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A Competence Set Approach and the Universities

Human Spare Parts Industry as an Illustrative Case

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Abstract

Over time, the role of universities has evolved from a traditional focus on education and research to active participation in economic development processes. Accumulating empirical evidence shows that universities contribute to economic development in a variety of ways at all levels. This paper argues that the roles universities play in economic development and innovation processes depend on the innovation ecosystems they are embedded into, as well as the transformation processes occurring in them. Consequently, instead of solely focusing on patenting, licensing and/or new business formation, both innovation policy and universities would benefit from a more nuanced strategic awareness of the trajectories along which industries evolve and the innovation processes that shape these trajectories unfold. This paper suggests that to truly understand how industries evolve and change and how universities contribute to their transformation, there is a need to focus on an entire innovation ecosystem, and analyse interacting and conflicting competencies that either enhance or hamper transformation processes. It is believed here that a competence set is the core of any innovation ecosystem, but it is also believed that different competencies are manifested in a variety of ways depending on the nature of the specific innovation ecosystem and related industries.

This paper sets to construct a focused model of innovation ecosystems that is based on competence sets, and elaborate the key concepts and the theoretical framework related to them. First, the concept of innovation ecosystem is briefly taken under scrutiny. It serves the analysis as a guiding metaphor, providing the study with an overall understanding of the organic and continuously evolving nature of relationships between main competencies and between actors and their environment. Second, the view opened by the concept of innovation ecosystem is complemented and specified by a scrutiny of competence sets, the aim being to construct such a conceptual framework that serves future empirical analyses. Third, the human spare parts industry is used to highlight the competence set model.

1 Introduction

1.1 Background and rationale

Over the past two decades, universities have increasingly been seen as the core instruments of local, regional and national economic development. All this seems new and fresh thinking but, in practice, many universities have been involved in industrial and societal development for a long time and, in some places, the primary motivation to establish a university has been to serve economic development. The emergence of innovation policy across the globe as an increasingly visible form of public policy has hoisted the role of universities. This may be a result of the observation that, as many traditional industries have been hollowing out, and as many local economies have been losing their leading firms, the university often emerges as one of the few solid and locally rooted resources to draw upon (Lester 2007). Simultaneously, there is an increasing understanding that innovation systems and policies need to be customized to better serve the needs of the country or region in question (Tödtling and Trippl 2005; Sotarauta and Kosonen 2013).

Lester (2007, 1) crystallizes the increased need to innovate by arguing that “the vigor and dynamism of local economies depend on the ability of local firms to adapt to changing markets and technologies by continually introducing commercially viable products, services, and production processes – that is, by innovating successfully”. He quite correctly reminds us about the importance of strategic adaptation (Sotarauta and Srinivas 2006). As Lester (2007, 15) puts it, “not all economies adapt to global economy with equal success, as the adaptive capacity depends on the capabilities of many organisations to take up new technological and market knowledge and to apply it effectively”. By now, it has become a well-known fact that most breakthrough innovations, and new businesses, are not created in isolation but through collaborative arrangements that enable organizations to combine knowledge from many sources and thus also integrate their individual offerings into coherent solutions. Strategic adaptation is an interactive process. Inspired by these observations, the number of studies focusing on different kinds of innovation (eco)systems has mounted during the past 25 years (see Fagerberg, Fosaas, and Saprasert 2012).

This paper continues the work that began in the Local Innovation System project in which the focus was on local capabilities for innovation (Lester 2007). Capabilities for innovation refers to the ability to conceive, develop and/or produce new products and services, to deploy new production processes, and to improve on those that already exist. Here, the focus is on ecosystems and competence sets. The competence set model, being rooted in Eliasson’s (2000) competence bloc theory, is used to specify the generic framework by focusing on the competencies needed in innovation ecosystems. The competence bloc theory is a useful conceptual construction for an understanding of embryonic innovation ecosystems and indigenous emergence of new industries, as this is exactly what it was designed for in the first place. It may, however, offer a limited conceptual toolkit for the study of other types of innovation ecosystems, and therefore it is here extended to cover additional competencies compared to the original theory. For the sake of clarity, the new conceptual construction is labelled competence set instead of competence bloc. In line with its predecessor, the competence set model focuses on the minimum set of actors with adequate competencies required in innovation, business growth and economic renewal (Eliasson 2000).

Universities are among the most important sources of highly educated people and new ideas that are universally called for in the knowledge economy. However, the overall economic significance of universities as sources of new business and innovation is often exaggerated. In practice: (a) most well-known cases of successful companies (Google, Cisco, etc.) directly related to universities are more atypical than typical examples; (b) business formation around university science and technology is a small fraction of the total rate of new business starts; (c) universities are a minor contributor to the overall stock of patented knowledge; and (d) most of the universities are not deriving significant financial benefits from technology transfer (Lester 2007). The economic significance of universities is high but more versatile than what has been acknowledged by many of the policymakers. For these reasons this paper suggests that to truly understand the economic role of universities in economic transformation, we need to study it 'outside in', through economic trajectories of different types of innovation ecosystems and by focusing on generic competencies called for in these processes.

