

Subtheme: Entrepreneurial Roles

Entrepreneurial University Activity: Can Field or Living Labs be Supportive?

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Abstract. 'Field labs' ('living labs') are explored to determine their role in bringing new knowledge from university to market. The case is the Netherlands, a country facing an innovation system in which much new knowledge is created by universities but small amounts are brought to market, apparently caused by various missing links. To arrive at a better understanding of such missing links the paper first explores failure/success of valorization at universities using data on the project level. The attention then moves to the concept of 'field labs' currently 'en vogue' in increasing efficiency of knowledge valorization. A state-of-the-art analysis of stakeholders and aims, and of key-characteristics of the concept is followed by an inventory of what is not known about concepts and practice but should be known to get 'field labs' properly structured and implemented. A preliminary assessment of their benefits in the context of valorization of university knowledge closes the analysis.

Key words: university, knowledge valorization, project level, The Netherlands, field labs, living labs.

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1. Knowledge valorization in an open innovation context

Bringing new knowledge to market is increasingly recognized as the third mission of universities today. Universities today are seen as creators of new knowledge while being involved in contract-research commissioned by the business sector, in collaborative research projects with business partners, in licensing of patents, in the creation of spin-off firms, etc. (Huggins and Johnston, 2009; McDowell, 2010; O'Shea et al., 2005; Shane, 2004). In Europe, this new role of universities started to grow in the early 1980s (Charles and Howells, 1992) and has now fully entered the research policy of modern universities (Hussler et al., 2010; Rasmussen et al., 2006).

Knowledge valorization (note 1) is broadly defined as “the process of creation of value from knowledge, by adapting it and/or making it available for economic/societal use and transform it into competing products, services, processes and new economic activity” (Innovation Platform, 2009, page 8). It is a complex and iterative process with interaction between knowledge institutes and business world as key in all stages. Knowledge valorization encompasses a chain of processes (partly cycles) that starts with first thoughts about market introduction (eventually together with a firm) and about steps to be taken to reach this through various channels (Bekkers and Bodas Freitas, 2008).

Since the early 2000s, the demand for a quicker market introduction and cost reduction in a globalized economy has many universities, technology institutes and firms urged to adopt models of open innovation. The underlying assumption of open innovation is that actors in innovation can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. In the line of Chesbrough (2003) and Chesbrough et al. (2006) open innovation among firms can be defined as: the systematic encouraging and exploration of a wide range of internal and external sources of innovation opportunities, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels (West and Gallagher, 2006).

The general logic of open innovation is based on the idea of distributed knowledge. However, opening up the innovation process is not about just giving up control and hoping for the best (Boudreau and Lakhani, 2009), it is about carefully implementing mechanisms to govern, shape, direct, and if necessary constrain external innovators. Note that certain aspects of open innovation are not new (like co-design) and that one organization may adopt various types of open innovation simultaneously, but also move to other types of open innovation over time. In addition, the term open means ‘relatively open’ and positions the learning on a wide spectrum of openness with fully closed and fully open on each of the ends (Dahlander and Gann, 2010; Gassman et al., 2010). A new development is the purposeful engagement of end-users or customers in open innovation processes and practices (Bogers et al., 2010; Thomke and Von Hippel, 2002). Using an active input of users as co-creators including their feedback in developing and testing is generally seen as important ways of better serving the needs of users, thus, increasing efficiency and speeding up market introduction.

Despite the current popularity of knowledge valorization in university policy and local/regional economic policy, much is still unknown, e.g. to what extent knowledge is actually brought to market, how long this process takes, and which factors exert a hampering influence on success of the process. It seems that the lack of understanding is mainly caused

by the comprehensiveness of the phenomenon of knowledge (different types, different channels, different levels of aggregation) (d'Este and Patel, 2007). Without knowing the causes of delay and failure of valorization from systematic research, many policymakers today embrace the concept of 'field labs' or 'living labs' as a concept to accelerate introduction to market. The small experience to date, however, suggests as much as advantages as drawbacks of the new concept, calling for a state-of-the art study and an assessment of potential drawbacks and success.

This paper takes The Netherlands as an example. As a relatively small country in Western Europe (a population of 16.4 million) it has committed itself to the Lisbon and Barcelona objectives to improve the competitive performance of Europe. The Netherlands is an interesting case study because of a *paradox* in its innovation system: it experiences a relatively strong performance in scientific output, and some of its universities – Technical University of Eindhoven and Delft University of Technology – are among the *world best universities* in scientific publications in collaboration with business partners (Tijssen et al., 2009). However, this situation goes along with relatively low levels of application of innovations in manufacturing and services (NOWT, 2009) and with a position of 'innovation follower' in the European Scoreboard (Pro Inno Europe, 2009). Apparently, university-industry interaction suffers from missing links in various stages of valorization.

