors, and [2] foster entrepreneurial behaviour amongst researchers and externals and supporting commercialisation and other entrepreneurial activities with various programs.
Through the latter role, iMinds has since its inception been engaging in technology and knowledge transfer activities. However, in the early years of the organisation (2004-2011), iMinds has adopted the common 'technology-push' knowledge transfer approach, while in more recent years the new, flipped knowledge transfer approach has been deployed. This case study describes and analyses the potential benefits and drawbacks of this approach, by analysing the effects on individual researchers' entrepreneurial appetite, dynamics in research groups and the ability of external entrepreneurs and SMEs to get access to and adopt new technologies and knowledge created in PROs.

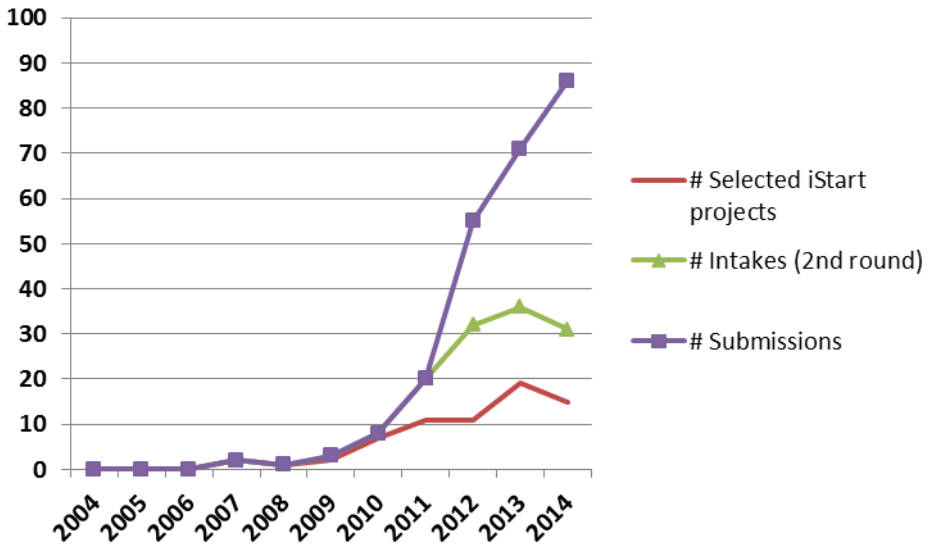
3.2. Results of the case study

Since its inception in 2004, iMinds has supported over 65 start-up and spin-off initiatives in its incubation program (called iStart). The projects in this program receive pre-seed funding and an intensive coaching program to help the entrepreneurs make the transition from technical proof-of-concept to a real business. The program started off from a rather classical technology transfer approach, where technologies and knowledge developed in the research groups were transferred to business and society using the common approaches (creation of spin-offs, licensing …). However, since 2011 not only spin-off projects started by iMinds' own researchers were / are supported, but independent entrepreneurs with innovative digital media and ICT applications are also welcome and can apply for support.
This new approach imposed a number of important challenges to the organisation. In the first place, it required an additional investment in terms of funding (required pre-seed funding for the incubation projects) and manpower (increase in coaches and supporting staff). These investments are however relatively limited in absolute and relative terms (approximately 1 million EUR). The second challenge related to corporate culture and mind-set, especially at the research side. Opening up the incubation program for external entrepreneurs required a quick intake and evaluation process, since especially in digital media and ICT the speed of innovation and technological progress forces entrepreneurs to keep up pace and make sure they benefit from short market windows. The overall intake and evaluation process was reorganised from a case-by-case evaluation whenever a potential spin-off project signed up (which took about 1-1.5 month to go through the intake process) to a call-based intake using a two-step evaluation (which only took 3 weeks from submission to final decision).