This paper is based on the conceptual development and first empirical observations of the on-going research project 'Innovation Ecosystems, Leadership and Innovation Policy', funded by the Finnish Funding Agency for Innovation (Tekes). It has set out to construct a focused model of innovation ecosystems that is based on competence sets and elaborate the key concepts and the theoretical framework related to innovation ecosystems. First, the concept of innovation ecosystem is briefly taken under scrutiny. It serves the analysis as a guiding metaphor, providing the study with an overall understanding of the organic and continuously evolving nature of relationships between main competencies and between actors and their environment. Second, the view opened by the concept of innovation ecosystem is complemented and specified by a scrutiny of competence sets, the aim being to construct such a conceptual framework that serves future empirical analyses. Third, the human spare parts industry is used to highlight the competence set model. The main scientific motivation is to open a focused view on innovation ecosystems and universities' roles in them by using the concept of competence set as an intermediating framework.

1.2 Illustrative case: The emergence of the human spare parts industry in Tampere[1]

The emerging regenerative medicine concentration in Tampere and the prospective Finnish human spare parts industry is used to highlight the conceptual discussion. The term regenerative medicine was coined in 2000 and is now widely used to describe biomedical approaches to healing the body by the stimulation of endogenous cells to repair damaged tissues or the transplantation of cells or engineered tissues to replace diseased or injured tissues (Riazi, Kwon, and Stanford 2009; see also Lysaght, Jaklenec, and Deweerd 2008; Mason and Dunnill, 2008b). The basic unit in regenerative medicine is a stem cell. Stem cells are biological cells found in all multicellular organisms. The potential of stem cells in clinical treatments is based

[1] Based on Sotarauta & Mustikkamäki (forth.)

on their multipotent ability. Stem cells are able to regenerate tissues and organs and act as building blocks for all tissues in the body (Nordforsk 2007; National Institutes of Health 2010). Regenerative medicine has grown rapidly in the past decade and the scientific achievements have created hopes of new treatments for severe incurable diseases, such as diabetes, Parkinson's disease, cancer and heart diseases. The promise of regenerative medicine is very exciting but simultaneously the cost of product development, and most notably clinical trials, for the high-end applications is very high (Mason and Dunnill 2008a, 351). The term 'human spare parts industry' is a metaphor that describes the potential embedded in regenerative medicine. For example, the City of Tampere has launched a vision that Tampere will become the center of human spare parts in Finland.

In a way, the case of regenerative medicine in Tampere is a fairly straightforward one; the universities have introduced a new technology and now it should be commercialized. We even might be able to argue that the Universities in Tampere are well positioned in the emergence of a new industry: human spare parts. But, this is not the full picture – not all the competencies are in place yet. The promise of regenerative medicine is very exciting as it may in the near future introduce a fourth form of healthcare industry beside medical devices, pharmaceuticals and biopharmaceuticals (Mason and Manzotti 2009, 783).

2 Innovation ecosystem

The rapidly mounting literature on innovation systems, and various variants related to it, have significantly increased our understanding of the ways new knowledge is generated, diffused and valorized to produce economic and/or social significance in different times and places (and thus also about the roles universities play in the innovation puzzle). The concept of an innovation **eco**system instead of that of an innovation system is used here, the aim being to complement the relatively established focus of (national, regional, sectoral) innovation system studies that primarily address organizations (actors as components of systems), rules of the game (institutions), interaction patterns (networks), innovation activities, knowledge flows and recently also knowledge bases (see, e.g., Asheim and Gertler 2005; Asheim and Isaksen 2002; Braczyk, Cooke et al 1997; Lundvall et al. 2002; Sternberg et al 2010). As Adner (2006) puts it, ecosystems, if they work well, allow firms to create value that no single firm could have done only by itself. However, as Adner (2006) also reminds us, innovation ecosystems also present new sets of risks for many firms. New interdependencies change the landscape in which firms and other actors are embedded, and all this can cause increased uncertainty and generate surprises, as ecosystems are not static and mechanical but constantly evolving organic entities. According to Adner (2006), managers tend to overlook the ways ecosystems emerge and change all the time. As an ecosystem is an organic and constantly evolving entity, actors cannot position themselves as strategically as believed earlier but they need to coevolve with their ecosystem.

