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Collaborate on Route 128: A resource-based exploration of University-Start-up Interaction

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Abstract

This paper explores the concept of University-Start-up Interaction (USUI) as a source of knowledge spillover and innovation. We first identify USUI practices and how universities and start-ups use these practices to achieve their objectives. Second, we study when the USUI process is mutually beneficial in terms of resources to both actor types. We develop a theoretical framework based on the objectives of both actor types, the resource-based view and three generic utilization mechanisms: education, creating new ventures support and university-industry interaction. Empirically, 36 qualitative interviews were conducted among clean-tech start-ups, universities and other experts, such as accelerators and incubator facilities in the Boston area, Massachusetts, USA, also known as ?Route 128?.
In total we identify 14 USUI practices. After analyzing the resources exchanged during these practices we find that USUI is largely based on intangible resources. Second, the resources that university transfer to start-ups mostly relate to organization and product development, but little to market development. Third, universities can mostly strengthen their (entrepreneurship) education programs and knowledge utilization objectives through USUI, but there is little added value to fundamental research.
Overall we conclude that whether USUI is beneficial largely depends how organizations value their different objectives.

Science based start-ups are more likely to benefit from USUI, while start-ups close to market might be better off with other support programs. Universities with a strong focus on fundamental research benefit less from USUI than universities that are more diverse, applied or that have strong focus on teaching and knowledge utilization.

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Overall we conclude that whether USUI is beneficial largely depends how organizations value their different objectives. Science based start-ups are more likely to benefit from USUI, while start-ups close to market might be better off with other support programs. Universities with a strong focus on fundamental research benefit less from USUI than universities that are more diverse, applied or that have strong focus on teaching and knowledge utilization. Based on our findings we formulate theoretical and managerial implications.

Keywords: University-industry interaction; entrepreneurship; start-ups; higher education; resource-based view

1. Introduction

The utilization of knowledge created at universities plays an important role in the development process of radical innovations that can help to overcome grand societal challenges, such as climate change (Elzen et al., 2004). However, knowledge utilization is often perceived to be lagging behind and universities are encouraged to devote more resources to this process (Grimaldi and Grandi, 2005). As a result, universities have taken several actions, such as establishing technology transfer offices (TTO's), incubators, supporting university spin-outs (Siegel, 2006) and providing entrepreneurship education (Schulte, 2004). As such, knowledge utilization practices can be categorized along three broad mechanisms: education, new venture support and university-industry-interaction (UII).

All three mechanisms are relevant in the process of *University-start-up Interaction* (USUI), which takes place during and after new venture creation. Start-ups are traditionally seen as an important source of innovation (Schumpeter, 1942; Audretsch, 2009), and these innovations are often considered the result of knowledge spillovers from universities (Audretsch et al., 2012). However, the interaction between start-ups and universities as source of these knowledge spillovers and innovations has remained underexposed in the literatures about new venture support and UII. In this paper we explore the concept of USUI. We motivate our research with three knowledge gaps.

First, it is important to consider *who* are involved in the process. Knowledge utilization has been widely studied in relation to existing industry (for an overview see: Rothaermel et al., 2007; Bozeman et al., 2013), but does not take into account that start-ups differ greatly from established firms: they have a stronger focus on generating product innovation (Ries, 2011), they have a higher dependency on their sales from innovative products (Criscuolo et al., 2012), they play an important role in exploring new technology markets (Almeida and Kogut, 1997), but are more likely to lack the resources required to successfully develop and market radical innovations (Vohora et al., 2004; Bruton et al., 2010). As such, the interaction between universities and start-ups deserves explicit academic attention.

Second, to understand knowledge utilization, it is important to understand *why* actors engage in this process. For this we need to look at the micro-incentives that the two different actor types receive from their own institutional context (Van Rijnsoever et al., 2014.). Universities are known to focus strongly on publications and scientific credibility (Latour and Woolgar, 1979; Hessels and van Lente, 2008), while start-ups focus on the creation of new organizations, products and markets (Bhave, 1994; Gaglio and Katz, 2001). For this they need crucial resources that can be exchanged with other actors via interaction practices (Lin et al., 2009). Only if knowledge utilization contributes to achieving the objectives of all actors involved, can it become viable in the long term. Most current studies focus only on only one actor type (Rothaermel et al., 2007), but to assess if USUI is a viable process it is important to look at how it affects the competitive position of both actor types involved.

Third, we need to understand *how* knowledge utilization takes place. The interaction between universities and start-ups has mainly been studied in the context of incubators (Hisrich and Smilor, 1988; Rothaermel and Thursby, 2005a, 2005b) or in a more descriptive sense of the entrepreneurial university (Etzkowitz, 2003; Schulte, 2004; Levie, 2014), but the simultaneous use of all three mechanisms has not systematically been assessed yet. This is unfortunate as achieving the objectives of an actor is the result of a combination of all three mechanisms.

Therefore, we first aim *to identify USUI practices and how universities and start-ups use these practices to achieve their objectives. Second, we study when the USUI process is mutually beneficial in terms of resources to both actor types.*

To these ends, we first develop a theoretical framework based on objectives for each actor type, the resource-based view (RBV) and the three utilization mechanisms. Empirically, 36 qualitative interviews were conducted among clean-tech start-ups, universities and other experts, such as accelerators and incubator facilities in the Boston area, Massachusetts, USA, also known as 'Route 128'.

Theoretically, this study is the first to systematically explore USUI as the interaction process between universities and start-ups from both sides considering practices from all three utilization mechanisms. By taking this broader perspective, it demonstrates how universities and start-ups can help each other to achieve their objectives and contributes to our understanding of the micro-incentives for interaction among different actor types. This enables policy makers and universities to promote knowledge utilization via start-ups.

2. Theory

This paper approaches USUI as a process that can be explained using the RBV (Penrose, 1959; Barney, 1991), which frames organizations as a bundle of resources and capabilities (Barney, 1991; Amit and Schoemaker, 1993). Resources that are valuable, rare and imperfectly imitable contribute most to the competitive advantage of the organization, and hence its survival (Barney, 1995; Grant, 1996).