Since opening up the incubation program in the summer of 2011, the number of submissions as well as the number of supported incubation projects has been on the rise (see Figure 1). In the period 2004-2013, 65 incubation projects have been supported, of which 22 originated directly out of academic research. These 22 projects would be the ones commonly described as academic spin-offs (ASOs).

During the incubation program (typically between 6 and 18 months), the start-up receive a small amount of pre-seed funding, as well as in-depth coaching. The aim of the program is to support start-up teams that at least have a proof-of-concept of their technology or first product towards market introduction of their first product(s) and (if needed) towards a stage where they are mature enough to attract follow-up investments by private (and public) investors. The coaching program consists of daily support by a dedicated coach, complemented with workshops and one-on-one in-depth coaching by industry and subject experts (e.g. on marketing and branding, business-to-business sales, pitching, usability or preparing investment rounds). In some cases, the teams are reinforced by an entrepreneur-in-residence, which temporarily joins the start-up team.

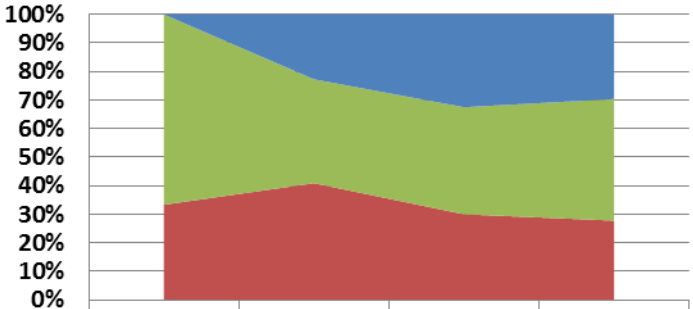
Figure 1 – Number of submissions and supported iStart projects (2004 – 2014)



What is more important, since 2011 iMinds has developed its flipped knowledge transfer approach, 54 new incubation projects have received substantial support. The origin of these 45 projects can be described as follows (see also Figure 2):

- 15 projects (28%) concerned ASOs, bringing academic technologies and knowledge to the market with researchers as lead entrepreneurs;
- The other 39 projects (72%) concerned start-up initiatives by external entrepreneurs, where the main product idea(s) did not find their origin in academic research;
- 16 of these 39 projects however (30% of the 'grand' total) have been matched with academic research, meaning the external entrepreneurs started a collaboration with one or more research groups to reinforce their technological and knowledge base and adopt and embed academic research results in their products and services.

Figure 2 – Origin of iStart projects (2011 – 2014)



	2011	2012	2013	2014
Matched with research	0	5	13	16
External entrepreneurs	6	8	15	23
Research origin	3	9	12	15

The net result of this flipped knowledge transfer approach is quintuple:

1. Academic research results find a more natural way towards 'real life' applications (given the demand-driven nature of the model). The start-ups involved greatly benefit from this direct input of (state-of-the-art) academic knowledge, while researchers get enthused by seeing their technologies 'at work'.
2. Researchers get feedback from the viewpoint of implementation, which often leads to further (contract) research. In many cases, the cooperation has led to joint project proposals to apply for innovation subsidies and joint research projects, in favour of both the start-up (which gets means to continue or even intensify the cooperation) and the research group (which receives additional funding ensuring continuity or even growth).
3. Barriers between small, young companies and researchers to interact have been diminished to a large extent. This does not only lead to more frequent and intense cooperation between the two actors, it also creates a channel for researchers (mainly PhD students) to find good employers (and vice versa for the start-up to be able to attract highly-skilled employees). This becomes even more relevant for the PhD students, since 80% of them need to pursue a career outside academia after successfully defending their PhD (Brentel, 2012; Marynen, 2012; Mascarelli, 2012).
4. SMEs and start-ups gain (easier) access to the latest developments in academic research, which enables them to differentiate their products and services through innovation based on relevant, demand-driven research. This could give them a competitive advantage or at least the opportunity to compete with more or less equal (knowledge) weapons against larger corporations.
5. PROs in the long run may attract more revenue for their research activities through long-term collaboration (joint research projects, contract research, funding of PhDs …). In one of the most successful cases, a start-up now funds two full-time PhD students at a research group and is involved in two joint research projects for which external funding has been obtained (one project funded by a regional innovation agency and one funded by the European Commission). This long-term cooperation has been supplemented with one-off revenue (lump sum) for the research group for the transfer of some intellectual property.