The paper has the following structure. Theoretical perspectives are examined in Section 2. This is followed by a discussion of the methodology of the empirical study and an examination of its results focusing on market introduction and failure (Section 3), including hampering factors (Section 4). The concept of 'field labs ('living labs') is introduced in Section 5. The knowledge that is missing on how they (should) work is discussed next, followed by an assessment of their potential role in accelerating valorization (Section 6). The paper closes with a summary and outlook on future research.

2. Factors affecting knowledge valorization

Factors potentially affecting valorization are given in Figure 1. Important *direct* factors, i.e. working within the university and within university-business interaction are shown in the oval. We mention type of inventions (e.g. radical/incremental, science-based/customer-driven, etc.), type of market and industry (regulation, subsidization, existing market demand, etc.) (Christensen, 2003; Utterback, 1996), size and composition of teams at university (Etzkowitz, 2003) and atmosphere and supporting institutions here.

2.1 Type of inventions and industry learning

Radical inventions requiring structural changes in manufacturing facilities and in systems of application (infrastructures) are facing more obstructions than inventions that are incremental and fit into existing structures (Geels, 2004). In addition, there may be many obstacles in the case of heavy regulation, like in designing new drugs, caused by the need for intensive testing and approval procedures (Van Geenhuizen, 2003). Conversely, inventions without such regulation and supported by public investment, may face an acceleration in speed to market, like in clean technologies and sustainable energy.

The industry is important regarding the type of learning at university and in university-business collaboration. There is a basic difference between science-based learning including laws of nature, like in life sciences and nanotechnology, and engineering or problem-based learning, like in micro-electronic systems, medical instruments and sports equipment, the

latter causing better outlooks on a quick market introduction (Asheim et al., 2007; Thomke and Von Hippel, 2002; Tidd and Bessant, 2009; Von Hippel, 2005).

2.2 *University and university-business tension*

Regarding teams at university, Etzkowitz (2003) describes an ideal model of research groups as ‘quasi’ firms. Such teams are led by a principal investigator and contain team members that are perfect in proposal writing to raise funds, writing and reviewing of scientific and applied articles, managing post docs, and membership of panels judging other teams or institutions, etc. However, in practice many research groups are not so skilled, due to younger age, small size, ‘unhappy’ mergers and re-organisation, etc.

An inherent tension between academic and commercial demands lies at the heart of problems of valorization of university knowledge (Ambos et al., 2008) and causes different results per faculty and university. This tension may take several forms. First, universities and industry are likely to prioritize different research goals. Industry usually focuses on less risky research with direct commercial applicability, while government-funded academic research typically undertakes projects with longer time horizons (often of a PhD research) and less predictability (Di Gregorio and Shane, 2003). Also, industry is facing the need to adapt quickly to changing circumstances in the market while universities can remain quite stable in their choices. Second, academia traditionally encourages knowledge dissemination and full disclosure of methods and results (in peer-reviewed journals) whereas the commercial sector often prefers to keep the new knowledge secret and seeks ownership or tight control of intellectual property. These contradictory demands create tensions at the organizational level as they make it difficult for universities to set clear priorities in terms of structures, resources and incentives. This situation may slowly change through the emergence of open innovation platforms, but many underlying tensions probably remain (West, 2008).

The tensions are also profound for individual researchers, leading to significant variation in entrepreneurial involvement among them (D’Este and Patel, 2007). First, there is a strong sense that academic and commercial activities represent fundamentally different and potentially contradictory activity (Bercovitz and Feldman, 2003). Communities of peers shape what constitutes a valuable avenue for scientific research, and this makes it risky for a scientist to deviate from the social norm of conducting academically rigorous research by seeking involvement in commercial activity. Second, commercial activities do not often carry weight in tenure and promotion decisions in HRM policies at university (Markman et al., 2005). A successful academic career requires significant investment in a specific style of research, paper-writing and network-building, leaving little time for pursuing other – commercial – activities. Third, many scientists lack the competence to undertake commercial activities as they require different skills and abilities than purely academic ones.