As observed by Papaioannou et al (2009), "ecosystems evolve through adaptation of living organisms to their environment". They argue further that this means that there is no need for external intervention as ecosystems have an internal dynamic that reproduces the interrelations between different actors and their environment. Therefore, in this study, 'the university' is not defined as something external to an innovation ecosystem but something that is embedded into it as one of the 'living organisms'. From an innovation policy perspective, this view is supported by the empirical observation that the borderline between policy making, firms and other actors has been blurring, suggesting that universities are not the only beneficiaries of a policy but active members in its design (Kuhlmann 2001; Sotarauta and Kosonen 2013). Additionally, innovation ecosystems are assumed here to be multi-locational in nature and thus transnational networks, for their part, shape innovation ecosystems (cf. Crevoisier and Jeannerat 2009). Indeed, we cannot assume that all the functions and competencies of an innovation ecosystem can be found, or can be constructed, in a single location, region or sometimes even a nation.

Applying our earlier study on universities' roles in local innovation systems (Lester, 2005; Lester and Sotarauta, 2007) and self-renewal capacity (Sotarauta 2009), it is possible to categorize innovation ecosystems and their evolution as follows.

Embryonic and fragile innovation ecosystem – indigenous emergence of a new industry

- The emergence of an innovation ecosystem in a field that has no direct antecedent in the economy. It entails the creation of new capabilities and/or major transformation of existing ones to support the enlargement of an embryonic ecosystem and thus also new industry.
- This type entails an incumbent industry that has some fragments of an ecosystem around it and some functions in place, but that has not developed as a system but only as individual elements; thus, some fragmented pieces of competence blocs may exist but several pieces are missing and/or have not been tapped into internationally.

An existing innovation ecosystem adjusts to a major firm relocating or to an industry imported from elsewhere

- This type of trajectory introduces an industry that is new to the economy. The primary mechanism is the importation of the industry from elsewhere, and thus the question of whether there is an ecosystem that is ready to support the new industry becomes relevant, or whether an existing ecosystem is able to adjust itself to support new transplanted firms and thus antecedent of a wider industry.

An innovation ecosystem in transformation, diversifying into related industries

- This category refers to transitions in which an existing industry declines, but its core technologies and/or competencies are redeployed and provide the basis for the emergence of a related new innovation ecosystem and an industry stemming out of it. This also entails the upgrading and enlarging of an ecosystem through major changes in its core capabilities, and also the introduction of new actors as well as the deactivation of others.
- This category also refers to an existing technology that is exploited in new ways in other industries.

Upgrading of an innovation ecosystem to support the internal renewal of an existing industry

- This type entails the upgrading of an incumbent industry through the infusion of new technologies or product or service enhancements. It also involves customization of ecosystem capabilities to support the upgrading process.

The human spare parts industry clearly belongs to the category of embryonic and fragile innovation ecosystem. The other innovation ecosystem types are not discussed here.

3 A competence set model

3.1 A competence bloc theory and the concept of competence

The competence set model is highly inspired by the competence bloc theory (Eliasson 2000), but as the competence bloc theory was constructed mainly to better understand and explain business growth in biotechnology, it needs to be extended with additional competencies to provide an analytical tool also for analysis of other innovation ecosystem types. Before discussing the extension, the concept of competence is defined and the basic tenets of the original competence bloc theory are introduced.

It is assumed here that to better understand how universities contribute to different types of innovation ecosystems, there should be more emphasis on interacting competencies instead of interacting actors. Additionally, it is assumed, following Avnimelech and Teubal (2008), that our understanding of innovation systems, universities' roles in them and related innovation policies ought to be dynamic and systems-evolutionary by nature to effectively trigger, reinforce and sustain market-led evolutionary processes of the economy. For these reasons, the main rationale in constructing a competence set model is to: (a) specify what competencies various actors bring into play in an innovation ecosystem; and (b) identify the competencies that keep an innovation ecosystem continuously adapting to changing economic landscapes, and thus renewing economies. A sole focus on actors and relationships between them, so typical in innovation system studies, may even blur the view on how systems actually function and what drives them, and hence it is important to make a distinction between organizations and competencies. As many organizations are large and heterogeneous entities (most notably universities) and have multiple roles, and consequently also multiple goals and expectations, they may have many competencies that contribute to an innovation ecosystem. All in all, by approaching actors indirectly through competencies it might be possible to clarify and specify the roles they play in translating new knowledge to viable products and services.