4. Implications and discussion

4.1. Implications of the case study

Research publications have been a traditional mechanism to disseminate new knowledge and research outcomes, mainly from a viewpoint to inform and inspire other researchers to further build on it. New methods may be needed, tailored to the needs of companies to transfer knowledge and get it adopted. Developing a new model of thinking about knowledge dissemination is certainly an intellectually interesting problem; where (part of) the solution may be to think out of the box and abandon a technology-push approach (or at least develop an alternative).

The implications of adopting a flipped knowledge transfer approach are threefold. Firstly, this model requires a new approach. Matchmaking between researchers and entrepreneurs needs to be done by people and organisations with enough domain expertise to lay links between the technological and knowledge needs and questions of companies (start-ups, SMEs) and research activities. This matchmaking is not trivial, since mostly these needs and questions are less explicit and somewhat masked (often entrepreneurs don't know exactly what they're looking for). As a result, the flipped knowledge transfer cannot be organised using the same, rather generic model as most PROs currently adopt. This new approach even more requires domain experts.

A second implication relates to the transferability of the approach, which differentiates from the classical technology transfer approach. Given the nature of the industry and domain (digital media and ICT), the technologies often concern 'softer' forms of knowledge (less patents, more software, algorithms and methodologies). Therefore, the terminology 'knowledge transfer' seems more appropriate than 'technology transfer', even though both forms relate to transferring new technologies and various forms of knowledge. However, in the flipped knowledge transfer approach, more attention is (and should be) devoted to closing the knowledge feedback loop within an ecosystem of a particular research and technology cluster. In industries with shorter R&D cycles and easier transfer of knowledge (such as digital media and ICT), adopting this flipped knowledge transfer approach may happen more easily.

Placing the demand-side central in this approach is the third implication. This requires efforts from both TTOs and researchers. By positioning research groups' assets well and implementing processes where collaboration between companies and researchers can emerge quickly, attractiveness of PROs towards SMEs and start-ups increases significantly. This entrepreneurial-friendly climate is a prerequisite for successfully implementing a flipped knowledge transfer approach, allowing entrepreneurs to build their growth strategies based on reinforcing their products and services with research-driven innovations.

4.2. Discussion

Worldwide most PROs have only been engaging explicitly in technology and knowledge transfer activities for the last few decades. Compared to their longstanding history and tradition in conducting research and providing education, which have been part of their core activities for centuries sometimes, this relatively new activity domain has been subject to debate and some form of experimentation to find the most appropriate model to achieve success. However, many PROs have not found the recipe yet to deploy successful technology transfer activities.

The value of this case study lies mainly in highlighting a different approach. PROs' 'classical' technology transfer approach builds on a technology-push or inside-out model, where new technologies developed within these PROs are 'pushed' towards business and society and they will hopefully find applications and be adopted. Prior studies have however demonstrated the relative pre-matureness of most PRO technologies when brought to the market (Druilhe and Garnsey, 2004; Shane, 2004), requiring substantial additional efforts in translating the technology into market-ready products and applications.

The case study on iMinds tries to bring up a different, more outside-in approach. This so-called flipped knowledge transfer approach adopts an inverse perspective, whereby market players interact much more frequently with researchers and whereby PRO technology and knowledge is 'pulled' outside the PRO in a more demand-driven approach. In this model, start-ups and entrepreneurs play a pivotal role.