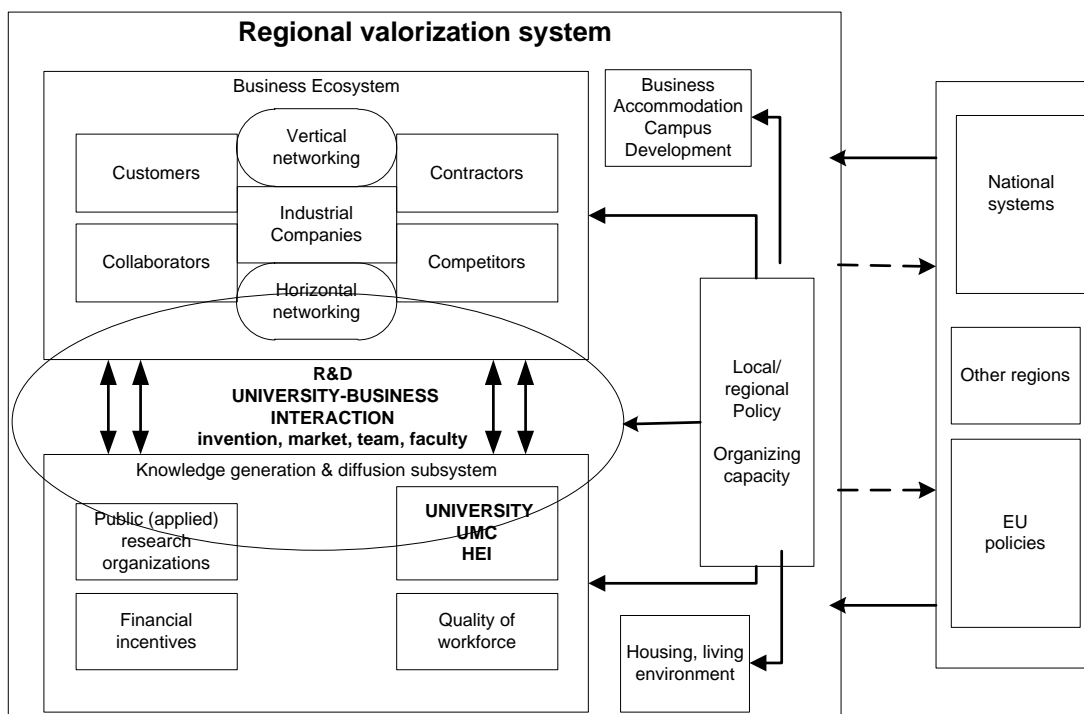
Universities usually deal with these tensions as an ambidextrous organization, by a *dual* structure that deals with conflicting situations. For example, within the universities technology transfer organization are engaged with commercialization, ‘third stream’ research is often concentrated in separate legal institutes within the university organization, and researchers concerned with commercialization follow different career paths compared to researchers involved in scientific research. Relatively few studies have investigated empirically these tensions and dual structures, and the nature of related inhibiting or, conversely, converging factors at university and in university-industry relations, but attention is quickly increasing (e.g. Bjerregaard, 2010; Bruneel et al., 2010). The idea is that universities today are different in smoothing the tensions and in bridging dual structures, for example, technical universities versus general universities (beta faculties), and universities

with an explicit entrepreneurial mission (in regional development) versus those without such mission.

2.3 Indirect factors

Figure 1 pictures the regional ecosystem of firms, including customers, contractors, competitors, and collaborators as a major set of factors that impact knowledge valorization in an indirect way. If well-developed, this ecosystem provides supportive services, potentials for subcontracting, knowledge collaboration with multinational firms, and collective learning including knowledge spillovers. These kinds of benefits have been indicated in theory on regional innovation systems, agglomeration economies and clusters (e.g. Bathelt et al., 2004; Cooke et al., 2004; Feldman, 1999; Porter, 2003). Figure 1 also pictures the knowledge generation and diffusion subsystem, encompassing universities and academic hospitals, organizations of applied education (HEIs) and of applied research, financial incentives, and quality of the labour market. The last not only refers to specialized academic knowledge workers but also to skilled practical workers.

Similarly, an adequate supply of business accommodation and land on industrial (science) parks is an important enabling factor (Soetanto and Van Geenhuizen, 2007). In addition, quality of life and ‘atmosphere’ are important, e.g. in retaining local graduates and attracting international top researchers and other creative people (Florida, 2002). Overall, the idea is that large metropolitan areas provide better opportunities than other regions.



UMC: university medical centre.

Source: author

Figure 1 A simplified model of a regional valorization system

Furthermore, the ‘organizing capacity’ of local/regional authorities increasingly attracts attention (Van den Berg et al., 2003). This capacity refers to achieving consensus with a sense of urgency on the direction of regional knowledge-based development and gaining commitment for daily policies supporting this direction. More specifically, it refers to connecting university, public policy actors and the business sector in gaining benefits from collaborative activities in each other realms: Triple Helix development (e.g. Etzkowitz, 2008) and in connecting even more actors in open innovation and ‘field labs’ today, like society and customer groups (Guldmond, 2011; Leydesdorff, 2011; Marcovitch and Shinn, 2011). Building such capacity differs between cities, like small versus large cities, and polycentric city systems home of various different universities versus monocentric cities with merely one university (OECD, 2007).