The RBV can easily be applied to start-ups, since the ability of entrepreneurs to acquire and develop resources is seen as crucial for survival (Dollinger, 1999). Especially knowledge about how do to business and access to social networks are considered important (Van Weele et al., 2013). Though less common, the RBV has also been successfully applied to the academic context (Powers and McDougall, 2005; Van Rijnsoever et al., 2008). As the environment in which universities operate has become more competitive and market-like (Powers and McDougall, 2005), universities put more effort in acquiring research funds, high quality faculty and the brightest students. Successful cooperation can increase the output of publications (contributing to the advancement of academic rank) and strengthens the researchers competitiveness for research grants (Latour and Woolgar, 1986).

We next develop our framework that serves as a basis for data collection and interpretation. First, a characterization is given of university and start-up *objectives* and the *core-activities* deployed to attain them based on the incentives they receive from their institutional environment. Secondly, using the RBV, several resources and their contribution to the previously defined university and start-up objectives and activities are discussed. Third, we discuss the three knowledge utilization mechanisms.

2.1. Objectives and core-activities of universities and start-ups

2.1.1 Start-up objectives & core-activities

A central focus of an entrepreneur is the establishment of a viable new organization (Liao and Welsch, 2008). Analytically, the creation of an organization can be divided into three main objectives: *organization development*, *technology & product development* and *market development* (Bhave, 1994; Gartner and Vesper, 1994; Gaglio and Katz, 2001), which are fulfilled by a set of core-activities that take place in an iterative, nonlinear and feedback-driven manner (Bhave, 1994; Liao and Welsch, 2008).

Organization development encompasses structuring both the conceptual and physical attributes of the organization (Bhave, 1994). Three activities are recognized to reach this objective:

- *Opportunity recognition* relates to the decision to start a venture based on a specific opportunity that the entrepreneur commits to. This commitment follows after a process of opportunity filtration, opportunity selection and opportunity refinement (Gartner, 1985; Bhave, 1994; Gaglio and Katz, 2001).
- *Business concept development* often follows, defining the business model and value proposition of the start-up. It involves action to define the business concept, and align customer-needs and the entrepreneur's perception of those needs (Ardichvili et al., 2003; Delmar and Shane, 2003).
- *Organization creation* is the activity of organizing of both physical structure as well as organizational processes that are required to produce and sell a certain technology at the core (Kilby, 1971; Gartner, 1985; Bhave, 1994).

Technology & Product Development may be considered a second objective of start-ups. Two activities are deployed to produce a functional product:

- *Technology development* refers to the development of technology fundamental to the product. For service ventures, the primary product is knowledge and expertise. New technology-based

start-ups that develop a new technology often need to perform research and development in labs to proof the technology concept (Bhave, 1994).

- *Product development*, in contrast, comprises the transformation of a product idea into a physical product, through allocation of resources (Gartner, 1985; Vesper, 1990). An important aspect of product development is the relationship between the entrepreneur, customers and market, as the first can use information from the customer and market to improve the product design (Bhave, 1994).

Market Development is the third objective start-ups need to fulfill. It includes a bi-directional interaction with the market, for both products and services (Gartner, 1985). Two activities are distinguished:

- *Customer outreach* relates to the process of acquiring (first) customers (Gartner, 1985; Bhave, 1994), in which start-ups have to overcome the supply and demand boundary by marketing.
- *Customer feedback*, subsequently, occurs as the start-up evaluates -and acts upon- feedback acquired from (potential) customer interaction (Gartner, 1985; Bhave, 1994). Sometimes, firms need to revise product features by revising existing equipment. Other times, an alteration of the business concept is required.

2.1.2. University objectives & core-activities

Traditionally, the two objectives of universities are teaching and research (Göransson et al., 2009). Furthermore, universities increasingly engage in knowledge utilization (Etzkowitz, 2004), although this seems to remain at odds with two traditional objectives. These three objectives form the basis for the incentives for USUI for universities and researchers.

Education generally takes place through undergraduate- and graduate programs. Furthermore, universities deploy programs that consider their students also as job-creators (Schulte, 2004; Levie, 2014). Three activities can be distinguished:

- *Training academic professionals* concerns the preparation of students for a faculty career (Austin, 2002). This activity includes education on the roles and responsibilities of faculty, such as teaching, managing research projects and the development of academic skills (Austin, 2002; Göransson, 2009).
- *Training high-quality workforce* adds the education of high-level practitioners that are able to fulfill a role within industry (Göransson, 2009). Training of high-quality workforce can be seen as an indirect technology transfer activity, providing academically educated and specialized personnel to industry (Carayannis et al., 1998).
- *Training entrepreneurs, then,* encompasses the transfer of knowledge to students, relevant to developing a business through endeavors such as business school programs and entrepreneurship courses (Schulte, 2004). Hereby, students are trained to start a new venture (Pirnay and Surlemont, 2003).

Concerning the objective of performing research, universities we discern three types of activities:

- *Performing fundamental research* summarizes the act of study with a basic orientation in science and engineering from a perspective of greater knowledge and understanding of subjects, without a specific application in mind (Gibbons et al., 1994). This knowledge is typically diffused by means of educating people and publishing scientific writings, without any direct commercial interest (Audretsch and Lehmann, 2005).
- *Performing applied research,* on the contrary, comprises proprietary research with strong practical implications, such as contract research on behalf of private enterprises and public authorities (Göransson, 2009). The results of which are often shared in a more restricted way (Schulte, 2004).