Even though this model is rather new, the first results indicate an interesting potential for PRO's technology transfer approach. These positive results refer to impact for individuals (mainly for researchers, who can find real-life applications for their knowledge and who could find interesting career options), start-ups and companies (who can gain a competitive advantage and improve their products with state-of-the-art research outcomes, as well as get access to highly-skilled people) and PROs (who get input from industry, and potentially get additional revenue streams and more extensive cooperation with business). However, the model and its effects, both directly and indirectly as well as in the short and long run, deserve further attention and research. It opens the debate for more studies on the impact of technology and knowledge transfer programs, as well as for further search for best practices and alternatives to boost the commercialisation of academic research output.
A second important contribution of this case study is its value in making the potential benefits for PROs of opening up their entrepreneurship programs and support towards 'externals' explicit. Tearing down the walls of the 'ivory tower' may have substantial positive impact in the short and long run, as well as on organisational and individual level. It is obviously clear that not all PROs can (probably) open up their TTO activities and entrepreneurship programs as widely as iMinds. It may be difficult for universities or other PROs to spend scarce resources on supporting totally unrelated start-ups or SMEs. Opening up such programs has far-reaching implications on an organisation, both in terms of competences required as well as means and processes that need to be adapted (mainly, but not limited to the TTO level). However, the authors firmly believe that a certain level of openness, embracing at least those entrepreneurs and start-ups that can be linked directly to researchers and benefit from input of academic knowledge, has a positive effect on the start-up, the PRO and the individuals involved (thereby maybe only excluding the category of fully external entrepreneurs of Figure 2). More frequent interactions between researchers and entrepreneurs foster knowledge spill-overs, reinforce the economic tissue in a region and act as enabler to form a cluster of innovation.

PROs may experience a number of obstacles when trying to implement a flipped knowledge transfer approach. The first one may relate to the legal framework. Not all PROs may be allowed to spend part of their scarce resources to support (initially) unrelated companies. Secondly, this transition requires a new set of procedures and processes on behalf of the PROs to deal with such cooperation in a very flexible and speedy manner. Specifically for start-ups, speed of go-to-market and agility are critical for their survival chances (De Coster and Butler, 2005; Power and Reid, 2005). For this kind of cooperation to become successful, both sides need to adapt. Another important element relates to the means in terms of people, expertise and (eventually) funding. A flipped knowledge transfer approach to foster entrepreneurship around a PRO can only become successful if it becomes part of a PRO's strategy. The authors believe, based on the first results, that sector expertise is required to fully realise the approach's potential, which has implications on TTO's staffing requirements. A fourth and last major success factor for successful implementation of the flipped knowledge transfer approach relates to the demand-driven nature of PRO research. iMinds is by definition a demand-driven PRO, where (almost) all research efforts are conducted in close cooperation with industry and society stakeholders. As a result, research efforts are closer to end-user applications and closer to the market. This may impose a challenge for a number of PROs, especially in safeguarding a good balance between fundamental and applied research (Poyago-Theotoky et al., 2002; Gibbons et al., 1994). Based on the results of this case study, the authors believe however that even when research

is partially reoriented towards more demand-driven needs, this will on a longer term also positively impact fundamental research, since new challenges and opportunities can be identified based on concrete implementation of new knowledge and technologies in entrepreneurial settings.

The current study has several limitations, which in turn lead to a number of opportunities for further research. The results of this case study are based on a relatively short term implementation of the flipped knowledge transfer approach. More research should be conducted on this approach on a longer term to fully understand its implications, benefits and challenges. Even though the first results are very promising and point in the direction of a positive effect on short, mid and long term for PROs and start-ups, further research should more deeply analyse to what extent the benefits surpass that of the 'classic' technology transfer approach. Secondly, this study was conducted on a single case study, which obviously has its limitations. Follow-up studies could replicate this study in other settings and organisations to fully understand the impact of local and organisational settings on the effect of applying the flipped knowledge transfer approach. Additionally, further research on how and when this approach can be replicated for other types of PROs could add substantial value to this field in general.