3. Valorization results on the project level

3.1 Methodology

There are three modes of knowledge valorization seen from universities as organizations (Markman et al., 2008). First, there is internal valorization at university, including development of new knowledge applications in projects and programs within faculties, activity of technology transfer offices (TTO’s) and valorization institutes. Secondly, there are various quasi-internal modes, in which the university has large stakes, like in business incubators and in hybrid public-private companies aimed at commercialization of university intellectual property. The third mode is externalization: commercialization takes place in spin-off companies, regional clusters, university research parks, etc. The current paper has a focus on the first mode: development of university knowledge towards the market within university. However, the above modes cannot be clearly separated in practice; by focusing on internal valorization in this paper, spin-off formation as an external mode enters the analysis as well.

The analysis of technology projects involved three steps. A scan of almost 370 projects in two regions was followed by an in-depth study of approximately 35 projects representing these regions, and an in-depth study on inhibiting factors derived from interviews with almost 50 experts. Technology Foundation STW (various years) (note 2) provides for each technology project that it subsidizes a short description and evaluation of results at 5 or (if relevant) 10 years after take-off of the project. This information, in some cases together with web-based information, allowed to identify different outcomes of the projects. The label ‘market introduction/use in society’ (Table 1 and Table 2) indicates that the projects have led to a product, process or method that was brought to market or to use in society. The label was also assigned if software (as main part of a project) was brought to market in open source ways. Failure was defined as ‘not having reached the stage of market introduction/use in society’. In a few cases this happened quite early with ceasing the project before the official end date (subsidization) or directly after. In most cases, however, it took a longer time before the project was stopped during which some research contracts with potential users and investment money could be gained. Aside from the two categories of end results, we distinguished between ‘stagnation or development unknown’ and ‘continuation’. In view of the long-lasting nature of bringing new technology to market, two different periods of project take-off were selected, i.e. the years 1995 to 1997 and 2000 to 2002. A reason for taking two different periods was also the change in economic climate in the early 2000s. In addition, each period covers a sufficient amount of projects representing the metropolitan core area and other areas in The Netherlands (note 3).

The second step - analysis of hampering factors - made use of a selected sample of approximately 35 projects representing market introduction/use and failure (delay), and covering the two types of regions. To avoid results on many different influences from technology/market circumstances, the sample covered a limited number of technology segments, i.e. biotechnology (medical and industrial), medical technology (instruments/software), new materials (nanotechnology), systems for sustainable energy, and automotive. Respondents in the in-depth interviews were the research project leaders at university.

3.2 Failure and market introduction

Failure was faced by a minority of the projects, 26% in both cohorts (Table 1 and Table 2). Conversely, market introduction was also faced by a minority of the projects, i.e. 22% among older projects and 15% among younger ones. Aside from the downturn in the economy, the last results also followed from the short time-period in consideration. With regard to the two types of regions, the results for the first period revealed a trend of a higher failure rate as well as a higher rate of market introduction in the core metropolitan area compared with other regions (Table 1), witness shares of 28% vs. 18% and 29 vs. 20% respectively. These outcomes supported the idea of higher levels of newness/creativity (breakthroughs) including a stronger risk-taking in the core area, but also favourable conditions in bringing projects to market/use in society here, based upon tighter connections with public decision-making on the national level (Delft University of Technology in Delft). Note that overall, the largest category of outcomes is ‘continuation after 10 years’.

In the second period, the core region had remained quite high in failure (29 vs. 20%) without a high level of market introduction (14%). This pattern suggests that the core region tended to remain ‘stuck’ in a high failure rate more recently. The causes behind this trend may be a remaining high risk-taking such as in genetic engineering (biology) and medical life sciences in the core region. Overall, the largest category of outcomes was ‘continuation’ (around 60%).

It appeared that valorization is a long-lasting process. In almost a third of the older projects (32%) R&D is still continued after 10 years (Table 1). In medical life sciences (drugs development) 15 to 20 years is not an exception. In medical technology (instruments, software) however, the time is shorter if the invention avoids time-consuming approval procedures. In general, time tends to be shorter if R&D is driven by demand from the business sector and takes place in close collaboration with a firm/customer group, or if the invention is a new application of existing knowledge. The last is exemplified by proven models of aerodynamics from aircraft design in improving wind turbine blades, taking only 5 to 8 years.

Table 1 A scan of project outcomes (take-off in 1995-97)

Outcome	Core		Other		Totals	
1) Failure after 5/10 years	45	28%	9	18%	54	26%
2) Stagnation/development unknown	27	17%	15	29%	42	20%
3) Continuation after 10 years	47	30%	19	37%	66	32%
4) Market introduction/use in society	39	25%	8	16%	47	22%
Totals	158	100	51	100	209	100%

Source: calculation based on information from STW and website information.