In innovation ecosystems, competencies (in direct and/or indirect interaction) generate, stimulate and/or frame the overall functioning of a system and its transformation (Eliasson 2000). Additionally, it may also be the case that an innovation ecosystem as a whole, or some competencies of it, is not at an adequate level. Missing and/or poor competencies may freeze an innovation ecosystem and lock it in the past, and thus the question may not only be about lack of an actor and/or policy tool of some kind, as is often seen. In organization and management studies, the concept of core competence has become one of the key concepts in the efforts to understand why some firms succeed while others do not. The basic idea is that an organization should comprehend its own core competencies and capabilities in order to be able to utilize the resources available (Pralahad and Hamel 1990). Additionally, it is also assumed that competencies change more slowly than products and markets. Thus the identity of an organization should not depend on products and markets but on something more lasting, something that lies at the very core of the organization's activities and success (Tuomi 1999, 82–83). All innovation ecosystems have resources, but by no means all of them are capable of utilizing these efficiently. Mere resources are frequently not enough to generate competitiveness, let alone to create a sustainable competitive advantage. Creating a competitive advantage generally requires the ability to make good use of resources, i.e., *capability* to handle a given matter and utilize the available resources and to create new ones. Durand (1998, 306) connects competencies: (a) directly to an organization's resources and property; and (b) to individual and organizational capabilities, knowledge, processes, routines and culture. Javidan (1998, 62) uses competence to refer to the combining and coordinating of capabilities cutting across functions. In organizations with many fields, competencies are thus sets of specific capabilities. Competence is here taken to be specifically capability and expertise that is potentially common to several organizations in an innovation ecosystem but that at all events is shared in an organization having a central position in an ecosystem. Competencies are thus distributed over many operations either within an organization or across them. Core competence, applying the theory of Pralahad and Hamel (1990), is predominantly a collective learning process across the innovation ecosystem, and thus much more than simply what an individual organization is good at. A core competence of an innovation ecosystem differentiates it from other ecosystems.

In innovation ecosystems, competence is a nested concept that covers capabilities of individuals, organizations and entire systems. A competence set model is geared to identifying how different capabilities of many actors could be integrated with one another so that such a constructed set would serve both the entire ecosystem and actors embedded into it. The competence set might also serve as a tool in a search for shared interests, problems, opportunities and capabilities (cf. Pralahad and Hamel 1990). It therefore follows that a competence set is a collection of generic competencies widely distributed within an innovation ecosystem. Applying Eliasson's (2000) thought, the competence set is defined as a configuration of competencies that in direct and indirect interaction generates new knowledge as well as its diffusion and valorization. Thus generated, new knowledge is linked to business growth, economic renewal and/or societal change through other competencies. Basically the competence set refers to an ability to achieve new forms of competitive advantage by highlighting the need to continuously renew competencies so as to achieve congruence with the changing environment. This notion is in line with Teece's et al (1997) dynamic capabilities theory that emphasizes the key role of strategic management in appropriately adapting, integrating and reconfiguring internal and external organizational skills, resources and functional competencies to match the requirements of a changing environment. The competence and dynamic capabilities theories focus on 'the firm' while the competence set model is more interested in 'the system', and therefore the question of strategic management appears as very different. In a system, there is no single controlling strategic leadership but a network of interdependent actors.

According to Eliasson (2000), the prime function of a competence bloc "is to guide the selection of successful innovations through its competence filter, induced by incentives and enforced by competition, and to move the innovations as fast as possible towards industrial scale production and distribution". Therefore, the competence of actors and their interaction determines the quality of a competence set and, as assumed here, also that of an innovation ecosystem. As Eliasson (2000) also says, a competence bloc is defined through its end results, i.e. "through a bundle of functionally related products and services in the market but not in terms of technologies or physical inputs". Additionally, a competence bloc attracts competent investors who contribute positively to the attractiveness of the competence bloc, and those whose contribution is not positive for the entire ecosystem are not selected. A minimum critical competence mass and variety are needed before a competence set bloc becomes self-propelled into a growing industry. The policy problem therefore concerns whether policy catalysts can be inserted to initiate a competence set bloc and/or induce it to boost an innovation ecosystem to reach critical mass faster and/or whether such catalysts are to be found in the science and/or business community.

According to Eliasson and Eliasson (1996), the following actors constitute a competence bloc (modified slightly):

- competent and active customers and users
- innovators who combine new knowledge and technologies in novel ways
- entrepreneurs who identify profitable innovations and prepare them for initiation in the market
- competent venture financiers who recognize and finance the entrepreneurs
- exit markets that facilitate ownership change
- industrialists and other established actors who take successful innovations to industrial-scale production.