This case study has explored the topic of a flipped knowledge transfer approach as tool to stimulate the creation of clusters of innovation and to strengthen market adoption of academic research in concrete applications. The more demand-driven approach stimulates start-ups and SMEs, which are key in creating clusters of innovation in a region and are responsible for the majority of wealth and job creation. In this sense, PROs can play a crucial role on a regional level in reinforcing (and also in creating) entrepreneurship. Despite the limitations of this case study, the first results of such approach have proven positive for the PROs, researchers and start-ups involved. PROs and their TTOs will play an increasingly important role in regional dynamics, especially for technology clusters and start-ups. This flipped knowledge transfer approach can be an additional tool in truly realising the potential of the Triple Helix Model and creating innovation hubs where new start-ups flourish and safeguard (or even improve) a region's wealth on mid to long term.

5. References

Argote, L., Ingram, P. (2000). Knowledge Transfer: A Basis for Competitive Advantage in Firms. *Organizational Behavior and Human Decision Processes* 82 (1): 150-169.

Birley, S. (2002). Universities, Academics, and Spinout Companies: Lessons from Imperial. *International Journal of Entrepreneurship Education* 1 (1): 133-154.

Bray, M. J., Lee, J. N. (2000). University revenues from technology transfer: Licensing fees vs. equity positions. *Journal of Business Venturing* 15 (5-6), 385-392.

Brentel, H. (2012). *Designing Spaces for Creative Thinking and Individual Development in Skills Training , Supervision and Career Paths - Concepts and Experiences at Goethe University Frankfurt am Main*. Goethe Universität: Dulbin.

Bresnahan, T., Gambardella, A., Saxenian, A.L. (2001). 'Old economy' inputs for 'new economy' outcomes: Cluster formation in the new Silicon Valleys. *Industrial and Corporate Change* 10 (4): 835-860.

Brooksbank, D., Thomas, B. (2001). An Assessment of Higher Education Spin-Off Enterprises in Wales. *Industry & Higher Education* 15 (6): 415-420.

Caputo, A. C., Cucchiella, F., Fratocchi, L., Pelagagge, P. M., Scacchia, F. (2002). A methodological framework for innovation transfer to SMEs. *Industrial Management & Data Systems* 102 (5): 271-283.

Christensen, C. M. (1997). *The innovator's dilemma: When new technologies cause great firms to fail*. Harvard Business Review Press: Harvard (USA).

Clarysse, B., Wright, M., Bruneel, J., Mahajan, A. (2014). Creating value in ecosystems: Crossing the chasm between knowledge and business ecosystems. *Research Policy* 43 (7): 1164-1176.

Clarysse, B., Moray, N., Heirman, A. (2002). *Transferring Technology by Spinning off Ventures: Towards an Empirically Based Understanding of the Spin-off Process*. Working Paper, Universiteit Gent, Faculteit Economie en Bedrijfskunde 131: 1-32.

Dale Meyer, G. (2011). The Reinvention of Academic Entrepreneurship. *Journal of Small Business Management* 49 (1): 1-8.

Debackere, K., Veugelers, R. (2005). The role of academic technology transfer organizations in improving industry science links. *Research Policy* 34 (3): 321-342.

De Cleyn, S. H., Tietz, R., Braet, J., Schefczyck, M. (2010). Report on the status of academic entrepreneurship in Europe: 1985-2008.

De Coster, R., Butler, C. (2005). Assessment of Proposals for New Technology Ventures in the UK: Characteristics of University Spin-Off Companies. *Technovation* 25 (5): 535-543.

Desouza, K. C., Awazu, Y. (2006). Knowledge management at SMEs: five peculiarities. *Journal of Knowledge Management* 10 (1): 32-43.

Di Gregorio, D., Shane, S. (2003). Why do Some Universities Generate More Start-ups than Others? *Research Policy* 32 (2): 209-227.