Table 2 A scan of project outcomes (take-off in 2000-02)

Outcome	Core		Other		Totals	
1) Failure after 5 years	31	29%	10	20%	41	26%
2) Continuation (incl. delay)	62	57%	32	64%	94	59%
3) Market introduction/use in society	15	14%	8	16%	23	15%
Totals	108	100	50	100	158	100

Source: calculated based on information from STW and website information.

3.3 Employment effects and spin-off establishment

Table 3 reports how much employment and how many spin-off firms have been generated by the technology projects in the two periods. Note that the results should be considered as tentative due to the small size of the samples. Employment impacts in the region (direct and indirect) tend to vary from 1 to 145 full time equivalent (fte), with a mean of 20 and a median of 4. The last indicates a skewed distribution dominated by many small effects and a small minority of large employment effects. Large employment effects are the result of establishment of spin-off firms that developed as ‘gazelles’. Older projects tend to generate zero to 5 spin-offs per project, with a mean of almost 1 spin-off per project. Of course, younger projects have produced less employment and less spin-off firms. Although standards for comparison are missing, we may assume that overall employment effects tend to be modest and large effects to be exceptional.

Table 3 Employment effect and spin-off establishment in the region (2009/2010)

	Employment (fte) (direct and indirect) a)	Number of newly established spin-offs
<i>Older projects (n= 22)</i>		
Min –Max	1.3 - 145	0 – 5
Median	4.0	1
Mean	20.1	0.77 per project
Totals (fte)	442	--
<i>Younger projects (n=16)</i>		
Min – Max	1.3 - 8	0 – 2
Median	2.8	0
Mean	3.7	0.38 per project
Total (fte)	59	--

a) A slight underestimation because not all forward linkages could be included.

Source: interviews by the author

In-depth insight into large employment growth indicates that this growth often stems from particular types of inventions/technology, i.e. user-oriented (as opposed to science-oriented), new applications of existing technology (as opposed to entirely new technology), and basic process technology used in many different applications, like new thin-layer technology in material science applied in solar cells, materials for rechargeable batteries and bio-ceramic implants (as opposed to a single new product).

4. Hampering factors

Table 4 reports the importance of various categories of direct and indirect factors. Broadly speaking, almost 60% of all factors in the first period reside in the ‘oval’ of the projects (direct factors), including the profile of the invention, the organizational context (team and university) and university-business interaction. By contrast, regional factors amount to almost 30%. Direct factors tend to have lost importance in the second period (fallen back from 59% to 43%). This change may indicate a move to more open innovation in which partners in the region have become more important, but – apparently - with some shortcomings.

What is not visible in Table 4 is that shortage in the organizational situation at university is the single most important hampering factor in the first period (29%). This situation is concerned with lack of affinity of researchers with valorization and a reward structure that could not encourage this activity. In addition, in some cases valorization suffered from reorganisation of faculties leading to closing down or regrouping of specialized research groups, and from a too small capacity of transfer organizations. Next are limitations in interaction with firms (19%), referring to ‘sudden’ changes in their involvement with the university due to upcoming risks, competing technology, and new strategies of closing down (or reduction) of R&D departments, sometimes connected with mergers and acquisition. Circumstances like these tend to slightly loose importance among younger projects (13.5%).

A factor worth attention is an ‘unfavourable’ profile of the invention (11 and 8% for old and younger projects respectively). Inventions without an outlook on mass production and inventions bearing strong technology risks in next steps of the research often suffered from lack of interest from firms/investors from the beginning.

Among *regional* factors, a lack of financial incentives tends to inhibit valorization most frequently in the first period (11% of all factors) but felt back in relative importance in the second period. Lack of financial incentives was concerned with investment subsidies to attract firms from outside the region and abroad (absent in the core area) and with easy access to large amounts of regional venture capital (short in all regions). In the second period, shortage in the business ecosystem and accommodation are in first position, mainly referring lack of ‘critical mass’ in non-core regions and to lack of cheap and nearby-academic-hospital-accommodation in core-regions. Lack of ‘critical mass’ of the regional economy (and university) is understood as missing the ability to reaching a certain size above which growth starts to propel itself, and therefore as remaining less favourable as a site to attract research departments of multinational firms from abroad.

Table 4 Factors hampering valorization

Factors	Projects 1995-97		Projects 2000-02	
	Abs.	%	Abs.	%
<i>Direct</i>				
University (invention; team and organization)	25	39.7	11	29.7
University-business interaction	12	19.0	5	13.5
<i>Totals</i>	<i>37</i>	<i>58.7</i>	<i>16</i>	<i>43.2</i>
<i>Indirect regional</i>				
Business ecosystem and accommodation	6	9.5	6	16.2
Financial incentives	7	11.1	4	10.8
Remaining factors	5	7.9	4	10.8
<i>Totals</i>	<i>18</i>	<i>28.5</i>	<i>14</i>	<i>37.8</i>
<i>Indirect national factors</i>	<i>8</i>	<i>12.7</i>	<i>7</i>	<i>18.9</i>
<i>Totals</i>	<i>63</i>	<i>100%</i>	<i>37</i>	<i>100%</i>

Source: interviews by the author.