Finally, from the utilization objective the following activities generally follow:

- *Research commercialization* entails the academic knowledge transfer to industry through efforts such as academic spin-off, spin-out, and spillover (Etzkowitz, 2004). Respectively, this means that university research is commercialized (1) through the formation of a high tech start-up company (Link and Scott, 2005), (2) using the technology license of a signed invention to create a new company for exploitation of the license (Di Gregorio and Shane, 2003), or (3) directly with firms in industry through contract research or joint research projects (D'Este and Patel, 2007).
- *Entrepreneurship support, au contraire, facilitates* new venture creation by means such as university supported incubation practices (Mian, 1996), aid in patenting and the establishment of science parks (Link and Scott, 2005). These practices are often oriented towards both the university community and society.

2.2. Resource requirements

To perform these activities, both types of actors need resources. Scholars using the RBV in context of the entrepreneurial firm generally distinguish four categories of resources: financial-, physical-, human- and social capital (Busenitz and Barney, 1997; Powers and McDougall, 2005). Due to the interest in academic activity and high-tech start-up firms, this study also identifies several resources unique to universities and high-tech start-ups, including scientific capabilities, expert knowledge and university research (Mansfield and Lee, 1996). Resources can be divided into two categories. Tangible resources reflect the assets of an organization with an actual physical existence (Galbreath, 2005), whereas intangible resources reflect the non-physical assets of an organization (Kristandl and Bontis, 2007).

2.2.1. Tangible Resources

- *Financial Capital* encompasses all monetary resources available for the deployment of organizational activities (Barney, 1997). Financial capital is critical for conducting research within the university. Besides federal funding, universities look for other sources of funding (National Science Board, 1998) which has become essential for today's university (Etzkowitz et al., 1998). Start-ups are often depending on external financial capital, especially in technology & product development and organization creation (MacMillan et al., 1987; Bhave, 1994).
- *Human capital* is the aggregation of labor force, differentiated based on educational training, entrepreneurial experience, working experience and ambition (Davidsson and Honig, 2003). For the university, human capital is essential for the quality of education and research (Powers and McDougall, 2005). For start-ups, human capital with expert knowledge and talent is an important resource for commercializing a cutting-edge technology (Powers and McDougall, 2005).
- *Physical capital* reflects the hardware used by organizations, such as the organization's facility and equipment and the availability of raw materials (Barney, 1991). For universities, the use of expensive or unique laboratory equipment can be essential to perform certain types of research (Thorsteinsdóttir, 2000). High-tech start-ups often require a place to work from or need specialized equipment for technology & product development (Roessner et al., 1998).

2.2.2. Intangible resources

- *Business knowledge* comprises the information and experience required for running a business (Vohora et al., 2004). Business knowledge contributes to research commercialization in universities, as it helps to transform research outcomes into a viable business (Powers, 2003). For entrepreneurs, business knowledge is essential in opportunity recognition, business concept development,

organization creation, promoting products across the supply & demand boundary and customer feedback (Chan and Lau, 2005).

- *Technical or scientific knowledge* refers to the information and experience with a specific technology, and can be a result of academic research (Rosenberg and Nelson, 1994). Developing technical or scientific knowledge in scientific publications is one the core activities of the university (Hessels and van Lente, 2008) and is considered a source of its competitive advantage (Van Rijnsoever et al., 2008). To start-ups, technical knowledge allows to effectively exploit the potential of technology, interpret new information (Cohen and Levinthal, 1990) and determine the optimal product design (Rosenberg, 1994).
- *Market knowledge* covers the information and experience that enables organizations to make a more accurate prediction of the commercial opportunities in their environment, so that they can take strategic action (Cohen and Levinthal, 1990). Knowledge about the market value of specific scientific discoveries can increase the university's ability to determine the commercialization potential of a technology (Shane, 2000). Knowledge on customer demands, customer preferences and the market is valuable for start-ups regarding product development and marketing (Shane, 2000; Von Hippel, 2007).
- *Social Capital* aggregates the organization's potential to extract benefits from its network and social structures (Davidsson and Honig, 2003), such as organizational culture. Through involvement with industry, universities develop a more entrepreneurial culture, which is beneficial to knowledge utilization (Etzkowitz et al., 1998). Social capital can enable start-ups to 'access' resources provided by third parties, and can therefore compensate for lacking essential resources at first (Borgatti and Foster, 2003).
- *Credibility* refers to the trustworthiness, reliability and expertise of an actor (Van Rijnsoever et al., 2014). Especially start-ups, often lacking any track record, suffer from a shortage in credibility (Vohora et al., 2004). Credibility helps universities to earn recognition, sustain and expand their practices (Latour and Woolgar, 1986) such as practices related to teaching, research or entrepreneurship. Based on a relation with an external actor, credibility allows start-ups to access resources such as other networks and financial capital (Shane and Cable, 2002).

2.3 Knowledge utilization mechanisms

Based on the extant literature we identify three knowledge utilization mechanisms are all relevant in the transfer process of these resources between universities and start-ups.

- *Education* (Saxenian, 1996; Etzkowitz, 2004) is an indirect utilization mechanism, since the fundamental knowledge is transferred by delivering specialized graduates to industry (Carayannis et al., 1998). In addition, universities can transfer knowledge on developing a business through entrepreneurship education (Schulte, 2004), thereby supporting graduates in starting a new venture (Pirnay and Surlemont, 2003). Education is important as the employment of graduate students is one of the most frequently used types of interaction between firms and universities (Schartinger et al., 2001). Moreover, ideas for new business are often formed during university education (Åstebro et al., 2012) and entrepreneurship education can be used to support business entry (Gartner et al., 1992). Despite its importance, it has received least attention in the utilization debate.
- *New venture support* entails directly supporting the creation of university spin-offs in the form new ventures (Mueller, 2006; Rothaermel et al., 2007). University research is commercialized by building a new business from scratch (Clarysse and Moray, 2004). Uninhibited by past structures, start-ups are able to generate radical innovations, introducing new products or even creating entirely new markets (Audretsch, 1995). Supporting the creation of new ventures is important as

building a new organization requires specific resources (Rothaermel and Thursby, 2005a) and entails entrepreneurial learning processes (Scillitoe and Chakrabarti, 2010; Wang and Chugh, 2014). Both can be supported by the university (McAdam and McAdam, 2008).