3.2 The human spare parts industry discussed through a competence set[2]

Eliasson (2000) associates competence blocs strongly with that part of the ecosystem that influences the selection of winning technologies and corporate winners, and conversely losing technologies and corporations. He points out that the selection involves the joint minimization of two errors: (1) to allow losers to survive for too long; and (2) to reject winners. However, an innovation ecosystem is not only about selection of 'winners' and 'losers' but more profoundly and broadly about economic renewal, and thus the question is about how new knowledge emerges, how it generates variation and how selection is made, and thus the original theory is extended to also cover other competencies. The rationale in extending the competence bloc theory is to better cover all three main functions put forward by the evolutionary theory. They are: (a) retention and transmission of information; (b) generation of novelty leading to diversi-

[2] Instead of using 'bloc' this paper adopts 'set' to highlight the collection of competencies that belong together or are otherwise found together. This is only to simplify the discussion, as 'bloc' is often understood to refer "to a group of countries or political parties with common interests who have formed an alliance" or "a combination of persons, groups, or nations forming a unit with a common interest or purpose" (Merriam-Webster Dictionary). 'Bloc' may also be confused with 'block', which refers to "an obstacle to the normal progress or functioning of something". For its part, 'set' refers to "a group or collection of things that belong together or resemble one another or are usually found together" (Merriam-Webster Dictionary). In practice, the competence set model is an extended competence bloc theory.

ty; and (c) selection among alternatives (McKelvey 1997). The competence set model reminds us that capabilities are the core in any effort to sustain, renew and/or create new knowledge for economic renewal. The value of thinking competencies in the context of innovation ecosystems is that: (a) it acknowledges the need to understand how complementing and conflicting knowledge, resources and abilities of different actors influence each other; but it also reminds that (b) these can be consciously reconfigured, redirected, transformed and appropriately shaped, and integrated into existing competencies as well as external resources (cf. Teece et al 1997).

Next, drawing upon literature on innovation systems and functions related to them, the competence bloc theory is extended to also cover legitimization and market formation, and some of the original components of the competence bloc theory are put slightly in different light. The competence set model covers seven generic competencies. They are related to: (1) knowledge creation, diffusion and valorization; (2) entrepreneurship; (3) venture finances; (4) legitimization; (5) market formation; (6) systematic production; and (7) identifying potential end-values. The seven generic competencies in conjunction form a competence set. Quite naturally, each of these includes a variety of specific capabilities that, for their part, construct the generic competencies. In a system-level analysis, the interaction of identified competencies provides further empirical analysis with a point of departure to identify the specific capabilities in a context of a specific transformation process of a specific innovation ecosystem. The illustrative case, the human spare parts industry, is discussed through a competence set and, conversely, seven generic competencies are discussed through the case.

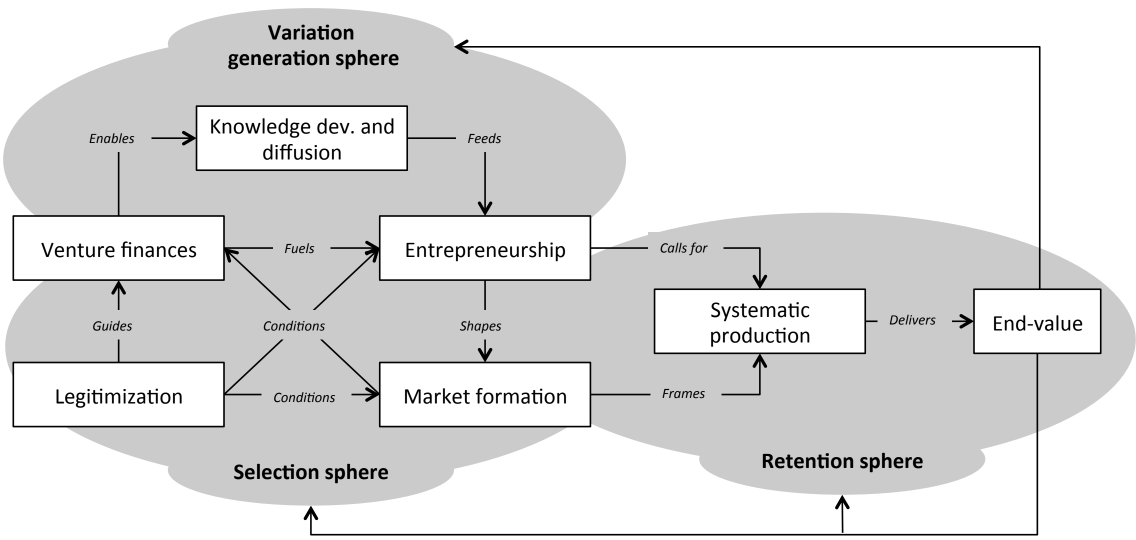

FIGURE 1. The competence set model.