5. Are ‘Field Labs’ or ‘Living Labs’ a solution?

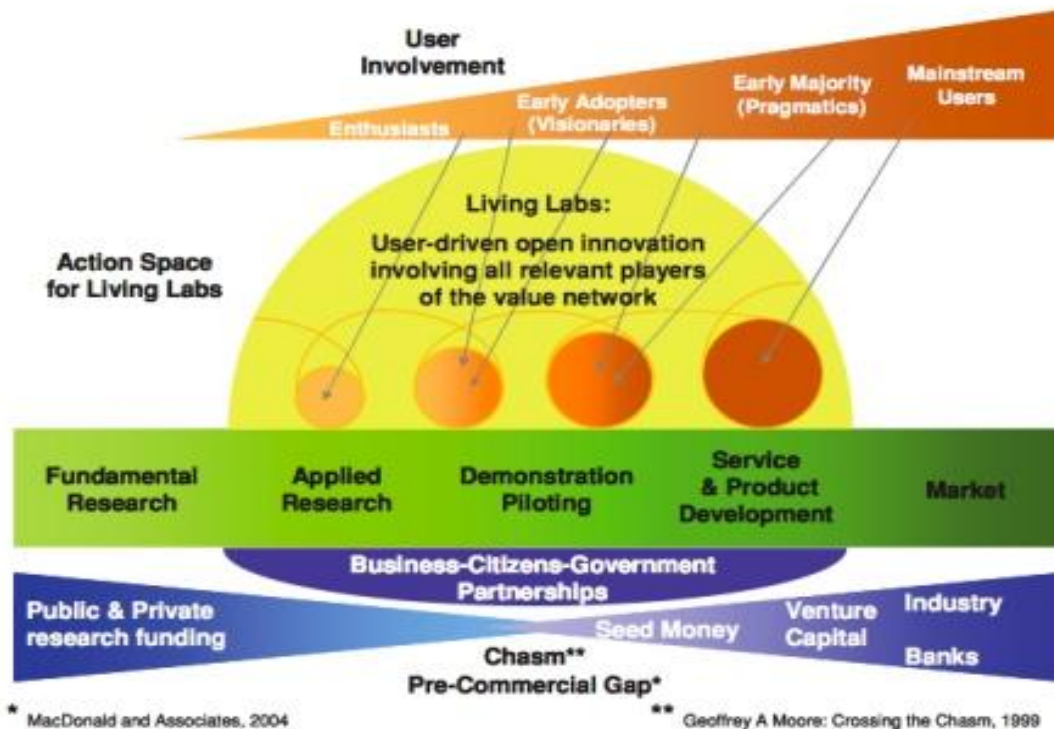
A new generation of innovation management concepts is emerging aimed at accelerating knowledge valorization in more open networks between researchers and customers, with key support of information and communication technology (EC, 2010). These concepts put an emphasis on the capacity of places/universities/cities to perform as ‘field labs’ or true ‘living labs’, thereby taking advantage from strategic intelligence in user communities.

‘Field labs’ are a physical setting or facility where needs (problems), ideas, and solutions come together through a structured innovation process, particularly with the input of user-groups (e.g. Guldmond, 2011). They are exemplified by living quarters in a city, hospitals’ surgery rooms, buildings based on sustainable energy use, sporting facilities (sailing port, hockey/soccer field), and material test labs at university, etc. ‘Field labs’ are also a network of all relevant stakeholders in the value chain, often based upon a public-private partnership. In fact, ‘field labs’ coordinate a research program consisting of various projects. With respect to university involvement, it is important to mention that ‘field labs’ can be hosted at the university (a physical room with new equipment and processes for experimentation provided to firms) or somewhere else, like a hospital, living quarter and sporting center.

‘Field labs’, compared with ‘living labs’, can be seen as a broader category of initiatives, not necessarily dealing with co-creation and monitoring in real-life living situations. ‘Living labs’ are basically concerned with 24-hour or less hours monitoring of performance of particular user-groups in daily living situations concerning products and services that are highly personalized. Despite this distinction, in part of the literature both terms are used interchangeably.

