From ‘Ivory Tower’ to ‘Living Lab’?
Unlocking university knowledge in the regional economy

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Abstract

The valorization of knowledge created at universities is recognized as the third mission of many universities in the developed world today. For this reason researchers and policy makers have started to give much attention to performance of universities in terms of patent applications, licenses, research joint ventures and alliances, and the formation of spin-off firms. In contrast, knowledge valorization starting from research projects has received small attention to date, causing a lack of knowledge on determining factors of success and failure of such projects. The current paper is an attempt to fill this gap by picturing the trajectory of university research projects in terms of success, delay and failure in market introduction, and by identifying major obstacles. The country taken as an example is The Netherlands. A difference is made between university cities in the western metropolitan area (Randstad) and those in other regions in the country. A causal model of knowledge valorization is explored by distinguishing between the following factors: (1) internal factors referring to characteristics of the invention, the project and the organizational context at university, (2) interaction factors concerning the relation between university researchers and firms, (3) external factors typical for the region, and (4) external factors typical for the country (national system).

The study draws on a database of almost 370 research projects and in-depth data of approximately 35 projects. The results indicate that failure (closure of projects without market introduction) is faced by a minority of projects (around 30%) whereas success in terms of market introduction is also faced by a minority of projects (22% among older projects and 15% among younger ones). Overall, the main hampering factors in valorisation turn out to reside in the organizational context at university and in university-industry interaction. Shortcomings in the region today mainly refer to financial incentives and to lack of ‘critical mass’ in the business ecosystem. In order to make knowledge valorization more successful and accelerate speed of the processes involved, many universities and local/regional government today step into network constructions like ‘living labs’ aimed at ‘open innovation’. The paper critically evaluates the new concepts in terms of responding to hampering factors in valorization.

Key words: university, knowledge valorization, project level, The Netherlands, regions, ‘Living Labs’.
1. Setting the Scene

Bringing new knowledge to market is increasingly recognised as the third mission of universities in various countries today. This holds particularly for The Netherlands facing a situation of high-level knowledge production but a low level of bringing knowledge to market. Accordingly, universities are seen as creators and developers of new knowledge being involved in contract-research commissioned by the business sector, in collaborative research projects (consortia) with business partners, in the licensing of patents, in the creation of spin-off firms, etc., all with the aim to use new knowledge owned by the university in a commercial setting (Huggins and Johnston, 2009; Kitson et al., 2009). In Europe, the rather new role of innovation creation started to grow in the early 1980s (Charles and Howells, 1992) and has now fully entered the research policy of modern universities as the ‘third mission’, also named knowledge valorization (Shane, 2004; Van Geenhuizen et al., 2008, 2010; Hussler et al., 2010).

Regional and local policies dealing with the ‘boosting’ role of universities have all one assumption in common, and that is that the region (or regional innovation system) is the best environment for bringing new university knowledge to market. Despite some doubt (e.g. Lawton-Smith, 2007; Huggins and Johnston, 2009) regional and local policies have continued to ascribe important roles to university knowledge in the urban and regional economy. In addition, many policymakers see the university – ideally - in a pivotal role in open innovation networks with large firms and small and medium-sized ones, including regional ‘testbeds’ and ‘living labs’ full of co-design, validation and testing of new products and processes on their way to market. However, differences in roles of universities according to regional-economic settings such as in core metropolitan areas and other (peripheral) regions are often not taken into account.

‘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). Knowledge valorization can be seen as a complex and iterative process in which interaction between knowledge institutes and business world is key in all stages. Conceived in this way, it encompasses an often long lasting chain of parallel 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.