Knowledge creation is an obvious generic competence in any innovation ecosystem. Quite naturally, the exchange and diffusion of knowledge are also of importance. If new knowledge does not circulate in an ecosystem, the lead idea of it becomes superfluous. Knowledge creation and diffusion potentially are the core functions in generation of novelty that again may lead to increased diversity. As research related to regenerative medicine, side by side with other branches of biomaterial research, has become institutionalized rapidly in Tampere (see Sotarauta and Mustikkamäki, forthcoming), the knowledge core of the human spare parts industry has developed favourably. The constructed knowledge concentration is based on a close collaboration between the University of Tampere and the Tampere University of Technology, and it has produced scientific breakthroughs most notably in facial bone replacements. The first discoveries were based on collaboration between biomaterial engineers, clinicians, cell biologists, technical experts and animal model experts (Sotarauta and Mustikkamäki, forthcoming).

It would not be an overstatement to say that the creation of scientific knowledge is at a high level. The unique nature of science and technology can be illustrated by the fact that in 2008, for the first time in the world, a patient's upper jaw was replaced with a bone transplant cultivated from the stem cells isolated from the patient's own fatty tissue (Sotarauta and Mustikkamäki, forthcoming). The patient had lost roughly half of his upper jaw because of cancer and traditional medicine was unable to offer remedial treatment. In the process, the scientists were able to produce new bone cells by combining stem cells and biomaterials and then growing them into a jawbone of the correct shape and size (with the aid of a titanium frame) inside the patient's stomach muscle (Suomen Kuvalehti 2008; Bionext 2010; Sotarauta and Mustikkamäki, forthcoming). This operation was a continuation of successful clinical treatments undertaken in 2007, in which two patients with bone deficiencies were treated, jointly with the Tampere University Hospital, with a combination of fat stem cells and biomaterials. By the end of 2010, based on this technology, approximately 30 patients with serious bone deficiencies had been treated in Finnish hospitals (Bionext 2010). In comparison, by early 2010, analogous treatment (external to the Tampere network) has been received by only one patient in Germany (Tekes 2010). Beyond any doubt, knowledge creation is at a high level and the clinical experimentations have been successful. The questions that have not yet been answered are: (a) How could the revolutionary technology become a permanent element of hospital treatments?, and (b) What is needed to move from individual treatments to a human spare parts industry?

These are tricky questions, as the industry is globally in an embryonic state, and therefore the issue of how to move from research and development to **systematic production** has not been answered yet. The concept of systematic production is used here instead of large-scale production as some innovations related to regenerative medicine may find their place in smaller-scale production systems. The main question is whether they become, one way or another, a permanent element of the health-care system and the economy or not. Science developing favourably, the pressure to detect commercially viable products and services is increasing steadily. The prospective human spare parts industry is deeply embedded into scientific research, and thus it is imperative for the firms operating in the field to have access to cutting edge research (Prescott 2011). Conversely, according to Heinonen (forthcoming), universities are expected to nurture innovations further into clinical trials before aiming to establish a start-up and hunt venture finance for it. In some countries, governmental centers have been established to fund clinical trials (Mason et al 2011). Any effort to construct systematic production calls for close collaboration between scientist and entrepreneurs, as well as hospitals – in practice between their differing competencies are called for. As the universities in Tampere do not have competencies to move forward in systematic production, the competencies of entrepreneurs and/or hospitals are called for.

As **entrepreneurs** take advantage of new business opportunities generated by themselves and/or new knowledge, and as they turn the potential of new knowledge, networks and markets into new business opportunities (Hekkert et al 2007), their competencies related to market understanding and creation may be of importance in moving towards systematic production, also in regenerative medicine. In addition, entrepreneurs possess competencies that enhance generation of diversity and diffusion of new knowledge. Entrepreneurial activity is one of the core activities in selecting viable alternatives from emerging ideas and knowledge. However, in the case of the emerging human spare parts industry, it may well be that competencies related to institutional entrepreneurship may be needed to change the hospital practices to take full advantage of the emerging field of medicine. It is hard to imagine an innovation ecosystem, and entrepreneurship related to it, without discussions of **venture finances**. A well-functioning innovation ecosystem requires competent venture financiers who recognize and finance the entrepreneurs, and hence, for their part, play an important role in the selection process. It has been shown that the catalytic role of venture financiers is often crucial in the emergence of new industries.

As regenerative medicine and the related human spare parts industry is still in an embryonic and emergent stage, funding is largely dependent on public funding, philanthropists and also military-related funding (Mason 2007; cited in Heinonen, forthcoming) Regenerative medicine is a fairly typical case of an emerging science-based field that draws heavily on public funding, and private venture financiers become interested in the potential of its innovations only in the later phases of clinical trials (Parson 2008). Competencies related to knowledge development and diffusion have been strengthening steadily in Tampere, and public funding has been extensively received to support emergence of regenerative medicine but private venture finance has not found its way to Tampere, or it has not been allowed to do so yet. All this may be due to the fact that, in spite of the huge promises, the market for the human spare parts industry is still to emerge, and therefore the competent companies and entrepreneurs have not seen the business opportunity yet.