- *University-industry interaction (UII)* entails the knowledge transfer and research support relationships of universities, primarily with existing industry (Santoro and Chakrabarti, 2002). Established firms have the resources and market power to make radical innovation successful (Chandy and Tellis, 2000), but are often inhibited by their own existing routines (Becker, 2004) and internal inertial forces (Hannan and Freeman, 1984). UII is important, since after venture creation start-ups still need access to resources such as specialized equipment, knowledge, social capital and legitimacy that are crucial for firm survival (Van Weele et al., 2013). Interacting with universities can provide access to these resources (Santoro and Chakrabarti, 2002; Van Rijnsoever et al., 2014).

3. Methods

3.1. Description of the case

We study USUI around clean-tech in the greater Boston area in Massachusetts, or as it is informally known: 'Route 128'. Clean-tech consists of "*a diverse range of innovative products, services and solutions that optimize the use of finite and renewable natural resources for long-term commercial and environmentally sustainability."* (Ernst & Young, 2011 p. 6 in; Davies, 2013). Clean-tech increasingly receives attention from both politics and academia (Caprotti, 2012) and is considered an area where knowledge utilization and innovation is necessary (June and Fargo, 2013). Furthermore, this industry includes a wide variety of societal actors and scientific disciplines that serve a common objective, making clean-tech a typical 'Mode 2' technology (Gibbons et al., 1994). Altogether, clean-tech is an outstanding empirical example to study USUI.

Massachusetts is the leading US state on clean-tech policy, having strong regulations mandates and powerful incentives in place for clean-tech development. The region is known for clean-tech leadership in early-stage technology-based firm development combined with a high capital attraction. Particularly the Boston area shows a high density of high-tech oriented start-ups, active in the clean-tech industry (June and Fargo, 2013), and also offers a large diversity of universities that show continuous interest in the clean-tech industry (June and Fargo, 2013). This includes top universities such as Harvard and MIT, but also smaller universities such as Babson College and Olin College. These dynamics make the Boston area a suitable location to study.

3.2. Data, data collection and measurements

The primary data for this study were acquired by means of conducting 36 semi-structured interviews on site, which enabled the researchers to gather in-depth information and created the possibility for further clarification and explanation of concepts. The interviews took 40 minutes on average.

Data were gathered among entrepreneurs (12), university representatives (10), incubator managers and other stakeholders (14) that are considered experts in the field of new firm creation and university-industry interaction (such as incubator managers, managers of accelerator programs, etc.). The sample was collected using web-queries, formal and informal introductions and referrals from earlier interviews. To increase the likelihood of theoretical saturation, the sample includes representatives from start-ups in different development stages of maturity, representatives from different universities in different function and also a large variety of other stakeholders.

Three types of interview schemes were used; one for the entrepreneur, one for university representatives and one for incubator managers and other stakeholders. The interviews were structured as follows. First, several background questions were posed. Entrepreneurs were asked to give a small introduction on themselves and their firm. Representatives from universities and incubators were asked to give a small introduction and to define their main purpose and core-activities. Secondly, the interviewees were asked to define if and why interaction takes place between the actors, from their own perspective. This interview section aimed at deriving an oversight of the organizational activities that benefit from USUI, and the by USUI acquired resources, according to the categories distinguished in the theory section. Further questions aimed for a more in-depth understanding regarding the methods used for interaction, the formal characterization of interaction, the interaction frequency and how the interaction was established. In conclusion, the interviews focused on the conditions in which USUI is successfully deployed. The interview scheme was refined and updated if new concepts or information surfaced during previous interviews. All interviews were digital recorded and literally transcribed. Data was collected until theoretical saturation was achieved, meaning no new concepts emerged (Glaser and Strauss, 1967).

3.3. Data Analysis

Prior to coding and analysis, a distinction was made between data from entrepreneurs, university representatives and third party representatives. After the differentiation, qualitative coding was used to analyze the data.

An inductive approach was used to analyze the data, but the connection between data and theory has been constantly monitored using the coding process of Corbin & Strauss (1990). In doing so, cross-actor patterns could be discovered.

Accordingly, the data coding process was divided into three phases. The 'open coding' phase was used to break down the data analytically. In this phase, concepts where identified and labeled, which led to the identification of the USUI practices. Through 'axial coding', objectives for collaboration, the resources shared and the utilization mechanism at work, as clarified in the theory section, where related to the practices. Through 'selective coding', these categories were merged and further refined, allowing for the identification of trends within USUI at a higher aggregation level. Using NVIVO, a qualitative analysis software program that is designed for systematic analysis of qualitative data, coding and data analysis was carried out. NVIVO records all methodological steps taken and all handlings can be traced back, minimizing the researcher's personal bias. Moreover, during the entire process we compared our results to what is already known from the current academic literature.

4. Results

We first discuss the context of the Boston start-up ecosystem related to USUI. Next, we identify the USUI practices. Finally, we relate the practices to our theoretical categories.

4.1 The Boston start-up ecosystem

The Boston start-up ecosystem is not as renowned as Silicon Valley, though it generated a diverse set of start-ups with hundreds of millions of dollars revenue in software, life sciences, robotics and materials industries (Marmer et al., 2012). These successful start-ups are located in the vicinity of universities that supply talent and knowledge to the clusters. In addition there are a lot of different programs and facilities that aim towards supporting a specific stage of start-up development (Business

plan, prototyping, manufacturing, etc.). This gives entrepreneurs an extra incentive to found their business in Boston. In addition, the interviews revealed that the culture of "forward paying" enables the founding of successful companies from the large pool of nascent entrepreneurs in the area. Actors in the ecosystem support start-ups, but it is expected that when these start-ups become successful companies they show their gratitude for this support. This culture supports USUI, as Boston universities build on this assumption when while supporting (donating time and money) entrepreneurs. Upon being successful, the entrepreneur can return the favor by becoming a mentor for new start-up or by giving a financial donation.