Key in ‘field labs’ and ‘living labs’ is early customer involvement in some or all stages of R&D, and secondly, performance in real situations, like living, working, travelling, recreation

and sport (e.g. Almirally and Wareham, 2008) (Figure 2). Customers are individual persons, households or workers in their physical environment. Customers may also be firms, non-profit organizations (like hospitals) and city/regional authorities. In addition, the type of users may differ per stage in the process/cycle, ranging from enthusiasts or pioneers to mainstream users. Note that ‘field labs’ or ‘living labs’ cover activities running from applied research to market introduction and customer services. However, returning to previous steps is part of the process if the outcomes of a particular step are not satisfactory (Figure 2).



Action space for Living Labs along the technology adoption cycle

Bron: Kresin (2009)

Figure 2 ‘Living labs’ and user involvement

The aims of ‘field labs’ or ‘living labs’ are still somewhat fluid and different for diverse stakeholders (e.g. Følstad et al. 2009; Dutilleul et al., 2010). Stakeholders may be involved for different reasons:

- Customers: through co-creation and feed-back in testing they influence the quality of products and services they will use by themselves, in such a way that their needs are better served (e.g. Bogers et al. 2010).
- Firms: through co-creation they get the opportunity to produce products and services that better match with customer needs, while shortening the time between invention and market introduction; using customer feedback they may increase efficiency.
- Knowledge institutes: they can bring more knowledge to market and it goes quicker; impacts of inventions and new findings can be tested in reality leading to more valid results and improved understanding.

- Intermediary and coordinating organizations: they support the establishment and performance of ‘living labs’ with particular services.
- Local/regional authorities: they may provide legitimation as a neutral actor to a ‘field’ or ‘living lab’; they may also act as a co-creator of various public services, like in its primary services (e-governance) and in other services like health- and childcare, and education.

6. Missing knowledge and speculations

This section reports on missing knowledge about ‘field labs’ and ‘living labs’ that prevents a sound design and implementation of them. Much is still unknown such that the performance of these labs in different stages of valorization remains uncertain. *First*, the best mix of stakeholders to be brought together in the organization, and ways to identify them and to align and maintain them (dynamic multi-actor situation) are virtually unknown. Particularly, it turns out to be difficult to commit the university and to turn part of it into a ‘field lab’, in which knowledge flows from outside enter and internal knowledge goes outside. In efforts of alignment, it seems that the traditional role of the university is difficult to change. Faculties need to be partly transformed from relatively closed organizations to organizations acting as interfaces between the own research organization and application in society with knowledge flows inside-out and knowledge flows outside-in. Related is lack of knowledge on the best rules for access and exit of partners (open/closed, fixed/fluid) and how that may change over time.

Secondly, the best way of governance of ‘field labs’ or ‘living labs’ and the best model of distributing costs and revenues over the partners are almost unknown. The best governance model could be a bottom-up model because the first initiatives are mostly bottom-up. However, it is plausible that in the early stage of ‘field labs’ or ‘living labs’ a mix of bottom-up and top-down is the best, while in later stages pure bottom-up models may be most adequate. Also, best governance may be different for ‘labs’ that are within university compared to external labs. Similarly, there is no experience with how to distribute costs (risks) and revenues over the partners in the best way, particularly in a public-private partnership construction. However, the possibility of ‘frontloading’ seems realistic in which risks (costs) are distributed over all partners from the early stage of co-creation. In such a situation, spin-off firms can be freed from unbearable high risks in their early years.

As a *third* point, IP issues are potential sources of tension in the traditional situation but dealing with IP issues in ‘field labs’ and ‘living labs’ remains equally important and is even more complicated because of a larger number of partners. Dealing with legal liability issues is not more complicated as in traditional situations, except for health care. The last matters because patients and age groups are participating in experiments that might lead - aside from beneficial results - to unexpected harmful medical effects. The *fourth* point to be forwarded is the best way to connect ‘field labs’ and ‘living labs’ to existing regional innovation instruments and existing innovation instruments in the industry sector. Of course, aligning ‘field labs’ or ‘living labs’ with existing innovation instruments and policy to benefit from synergy would be highly desirable, but there is no experience with such situations. As a *fifth* point we mention that ‘field’ or ‘living labs’ are constrained by two factors, the extent to which customers are interested to be involved and the extent to which they are allowed to be involved due to strict regulation. The first addresses the fact that part of the research is still at

a distance from application in user-situations due to a more fundamental character, and the second addresses regulation that forbids user-involvement in particular stages, mainly in health and medical areas. These circumstances suggest the need to study how user-involvement - if useful in the process - can be further increased.

Overall, the above situation suggests that much research is still needed, particularly to collect experiences and best practices, and also to develop and test analytical models of determining factors. Given the poor level of understanding of ‘field labs’ (‘living labs’) to date, we can only propose a list of preliminary benefits of them in improving knowledge valorization (Table 5).