Fairly often the issues related to ways how new markets emerge and existing ones change are not considered as elements of innovation ecosystems in the literature. Nor are competencies related to how market formation can be influenced and/or understood linked to other relevant competencies. But, it is a well-known fact that, in many fields, radical innovations do not penetrate economies without emergence of a new market or significant changes in an existing one, and therefore understanding the dynamics of **market formation** is here seen as one of the generic competencies. An elaborate understanding of market formation processes needs to take into account coevolution of the technological, institutional, political and user-related aspects of an innovation and related markets (Dewald and Truffer 2011, 286). Market formation is often described as proceeding from a nursing phase to a bridging phase to a mass market (Jacobsson and Bergek 2004), and each of these phases is associated with specific barriers and challenges (Dewald and Truffer 2011, 287). It is obvious, as Heinonen (forthcoming) observes, that the set of the potential regenerative medicine-related industries is quite wide, and there are many paths from new knowledge to systematic production. According to him, these are related to cell therapies, tissue engineering, gene therapy, tools and devices, regenerative compounds, and aesthetics medicine (Mason, 2007; Mason and Dunnill, 2008; Parson 2008). Even though market formation is considered here as one of the generic competencies in a competence set, its driving forces are more often than not considered as exogenously defined, and typically it is seen to follow linear change patterns. In practice, to push development into new directions, various actors often need to innovate against the logic of an innovation system that is supposed to support them (Hung and Whittington 2011).

All in all, the human spare parts industry is still to emerge; market formation has barely begun. According to Bonfiglio (2014), there are approximately 700 regenerative medicine-related companies in the world, the dominant locations being the USA (56%) and the UK (19%). Li et al (2014) estimate that, from 1992 to 2012, there have been 1,058 novel stem cell clinical trials globally, the share of the US being high. Since 2006 the number of clinical trials has been increasing rapidly in the Asian countries but also in South America. Especially China, India and Brazil have invested heavily in research related to regenerative medicine with a target to take the leading positions in the global competition from the very beginning (Salter 2009; McMahon and Thorsteinsdottir 2013).

As Hekkert and Negro (2009, 587) maintain, an innovation has to become part of an incumbent regime. Sometimes new products or processes may even need to overthrow the existing regime that frequently causes uncertainty and social anxiety. Simultaneously with the high hopes generated by regenerative medicine, the emerging human spare parts industry faces complex ethical and legislative issues and hence the emergence of it cannot be fully analyzed without full appreciation of the issues related to legitimization. Reduction of social uncertainty and resistance to change are among the competencies needed in an innovation ecosystem. These are here combined under the concept of legitimization. **Legitimization** refers to the socio-political process of legitimacy formation through actions by various organisations and individuals. Central features are the formation of expectations and visions as well as regulative alignment, including issues such as market regulations, tax policies of the directions of science and policy. (Bergek et al 2008) Legitimization is about acquiring a social acceptance of innovation, and it is a process that makes an innovation conform to the prevailing institutions (norms, values, habits and regulations), and/or to a process that targets the change of institutions for something new to emerge (Johnson 2001). Therefore, legitimization is one of the most central of the selection mechanisms in any innovation ecosystem.

Statutes concerning clinical medical research in general cover much of the stem cell-based research and only a few countries have adopted legislation devoted to stem cell research per se. The legislation on stem cell research varies widely in Europe. In Finland, the ethical atmosphere and legislation have mostly been permissive (Nordforsk 2007). According to McMahon and Thorsteinsdottir (2013), there are significant differences in how the human embryonic stem cells (hESC) are accepted for research purposes. For example, in Brazil, the Catholic Church was against the use of the human embryonic stem cell and this caused significant consequences, but in China and India this kind of research is allowed (Salter 2009; McMahon and Thorsteinsdottir, 2013). Even in the European Union different countries have different regulations regarding hESC. For example, the UK, Sweden and Belgium allow production of the hESC lines, but in other EU countries it is more or less limited (Heinonen, forthcoming). It is virtually impossible to fully appreciate the development and policy needs of regenerative medicine without full scrutiny of issues related to legitimization.