4.2 Identifying USUI practices

In total we identified 14 USUI practices. These are discussed below:

1. Entrepreneurship case studies comprise the invitation of start-ups into the university classrooms to talk about and study- real-life business problems. Hereby, new knowledge on strategies in specific business situations is generated.

Start-ups benefit as entrepreneurship case studies allow for a 'community of practice' (Wenger, 1998) to occur, in which start-ups acquire business knowledge in support of business concept development, organization creation, product development, customer outreach and customer feedback.

Universities, on the other hand, also receive business knowledge as start-ups offer state-of-the-art empirical data. The knowledge generated is used directly to shape entrepreneurship education. Therefore, the subject material is considered as 'shaped at the frontier' and adds to the universities' credibility in training entrepreneurs. Moreover, universities acquire social capital through entrepreneurship case studies, as this 'service' to entrepreneurs is nourishing alumni networks.

2. Engineering & scientific case studies entail university-start-up collaborations such as capstone projects or other scientific projects with direct student involvement. These projects aim at solving technical problems for start-ups, while the students involved earn course credit at the university.

Start-ups acquire technical or scientific knowledge as students work on technology or product related problems, contributing to the technology development and product development of the firm.

In return, university staff and students acquire technical or scientific knowledge, while working with state-of-the art technologies. Moreover, they gain insights in "the business side of things" (Professor), due to the start-up's commercial orientation. As such, the practice adds to training academics, training high quality workforce, and performing applied research. Moreover, being 'involved' with state-of-the-art technologies yields credibility in performing collaborative research with high-tech industry, which favors performing applied research.

3. Hiring graduates refers to the hiring of (specialized) graduate students by start-ups and is one of the most frequently used USUI practices by start-ups.

Start-ups receive human capital by hiring graduates, who may carry business knowledge, technical or scientific knowledge, direct links with the university (social capital) and university degree that grants the firm credibility. Start-ups allocate business knowledge to business concept development and organization creation, whereas technical or scientific knowledge and network support technology development and product development. Credibility is used as an asset in fundraising, which is in favor of all core-activities.

Meanwhile, universities acquire social capital as their network expands by including new start-ups. Moreover, universities earn credibility as they deliver a suitable education, which is an argument used to attract new students and evidence that they train a high quality workforce.

4. Product development courses aim at solving real-life problems and bring students from different disciplines together by building a functional and marketable product in class. Some of these project groups start a new company based on their work in class. Therefore this practice facilitates opportunity recognition. Second, the project group is a first human capital base for the start-up to draw from. During the course, the (pre) start-up is offered workspace and tools (physical capital), business knowledge and technical or scientific knowledge by professors and experienced entrepreneurs. This adds to business concept development and organization creation. Moreover, the acquired technical or scientific knowledge is helpful to technology development and product development in the start-up. Finally, originating from a university gives the start-up credibility with stakeholders like investors.

Again universities can expand their network (social capital) with new entrepreneurs and gain credibility from successful start-up. Overall, they strengthen the core–activities to train a high-quality workforce and entrepreneurs.

5. Entrepreneurship courses entail the transfer of knowledge on developing a business through class and action based learning. Students receive course credits while working on a business plan, allowing them to concentrate on both their education and founding a company. Therefore, this practice entails both education and new firm mechanisms

In some cases, start-ups are formed during entrepreneurship courses, and benefit directly from the availability of human capital and business knowledge present in the classroom. Moreover, credibility is earned through the affiliation with the university. These resources contribute to opportunity recognition, business concept development, organization creation and product development.

Universities benefit as the constant application of entrepreneurship theories in practice creates opportunity to study best practices at their core, and generate business knowledge. Furthermore, universities enlarge their social capital and gain credibility. The practice reinforces universities in training entrepreneurs, and entrepreneurship support.

6. Internships mean the participation of university students in start-ups as interns

Internships enable start-ups to hire high quality human capital against relatively low costs. Interns fulfill roles in both entrepreneurial and engineering assignments, depending on their training at the university. As such, the core-activities technology development, product development, customer outreach and customer feedback are supported.

Through internships, universities that supervise the student interact with the start-up and acquire tacit technical or scientific knowledge and business knowledge, as well as network contaxts. This increases their students' value on the labor market. Second, it enables future academics to better contribute to the activity of performing applied research. Last, internships at start-ups provide credibility to the university as it demonstrates that their graduates do relevant work. Therefore, internships adds to the training of academic professionals, high-quality workforce and entrepreneurs, performing applied research and research commercialization.

7. Competitions refer to business competitions for start-up teams at universities.

With competitions, universities allocate mentors to the competing start-ups that coach the teams. These mentors often have experience in business and are therefore considered a valuable source for transferring business knowledge. This is an important aid to start-ups in business concept development and product development. Furthermore, working with mentors may give access to a network, which has

shown to be helpful for later fundraising and to speed up product development. Last, competitions elect winners and finalists that are compensated financially and announced publicly. This gives start-ups financial capital, and credibility that aids with raising more funds.

Through competitions, universities gain social capital and credibility, as they connect with start-up teams that reflect the technological and entrepreneurial abilities of the university. Consequently, students become encouraged to start their own business or take entrepreneurship classes, creating a support base for training entrepreneurs and entrepreneurship support.

8. Mentor service provided by universities,, entails the long term appointment of voluntary individuals (mostly experienced entrepreneurs or alumni) to start-ups.

Start-ups benefit from the professional experience of the mentors and their professional network, as they have access to technical or scientific knowledge, business knowledge and social capital. Mentor time is mainly spent on coaching for business concept development and organization creation. To a minor extent, mentors help to solve technical problems and contribute to technology development and product development. Finally, the mentors' network indirectly provides access to expert knowledge or introductions to first customers.

Universities engage in this practice because of the social capital gained through working with both the start-ups and mentors. Furthermore, the establishment of a successful mentor service can draw attention and be a source of credibility towards nascent entrepreneurs. Both can attract mentoring volunteers, reinforcing the activities of training entrepreneurs and entrepreneurship support.