Djokovic, D., Souitaris, V. (2008). Spinouts from Academic Institutions: A Literature Review with Suggestions for Further Research. *Journal of Technology Transfer* 33 (3): 225-247.

Doeringer, P. B., Terkla, D. G. (1995). Business Strategy and Cross-Industry Clusters. *Economic Development Quarterly* 9 (3): 225-237.

Dosi, G., Llerena, P., Labini, M. S. (2006). The relationships between science, technologies and their industrial exploitation: An illustration through the myths and realities of the so-called 'European Paradox'. *Research Policy* 35 (10): 1450–1464.

Druilhe, C., Garnsey, E. (2004). Do Academic Spin-Outs Differ and does it Matter? *Journal of Technology Transfer* 29 (3-4): 269-285.

Engel, J. S. (2014). *Global clusters of innovation: Entrepreneurial engines of economic growth around the world*. Edward Elgar: Cheltenham (U.K.).

Engels, J. S., del-Palacio, I. (2009). Global networks of clusters of innovation: Accelerating the innovation process. *Business Horizons* 52 (5): 493-503.

Etzkowitz, H. (1998). The Norms of Entrepreneurial Science: Cognitive Effects of the New University - Industry Linkages. *Research Policy* 27 (8): 823-833.

Etzkowitz, H., Klofsten, M. (2005). The Innovating Region: Toward a Theory of Knowledge-based Regional Development. *R&D Management* 35 (3): 243-255.

Etzkowitz, H., Webster, A., Gebhardt, C., Terra, B. R. C. (2000). The Future of the University and the University of the Future: Evolution of Ivory Tower to Entrepreneurial Paradigm. *Research Policy* 29 (2), 313-330.

European Commission (1995). *Green Paper on Innovation*. European Commission: Brussels.

Festel, G., De Cleyn, S. H., Boutellier, R., Braet, J. (2011). Optimizing the R&D Process Using Spin-Outs: Case Studies from the Pharmaceutical Industry. *Research-Technology Management* 54 (1): 32-41.

Freeman, J., Engel, J. S. (2007). Models of innovation: Startups and mature corporations. *California Management Review* 50 (1): 94-119.

FSB (2014). *Statistics. Federation of Small Businesses*. Avaliable online at http://www.fsb.org.uk/stats.

Fujita, M., Krugman, P., Venables, A. J. (2001). The spatial economy: Cities, regions and international trade. MIT Press: Massachusetts (USA).

Giacometti, M. (2001). Italian Policies for University Spin-off Companies. *Industry & Higher Education* 15 (4): 233-237.

Gibb, A. A. (2000). SME Policy, Academic Research and the Growth of Ignorance, Mythical Concepts, Myths, Assumptions, Rituals and Confusions. International Small Business Journal 18 (3): 13-35.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. Sage Publications: London (U.K.).

Goldfarb, B., Henrekson, M. (2003). Bottom-up versus Top-down Policies towards the Commercialization of University Intellectual Property. *Research Policy* 32 (4): 639 - 658.

Gonyea, R. M. (2005). Self-Reported Data in Institutional Research: Review and Recommendations. *New Directions for Institutional Research* 127: 73-89.

Gross, C. M. (2013). The growth of China's technology transfer industry over the next decade: implications for global markets. *Journal of Technology Transfer* 38 (5): 716-747.

Gunasekara, C. (2006). Reframing the Role of Universities in the Development of Regional Innovation Systems. *The Journal of Technology Transfer* 31 (1): 101-113.

Guston, D. H. (1999). Stabilizing the Boundary between US Politics and Science: The Role of the Office of Technology Transfer as a Boundary Organization. *Social Studies of Science* 29 (1): 87-111.

Heinzl, J., Kor, A.-H., Orange, G., Kaufmann, H. R. (2013). Technology transfer model for Austrian higher education institutions. The Journal of Technology Transfer 38 (5): 607-640.

Henderson, R., Jaffe, A. B., Trajtenberg, M. (1998). Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting, 1965–1988. *The Review of Economics and Statistics* 80 (1): 119-127.