‘Field labs’ (‘living labs’) provide good potentials for speeding up valorization and diminish risk and failure, in particular for smoothening university-industry relations through early customer interaction, change of attitudes, improved knowledge about business at university, and additional synergy and serendipity. Further, we may expect advantages from new models of investment and financing, and from increasing ‘critical mass’ in small scale regional business ecosystems. Shortages of incubation room may also be partly solved in ‘field labs’ networks.

Table 5 Potential contribution of ‘field labs’ (‘living labs’) to knowledge valorization

Challenge	Potential contribution
Increase speed of valorisation and smoothen university-industry relations (<i>all regions</i>)	-Early interaction of university and firms with customers, including testing and insights into customer preferences -Change of attitude at university towards industry (vice-versa) and reduced uncertainty for universities through co-design -Improved knowledge at university on marketing, market value of inventions, and strategic behaviour of (larger) firms -Synergy and serendipity stimulated by collaboration of a variety of partners
Improve (regional) system of financial tools/incentives (<i>all regions</i>)	-Establishment of new investment - and venture funds stimulated by connectedness of a variety of partners that fuel these funds -Rise of new models of financing in co-design and testing (<i>frontloading</i> , in which risk is shared by all partners already in early stages)
Increase ‘critical mass’ in business ecosystem (<i>non-core regions</i>); create ‘metropolitan atmosphere’ (<i>non-core regions</i>)	-Increased ‘critical mass’ for co-design, validation and testing (larger and more varied knowledge bases) by linking ‘living labs’ nationally and internationally -Connections with ‘living labs’ in large cities elsewhere might come with broader connections enabling exchange such as in cultural affairs
Solve shortage of incubation room (<i>core regions</i>)	-Decreased demand for physical labs, and better opportunities for pooling different kinds of functional rooms among partners

How successful ‘field labs’ perform in reality remains to be seen, as documented experience is still scarce, particularly on critical issues like cost and revenue distribution and dealing with IP and legal liability, whereas these labs in their current stage of development are also emergent or fluid in various respects. Universities could take the lead in gaining and analysing ‘lab’ experience including engagement by industry and local communities.

7. Concluding Remarks

This paper responds to two knowledge gaps, first, a lack of knowledge on practice of valorization at universities, and secondly, a lack of knowledge on ‘field labs’ as an increasingly proposed solution to failure and delay in valorization. In the empirical part of the paper, the focus was on valorization at universities in The Netherlands, particularly on technology projects. Failure was faced by a minority of projects whereas market introduction was also faced by a minority of projects. The largest categories were stagnation and continuation. With regard to different regions, older projects in the core area tended to experience a relatively high rate of market introduction but also a relatively high failure rate. With regard to more recent projects, however, the differences between core area and other regions tended to disappear. In general, factors at university and in university-business interaction were causing a relatively high failure rate or delay, but over time this situation tended to improve. At the same time, regional factors tended to increase in importance, particularly the business eco-system and business accommodation. Non-core areas were typically facing a lack of ‘critical mass’ in their business eco-system while core regions were typically facing shortage in accommodation for spin-off firms.

The increasing importance of regional factors in hampering valorization pointed to the need to pay more attention to new regional innovation concepts discussed in this paper, i.e. ‘field labs’ or ‘living labs’. These concepts appeared to have large potentials in improving the situation, due to ‘opening’ of university research to various stakeholders, particularly early involvement of user groups and new models of financing research and development. However, major hurdles need to be taken, not at least in identifying the best structure and practical modes of implementation and governance.

The empirical work on entrepreneurial activity of universities in this paper contains some limitations. The first one follows from the use of data from one particular source of financing technology projects, with its specific criteria in granting project financing. Other financing programs may produce a somewhat different picture. However, the in-depth interviews were structured in such a way that a broader picture of financing sources could be reached. Accordingly, the results of the study on most important obstacles to valorization have larger implications. Secondly, this study had to narrow with regard to technologies and applications. Fields like micro-electronics and information and communication technology have remained outside the study.

Given the previous results and implications, the following research avenues can be envisaged. First, in the current empirical study the emphasis is somewhat on science-based research. Next part of the research could have a stronger focus on user-driven projects. Secondly, the current study is descriptive in nature. Next step could focus on testing causal models of knowledge valorization on the basis of a larger and more diverse database. Thirdly, there is a need to better clarify the concept of ‘field labs’ and its practical application.

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Notes

1. Different from knowledge commercialization, the term knowledge valorization is more comprehensive by also including non-commercial (societal) applications.
2. STW brings together researchers and potential users of the projects. The ‘users’ provide input and also financial or other contributions, like consultations during the projects.
3. Relevant universities (technical universities and general universities including bèta-faculties and medical schools/hospitals): six in the core area (100% coverage) and three at a substantial distance from this area in the eastern and southern part of the country (75% coverage).

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