9. Incubation covers the services provided by the university to launch new start-ups.

Through the university incubator, start-ups have a place to work (physical capital), which contributes to the physical organization creation. Second, most universities have funding available for their incumbents, providing start-ups with the financial capital required for the production of prototypes, aiding product development. Third, incubated start-ups may enroll for classes and incubator staff may also provide business knowledge. The staff may also connect the start-ups with important contacts, expanding the start-ups' social capital. Last, the relationship with the university gives the start-ups credibility, which may be helpful in later fundraising.

In terms of benefits, universities gain social capital and credibility from the incubated start-ups., The facilitation of entrepreneurship teams brings together students from different schools, benefitting the social cohesion within universities. Second, universities gain credibility for their abilities to promote entrepreneurship, which attracts new (entrepreneurship) students. This complements on the universities entrepreneurship education and creates a basis for entrepreneurship support.

10. Collaborative research refers to the collaborative research between universities and start-ups, including, renting out lab space and specialized equipment possibly against a fee.

Collaborative research provides start-ups with university owned lab space and specialized equipment, which type of physical capital is scarce to them. Furthermore, start-ups acquire technical or scientific knowledge through collaborative research. University researchers can also join firms for a longer period of time, as an employee, to carry out research. This allows for more hands on transferring of university knowledge, and add to human capital**.** These resources benefit the technology development of start-ups, or may clarify whether a technology has real commercial value (opportunity recognition). Moreover, collaborative research is a source of credibility as the expertise of the university is reflected on the start-up.

For universities, collaborative research is a means to acquire financial capital through research funding or renting out physical capital. In addition, collaborative research allows universities to acquire technical or scientific knowledge. Moreover, the collaboration expresses researchers expertise in a

specific discipline and thus provides credibility. Which helps attracting additional funds. This practice strengthens performing applied research and contributes to research commercialization.

11. Academic consulting is when university staff provides direct advice or expertise to the start-up. In addition it comprises providing network opportunities. As such, academic consulting allows universities to train students outside the curriculum in a highly goal-oriented manner.

The university staff is thus an external source for business, technical or scientific knowledge and to some extent social capital and credibility. These resources can be used to improve business concept development, organization creation, technology development and product development.

Consulting may be free for start-ups if it is considered a small service for the staff. If consulting requires more time, the university may ask a financial compensation. In addition academic consulting contributes to social capital and credibility of academics. Overall, academic consulting contributes to training a high-quality workforce, training entrepreneurs and research commercialization.

12. Donating is the act of giving resources away for free, as a sign of gratitude or encouragement.

In this way, universities supply start-ups with financial capital and physical capital, such as a small fund to further develop a technology (technology development) or old furniture for an office space (organization creation). Donation is an important USUI practice in the culture of "paying it forward"; there is reason to providing an act in return.

The entrepreneurs supported by the university often want to return the favor. Based on this practice, universities acquire financial capital and other offers from experienced and successful entrepreneurs, such as volunteer work as a mentor (human capital). Donations are also a source for credibility of the university to support entrepreneurship. These donated resources are mostly employed to support start-ups through other USUI practices, such as incubation, mentor service and competitions. Therefore, donation strengthens training entrepreneurs and entrepreneurship support.

13. Licensing is a USUI practice to support the protection and commercialization of intellectual property (IP).

Licensing contributes to opportunity recognition in start-ups as the knowledge it protects forms the basis to start a business. Moreover, when licensing a technology, it was not uncommon for universities to supply the founding researchers with funding (financial capital) to spin-off and further develop the licensed technology for commercialization (technology development). Last, patents were seen as source of credibility to start-ups, as it is a mark of originality of a technology.

As licensing IP is costly, the universities see gap funding as an investment. Most universities own the IP, receive some sort of financial reimbursement (financial capital) when start-ups generate profit, which universities can allocate to entrepreneurship education and entrepreneurship support: we set aside 30 percent of any revenues that flow back to for the inventor pool." (Professor). Moreover, having licensed successful companies provides universities with credibility for their ability to commercialize knowledge.

14. Piloting refers to the activity of universities to provide start-ups with a pilot site for their product, usually the campus.

Start-ups acquire financial capital through piloting, as the university becomes the first customer of their technology. This allows the start-up to test its products behavior and durability in real life, and to interact with lead consumers (students and staff), providing technical or scientific knowledge and market knowledge. Moreover, they can test their business model.. Through multiple iterations piloting contributes to business concept development, customer outreach and customer feedback. Furthermore,

having a university as customer increases the credibility of the start-up, and may be used as an argument in fundraising.

With these new technologies on campus, universities may also gain financial capital by contract. Moreover, the visibility of being an test bed for innovations provides credibility, which will generate support for entrepreneurship support. Given that we studied cleantech start-ups, we also found that campus sustainability offices value the new technologies to establish a "green" campus culture.

The practices listed are diverse and cover all three utilization mechanisms. Some are already well known from the literature. However, less attention has been paid in the context of the knowledge utilization debate to education practices like internships. We did not find any evidence for post graduate education practices such as professional workshops or courses taught at the work place as USUI practices (Rahm, 1994). The reason for this is that the entrepreneurs were often students or recent graduates of the university, which lowers the need for post-graduate teaching.

The interviews also presented some difficulties regarding successfully implementing USUI practices. In line with findings on UII (Kaufmann and Tödtling, 2001), the major barrier for USUI is that universities and start-ups operate at different paces. While universities strongly focus on generating accurate knowledge and take time in doing so, start-ups have shorter time-cycles and are more application oriented. When actively collaborating, this difference between both actor types implies different work speeds. Combined with a large overhead, universities may therefore become a too costly partner for start-ups if any payment is involved. Moreover, some universities viewed interacting with start-ups as problematic, because their dynamic nature made it difficult to establish a long-term relationship.