Hershock, P. (2011). *Information and Innovation in a Global Knowledge Society: Implications for Higher Education*. In: Neubauer, D. E., The emergent knowledge society and the future of higher education: Asian perspectives. Routledge: London, 12-48.

Ho, M. H.-C., Liu, J. S., Lu, W.-M., Huang, C.-C. (2014). A new perspective to explore the technology transfer efficiencies in US universities. *The Journal of Technology Transfer* 39 (2): 247-275.

Howells, J. (2005). Innovation and regional economic development: A matter of perspective? *Research Policy* 34 (8): 1220-1234.

Huggins, R. (2008). The Evolution of Knowledge Clusters: Progress and Policy. *Economic Development Quarterly* 22 (4): 277-289.

IFC (2012). *IFC and Small and Medium Enterprises*. Available online at http://www.ifc.org/wps/wcm/connect/277d1680486a831abec2fff995bd23db/AM11IFC+IssueBrief_SME.pdf?MOD=AJPERES.

Inkpen, A. C., Tsang, E. W. K. (2005). Social Capital, Networks, and Knowledge Transfer. *Academy of Management Review* 30 (1): 146-165.

Jones-Evans, D., Klofsten, M., Andersson, E., Pandya, D. (1999). Creating a Bridge between University and Industry in Small European Countries: The Role of the Industrial Liaison Office. *R&D Management* 29 (1): 47-56.

Kafouros, M., Wang, E. Y. (2014). Technology transfer within China and the role of location choices. *International Business Review* (in press). DOI: 10.1016/j.ibusrev.2014.08.007.

Kaufmann, A., Tödtling, F. (2002). How effective is innovation support for SMEs? An analysis of the region of Upper Austria. *Technovation* 22 (3): 147-159.

Kessler, E. H., Chakrabarti, A. K. (2003). Speeding Up the Pace of New Product Development. *Journal of Product Innovation Management* 16 (3): 231-247.

Klofsten, M., Jones-Evans, D. (2000). Comparing Academic Entrepreneurship in Europe - The Case of Sweden and Ireland. *Small Business Economics* 14 (4): 299-309.

Krugman, P. (1991). *Geography and trade*. MIT Press: Massachusetts (USA).

LaBahn, D. W., Ali, A., Krapfel, R. (1996). New product development cycle time: The influence of project and process factors in small manufacturing companies. *Journal of Business Research* 36 (2): 179-188.

Lee, Y. S. (1996). 'Technology transfer' and the research university: a search for the boundaries of university-industry collaboration. *Research Policy* 25 (6): 843-863.

Leydesdorff, L. (2000). The Triple Helix: An Evolutionary Model of Innovations. *Research Policy* 29 (2): 243-255.

Liou, D.-Y., Liou, J. D. (2009). The structure and evolution of knowledge clusters: a system perspective. *International Journal of Technology Management* 46 (3): 307-325.

Lockett, A., Wright, M. (2005). Resources, capabilities, risk capital and the creation of university spin-out companies. *Research Policy* 34 (7): 1043-1057.

Macho-Stadler, I., Pérez-Castrillo, D., Veugelers, R. (2007). Licensing of university inventions: The role of a technology transfer office. *International Journal of Industrial Organization* 25 (3): 483-510.

Markman, G. D., Phan, P. H., Balkin, D. B., Gianodis, P. T. (2005). Entrepreneurship and University-based Technology Transfer. *Journal of Business Venturing* 20 (2): 241-263.

Marynen, P. (2012). *Brain mobility: an added value in your career planning*. K.U. Leuven: Leuven.

Mascarelli, A. (2012). Stepping stones. *Nature* 490 (25 October 2012): 571-573.