Liu and White (2001) suggest that, in the spirit of demand-led innovation, end-use-generated innovation needs to be acknowledged. In the early stages of regenerative medicine-related products and services, it is fairly hard to see user- or demand-led innovation emerging. The entire field is pushed forward by new developments in science, and the 'customer imagination' is not developed enough to demand new kinds of services. However, as the field is characterized by high hopes and global hype, there are also a variety of expectations. Public policymakers and funding bodies may look forward to increased employment and globally leading positions in a new sexy field. Scientists, for their part, aim to push the scientific frontier forward but also hunt for citations and fame. And of course, ultimately, there are incurable or difficult to cure diseases, and thus there are plenty of patients who look forward to scientific breakthroughs that might provide them with new hope. Innovation ecosystems, and potential and actual beneficiaries of developments in them, consist of a heterogeneous set of actors that all have their own hopes and fears. Therefore the primary function of an ecosystem, and related expectations, are not as clear as we might assume; an innovation ecosystem is a nexus of many expectations and objectives. Therefore, it is important to scrutinize what the potential end results are by focusing not only on end-use of specific innovations, or demand-led innovation, but the **end-values** various actors expect to get out of an innovation ecosystem. Thus it is important to note that 'a firm' is not an end-value, as is often seen, but the value generated for the society, economy, innovation ecosystem and/or the customers. Firms, of course, are among the most important means to generate value at large.

TABLE 1. The core definitions related to generic competencies (own definitions based on Shane and Venkataraman 2000; Hekkert et al 2007; Hekkert and Negro 2009; Johnson 2001; Bergek et al 2008) and the main questions guiding the research.

Competence	**Definition**	**Questions (examples)**
Knowledge development	The breadth and depth of the formal and informal knowledge bases and the ways knowledge is generated, diffused and combined in the ecosystem	What are knowledge dynamics like? How is new knowledge diffused; what channels are used?
Venture finances	Monetary investment to support the start of something new or different that usually involves risk	What are the most important private and public funding bodies and how do they function? How is the funding provided?
Entrepreneurship	The discovery and exploitation of profitable opportunities	What factors support and constrain entrepreneurship? How do entrepreneurs build market understanding for selection pf the most prominent opportunities, on the one hand, and creating them on the other hand?
Legitimization	Acquiring social acceptance of innovation that is a socio-political process, central features being the formation of expectations and visions as well as regulative alignment to support emergence of new sources of economic growth and renewal	What is the socio-political situation in a given field like, and in what ways may emergence of innovation be supported through a consciously defined legitimization process?
Market formation	The ways economic activity, and especially the forces of supply and demand, interact and change in time	What is the size of market, who are the leading players and where are the dominant locations in the field in question? How do new markets emerge and existing markets transform?
Systematic production	Innovation becomes part of the economy and society at large with organized regularity that forms a system	How are innovations institutionalized?
End-value	The desirability and/or worth of an innovation for users of it	What are the whole array of potential users and benefits of an innovation like? Of course, it is by default impossible to know what end-values unknown products and processes will generate in the future but it is important to discuss the ways different societal groups may be affected by new developments.

4 Conclusions

This paper suggests that to truly understand, firstly, how industries evolve and change, and secondly, how universities contribute to their transformation, there is a need to focus on an entire innovation ecosystem and analyse interacting and conflicting competencies that either enhance or hamper the overall evolution. In this paper, for empirical analysis, a set of generic competencies was introduced. The dominant competencies are related to the generation of new knowledge and the selection of winning knowledge, products and/or services and retention of them in the economy. The competence set model discussed here is in a very early stage of development, and only after proper empirical testing and operationalization of the generic competencies in relation to each other will it be possible to say anything definitive about its usefulness in research and in innovation policy. The assumption here is that the competence set determines the dynamism of an innovation ecosystem.

For an innovation ecosystem to self-propel into a growing industry, the various competencies are supposed to support each other, and not be in conflict. The policy problem therefore concerns whether policy catalysts can be inserted to initiate a competence, change existing ones or to make them more in line with each other. All this requires, as Avnimelech and Teubal (2008) maintain, customized and discrete policy interventions that are directed at varying areas of system/market failure that emerge at difference phases of the overall evolution of an innovation ecosystem. A competence set with an evolutionary understanding provides policymakers with knowledge about how to detect the need and timing for interventions. Avnimelech and Teubal (2008) propose further that implementation of a policy "in crucial transition points of market-led development processes could have a significant influence on the effectiveness of market forces" and that "policy targeting is often based on leveraging the success of key market agents in a particular area". Indeed, this is why we need to identify the competencies that make innovation ecosystems function well. Their main contribution is to provide added knowledge of how to target customized innovation policies (cf. Sotarauta and Kosonen 2013) and to help universities position themselves in innovation ecosystems. The Tampere case shows how difficult it is to move beyond science in an emerging field, in which not all the competencies have developed yet. It is clear that the role of universities is crucial in the emergence of the human spare parts industry, as they possess the main knowledge creation competencies but, as Heinonen (forthcoming) summarizes, with the emergence of the human spare industry, the main obstacles are related to insufficient funding, difficulties in the technology transfer processes and issues related to intellectual property, poor understanding of emerging markets and acquisition of capabilities needed in a new field. Many of these issues are beyond what can be expected from universities, and quite naturally the emergence of the human spare parts industry is dependent on many competencies of many actors.

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