4.3 Relating USUI practices to resources, objectives and activities

In Table 1 we categorize each USUI practice per utilization mechanism, associated resources and the objectives and activities to which it is related. 'x' indicates that a concept is associated with a practice. Higher categories of theoretical aggregation are given in bold, if a concept is present at the lower level, then it is also present at the higher level.

USUI Practices	**Knowledge Utilization Mechanism**			**Resources acquired by start-ups**										**Objectives & core-activities of start-ups**									
	Education	**New venture support**	**University-Industry Interaction**	Financial capital	Human capital	Physical capital	**Tangible resources acquired**	Business knowledge	Technical/scientific knowledge	Market knowledge	Social capital	Credibility	**Intangible resources acquired**	Opportunity recognition	Business concept development	Organization creation	**Organization development**	Technology development	Product development	**Technology & product development**	Customer outreach	Customer feedback	**Market development**
Entrepreneurship case studies	**x**							x					**x**		x	x	**x**		x	**x**	x	x	**x**
Engineering & scientific case studies	**x**								x				**x**					x	x	**x**			
Hiring graduates	**x**				x		**x**	x	x		x	x	**x**		x	x	**x**	x	x	**x**			
Product development courses	**x**	**x**			x	x	**x**	x	x			x	**x**	x	x	x	**x**	x	x	**x**			
Entrepreneurship courses	**x**	**x**			x		**x**	x				x	**x**	x	x	x	**x**		x	**x**			
Internships	**x**		**x**		x		**x**	x	x	x	x		**x**					x	x	**x**	x	x	**x**
Competitions		**x**		x			**x**	x			x	x	**x**		x		**x**		x	**x**			
Mentor service		**x**						x	x		x		**x**		x	x	**x**	x	x	**x**			
Incubation		**x**		x		x	**x**	x			x	x	**x**		x	x	**x**		x	**x**			
Collaborative research			**x**		x	x	**x**		x		x	x	**x**	x			**x**	x		**x**			
Academic consulting			**x**					x	x		x	x	**x**		x	x	**x**	x	x	**x**			
Donating			**x**	x		x	**x**	x				x	**x**			x	**x**						
Licensing		**x**	**x**	x			**x**		x			x	**x**	x			**x**	x		**x**			
Piloting		**x**	**x**	x			**x**		x	x			**x**		x		**x**		x	**x**	x	x	**x**

Table 1a: USUI practices by knowledge utilization mechanism, resources, and objectives & core activities for start-ups. Higher levels of theoretical aggregation are given in bold. 'x' indicates that a concept is present. If a concept is present at the lower level, then it is also present at the higher level.

USUI Practices	Knowledge Utilization Mechanism				Resources acquired by universities									Objectives & core-activities of universities								
	Education	**New venture support**	**University-Industry Interaction**	Financial capital	Human capital	Physical capital	**Tangible resources acquired**	Business knowledge	Technical/scientific knowledge	Market knowledge	Social capital	Credibility	**Intangible resources acquired**	Training academics	Training high-quality workforce	Training entrepreneurs	**Education**	Performing fundamental research	Performing applied research	**Research**	Research commercialization	Entrepreneurship support	**Utilization**
Entrepreneurship case studies	**x**							x			x	x	**x**			x	**x**						
Engineering & scientific case studies	**x**								x			x	**x**	x	x		**x**		x	**x**			
Hiring graduates	**x**										x	x	**x**		x		**x**						
Product development courses	**x**	**x**									x	x	**x**		x	x	**x**				x		**x**
Entrepreneurship courses	**x**	**x**						x			x	x	**x**			x	**x**					x	**x**
Internships	**x**		**x**					x	x		x	x	**x**	x	x	x	**x**		x	**x**	x		**x**
Competitions		**x**									x	x	**x**			x	**x**					x	**x**
Mentor service		**x**									x	x	**x**			x	**x**					x	**x**
Incubation		**x**									x	x	**x**			x	**x**					x	**x**
Collaborative research			**x**	x	x		**x**		x		x	x	**x**	x			**x**		x	**x**	x		**x**
Academic consulting			**x**	x			**x**				x	x	**x**		x	x	**x**				x	x	**x**
Donating			**x**	x	x		**x**				x	x	**x**			x	**x**					x	**x**
Licensing		**x**	**x**	x			**x**					x	**x**								x	x	**x**
Piloting		**x**	**x**	x			**x**					x	**x**									x	**x**

Table 1b: USUI practices by knowledge utilization mechanism, resources, and objectives & core activities for universities. Higher levels of theoretical aggregation are given in bold. 'x' indicates that a concept is present. If a concept is present at the lower level, then it is also present at the higher level.

Based on Table 1a we focus on the benefits that start-ups receive from USUI. To start-ups, all three utilization mechanisms offer both tangible and intangible resources. For education the only tangible resource that is transferred is human capital, while new venture support gives financial and physical capital. UII practices involve all three types of tangible resources. For intangible resources it is clear that universities can transfer these to start-ups through all USUI practices. This result can be explained by the fact that knowledge as key-resource from universities is intangible and associated with all these USUI practices.

Organization development is supported by all practices except engineering & scientific case studies, and internships; both come from education. There is thus a strong focus on organization development, albeit some practices contribute to this process through opportunity recognition, which is the very first stage of the organization development process. Universities also contribute strongly to technology & product development. All education practices contribute to this objective, and most other USUI practices do as well. Only donating does not. However, when it comes to market development, only a few USUI practices actually contribute this process. Even though market development is according to some, the most important objective for a start-up (Ries, 2011; Blank, 2013), universities do not seem to have many ways to promote this. This is likely because market development is not part of the core competences of university. A notable and creative way in which the university can contribute to this is piloting, which allows universities to be a test-bed for new products. It is not possible to do this for all products, but it can contribute to market-development for some start-ups. More indirectly mentors can create awareness and give credibility that help with market development.

The university also receives benefits from USUI (Table 1b). Notable is that education practices do not directly result in the return of any tangible resources, nor do practices that are solely based on supporting new ventures. However, these practices provide social capital to the universities, which in turn contribute to the practice of donating. This provides financial capital and human capital for universities. Here, the ecosystem characteristic “paying it forward” is important, as it is the main reason for donating to exist. Moreover, the diversity of support within the ecosystem allows universities to receive financial and human capital from a variety of industries.