Miesing, P., Tang, M., Li, M. (2014). University Technology Transfer in China: How Effective are National Centers? In: Corbett, A. C., Siegel, D. S., Katz, J. A., *Advances in Entrepreneurship, Firm Emergence and Growth*, Vol. 16, Emerald: Bingley (U.K.).

Nunes, M. B., Annansingh, F., Eaglestone, B., Wakefield, R. (2006). Knowledge management issues in knowledge‐intensive SMEs. *Journal of Documentation* 62 (1): 101-119.

Owen-Smith, J., Powell, W. W. (2001). To Patent or Not: Faculty Decisions and Institutional Success at Technology Transfer. *The Journal of Technology Transfer* 26 (1-2): 99-114.

Poyago-Theotoky, J., Beath, J., Siegel, D. S. (2002). Universities and Fundamental Research: Reflections on the Growth of University–Industry Partnerships. *Oxford Review of Economic Policy* 18 (1): 10-21.

Porter, M. E. (2000). Location, competition, and economic development: Local clusters in a global economy. *Economic development quarterly* 14 (1): 15-34.

Porter, M. E. (1998). Clusters and the new economics of competition. *Harvard Business Review* 76 (6): 77-90.

Power, B., Reid, G. C. (2005). Flexibility, Firm-Specific Turbulence and the Performance of the Long-lived Small Firm. *Review of Industrial Organization* 26 (4): 415-443.

Powers, J. B., McDougall, P. P. (2005). University start-up formation and technology licensing with firms that go public: A resource-based view of academic entrepreneurship. *Journal of Business Venturing* 20 (3): 291-311.

Rogers, E. M., Takegami, S., Yin, J. (2001). Lessons learned about technology transfer. Technovation 21 (4): 253-261.

Rothaermel, F. T., Agung, S. D., Jiang, L. (2007). University Entrepreneurship: A Taxonomy of the Literature. *Industrial and Corporate Change* 16 (4): 691-791.

Santos, F. M. (2003). The coevolution of firms and their knowledge environment: Insights from the pharmaceutical industry. *Technological Forecasting and Social Change* 70 (7): 687-715.

Saxenian, A.L. (1994). *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*. Harvard University Press: Cambridge (USA).

Shane, S. (2004). *Academic Entrepreneurship - University Spinoffs and Wealth Creation*. Edward Elgar: Cheltenham (U.K.).

Siegel, D. S., Waldman, D., Link, A. N. (2003a). Assessing the impact of organizational practices on the productivity of University Technology Transfer Offices: An exploratory study. *Research Policy* 32 (1): 27-48.

Siegel, D. S., Westhead, P., Wright, M. (2003b). Assessing the Impact of University Science Parks on Research Productivity: Exploratory Firm-Level Evidence from the United Kingdom. *International Journal of Industrial Organization* 21 (9): 1357-1369.

Singh, R. K., Garg, S. K., Deshmukh, S. G. (2010). The competitiveness of SMEs in a globalized economy: Observations from China and India. *Management Research Review* 33 (1): 54-65.

Teece, D. J. (2003). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. In: Teece, D. J., *Essays in Technology Management and Policy*, World Scientific: Singapore.

Teece, D. J. (1998). Capturing value from knowledge assets: The new economy, markets for know-how, and intangible assets. *California Management Review* 40 (3): 55-79.

Thursby, J. G., Thursby, M. C. (2002). Who Is Selling the Ivory Tower? Sources of Growth in University Licensing. *Management Science* 48 (1): 90-104.

Tijssen, R. J. W., van Wijk, E. (1999). In search of the European Paradox: an international comparison of Europe's scientific performance and knowledge flows in information and communication technologies research. *Research Policy* 28 (5): 519-543.

Yin, R. K. (2014). Case Study Research: Design and Methods. Sage Publications: Thousand Oaks (USA).

Zucker, L. G., Darby, M. R., Armstrong, J. S. (2002). Commercializing Knowledge: University Science, Knowledge Capture, and Firm Performance in Biotechnology. *Management Science* 48 (1): 138-153.