Universities only gain tangible resources from USUI practices through UII practices. This can be explained by the fact the start-ups often have limited tangible resources themselves. However, all practices do contribute to the intangible resource base of the university, primarily through credibility and building social capital. Both resources are important for gaining access to tangible resources like government grants (Van Rijnsoever et al., 2014). Universities gain in some instances business knowledge from start-ups, but surprisingly no market knowledge is gained. The business knowledge can be used to enrich the teaching curriculum. As such, the education objectives benefit from all USUI practices except from licensing and piloting. However, it should be noted that it is mostly the entrepreneurship education that benefits. Research on the other hand has little association with USUI practices. There are examples that research benefits from education and UII, but not from new venture support. Moreover, only applied research is strengthened. If the objective of the university is indeed solely to strengthen its scientific credibility (Latour and Woolgar, 1979) then interacting with start-ups seems to offer limited potential. Finally, USUI practices do directly contribute to the knowledge utilization objective, especially all practices from new venture support and UII. Education in this context does not always contribute to knowledge utilization, but the knowledge the graduates receive during education can later be applied in society. As such, the knowledge utilization through educations is also an indirect process.

5. Conclusion and discussion

This research aimed to identify USUI practices and how universities and start-ups use these practices to achieve their objectives. Second, we studied when the USUI process is mutually beneficial in terms of resources to both actor types. To this end we identified 14 USUI practices, we categorized the resources that are transferred through these practices and looked at how these practices contribute to the objectives of both start-ups and universities. By taking the perspectives of both start-ups and universities into consideration, we recognize that both are involved in the process. By relating resources to objectives and activities we learned why USUI takes place. Thereby this study has given insights into the micro incentives of USUI. It is evident from results that the USUI concept is different from conventional university-industry-interaction (Perkmann et al., 2013), because start-ups need different resources than large firms (Ries, 2011). We summarize the following conclusions and their implications:

- We found that USUI is largely based on intangible resources. These are often important for gaining a competitive advantage as they are more likely to be rare and inimitable (Amit and Schoemaker, 1993). However, their presence and thus their added value is hard to quantify, which makes it difficult to see the use of USUI practices. Within an ecosystem with a culture of "paying it forward" and high diversity, universities do transfer crucial tangible resources to the start-ups, with the hope that the favor will be returned in the future when the start-up has matured, for example in the form of contributions to education programs or even financial donations. However, indicators need to be developed that allow better measurement of the added value of each of the practices. This is an avenue for further research.
- The resources that the university transfers to start-ups mostly related to organization and product development, but little to market development. If universities wish to strengthen their venture support activities then strengthening market development is an opportunity that might be worthwhile to pursue. Universities are taking-up this challenge by incorporating market development in their programs, for example by following the lean start-up method (Ries, 2011; Blank, 2013). Further, using the university as pilot place for new ventures is one interesting avenue. However, start-ups that have a product that does not benefit from the technical or scientific knowledge or credibility from universities should consider carefully the added value being involved in start-up support programs that originate from the university. Support programs that originate from corporations or independent programs might better fit their needs. Using our results, future research needs to look at the decision of start-ups to engage in USUI practices in comparison to other start-up support mechanisms or working with other actor types.
- Universities can mostly strengthen their education programs through USUI, specifically those related to entrepreneurship. Also the knowledge utilization objective benefits from USUI. This means that the USUI practices largely provide resources that reinforce themselves. However, there are no clear links to fundamental research, which many universities value as their core activity and which is the source of much scientific credibility (Latour and Woolgar, 1986). Universities with a strong focus on fundamental research thus have less incentive to engage in USUI practices than those that focus more on application. The lack of a strong connection between fundamental research and USUI practices is not a direct problem since USUI partly reinforces itself and caters to the demand of students that have a more practical orientation. However, if the aim of USUI practices is also to strengthen the fundamental research activities, then practices should be invented to bring the world of starting new ventures and fundamental research closer together. Policy makers can catalyze this process by providing incentives for universities to develop fundamental knowledge in collaboration with start-ups. An example of this is the SBIR-scheme in the United States. Future researchers need to focus attention on under what conditions researchers from universities are likely to engage in USUI practices. The list of resources and objectives provided here can serve as input for such a study.

This leads us to draw the overall conclusion that whether USUI is beneficial largely depends how organizations value their different objectives. Science based start-ups are more likely to benefit from USUI, while start-ups close to market might be better off with other support programs. Universities with a strong focus on fundamental research benefit less from USUI than universities that are more diverse, applied or that have strong focus on teaching and knowledge utilization.

There are a number of limitations that should be taken into account. First, the use of the Resource Based View perspective for the theory and data analysis resulted in a clear overview of the exchange of resources and of the potential of benefits universities and start-ups can create through collaboration. However, the framework ignores the conditions for successful interactions or implementation requirements to benefit from the resources. This may be a consideration for future research.

Secondly, universities are heterogeneous in their orientation towards the knowledge utilization objective (D'Este and Patel, 2007; Perkmann et al., 2013). According to Göransson (2009) a countries history influences the role of universities beyond teaching and research. Respectively, the objectives will vary strongly based on the location of universities (Göransson, 2009), and affect the pattern of USUI. Moreover, we noticed that characteristics of the ecosystem influence the viability of USUI, as we have seen with the characteristics "paying it forward" and diversity. Therefore, the findings of the study should be placed into its context when deriving theoretical and practical implications.

Furthermore, the sample was taken among start-ups in the clean-tech industry. As the results show that the high-tech character of the clean-tech start-up and the resource base of universities shape USUI, the interaction between universities and start-ups that have a different industry orientation (such as Information Technology or Life Sciences) is likely to entail different resource exchange patterns. Future research may focus on the interactions between universities and these types of start-ups.

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