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 or stimulating influence on the speed and success of the process, including regional factors. It seems that the lack of insight and understanding is mainly caused by the comprehensiveness of the phenomenon of knowledge, and consequently of its valorisation. The many forms knowledge may take make it difficult to picture the flow of knowledge. Knowledge may be tacit and it may be codified in journals, patent descriptions, etc. At the same time, knowledge valorization may take many modes or channels, like licensing of a patent to a firm, university-business research joint ventures, university-business collaboration, university staff detached in business research departments, and the above-mentione spin-off firms. An increasing literature in recent years has been devoted to what makes university researchers being involved in knowledge valorization, looking at the level of the researcher and level of sectors (e.g., Bekkers and Boddas-Freitas, 2008; Bercovitz and Feldman, 2008; d’Este and Patel,
2007), but what is missing is research on the level of projects in which university-business collaboration is established and introduction to market may be reached.

In addition to this gap in understanding, policies to take advantage of the role of universities have seldom been differentiated between regional systems in core economic areas (usually seen as more competitive) and other areas (non core, less competitive). This despite the fact that increasing evidence is being found or argued between such systems in European countries (like the UK) (Huggins and Johnston, 2009) but also countries like Korea (e.g. Sohn et al., 2009), see also Tödling and Trippi (2005) and Lagendijk et al. (2007). This paper responds to the above two gaps in understanding, by addressing the following questions: (1) To what extent are research projects aimed at bringing knowledge to market successful reaching the aim of market introduction? How does this vary between different regions? (2) Which factors hamper an effective and quick valorisation? (3) In which ways could ‘living labs’ respond to needs for a more comprehensive and quicker way of commercialization?

The study takes The Netherlands as an example. The Netherlands is a relatively small country with a population of 16.4 million. It has committed itself to the EU’s Lisbon and Barcelona objectives to improve the competitive performance of Europe. However, the country is facing particular circumstances in its innovation system that can be characterised as a paradox and this is connected with a position in the 2009 European Scoreboard as ‘innovation follower’ (Pro Inno Europe, 2009). The Netherlands has a relatively weak performance in R&D expenditure but a strong performance in scientific output. However, the high level of scientific output goes along with relatively low levels of application of innovations in manufacturing and services (NOWT, 2009). Apparently, university-industry interaction suffers from various shortcomings.

The paper has the following structure. Various theoretical perspectives that contribute to an understanding of outcomes of knowledge commercialization are examined in Section 2. This is followed by a discussion of the regional valorization system (Section 3). The paper proceeds with a discussion of the methodological characteristics of the empirical study, and with empirical results on market introduction and failure (delay), particularly regional differences in these outcomes (Section 4 and Section 5). Factors underlying failure and delay in valorization are discussed in Section 6, and suggestions for policies responding to these factors are proposed in Section 7, with special attention for ‘living labs’. The paper closes with a summary and outlook on future research.

2. Theoretical Perspectives

The extent in which new knowledge is brought to market is subject to a myriad of influences according to theoretical studies. Innovation studies in general tell us that market introduction depends on the nature (profile) of the invention (radical/incremental) including its cost level, the market (regulation, subsidies, market demand), the strategies of the firms that are involved, and the learning models used by university and industry (Utterback, 1996; Christensen, 2003; Tidd and Bessant, 2009). In terms of radical/incremental character, it seems that radical inventions requiring structural changes in infrastructures or even transitions (like the fuelling infrastructure in the case of electric cars, and road construction and equipment in the case of automated guided vehicles) face more obstructions than inventions that are incremental and fit into existing structures (Geels, 2004).
Of course, the cost level plays a role and the trade-off between newness/additional benefits of the invention and additional costs compared with existing products or processes. In addition, the way to market introduction may be full of obstacles in the case of heavy regulation, like in designing new drugs due to intensive testing and approval procedures. Conversely, inventions without such regulation and at the same time a strong subsidization by public money, may face an acceleration of their way to market. Such inventions may be dealing with cleaning the environment, like treatment of solid waste, polluted air and water. In connection with the previous factors, innovation strategies of the involved firms may play an important role in bringing inventions to market. For example, firms may follow the path of first movers or follower (Lieberman and Montgomery, 1998; Hall and Lieberman, 2007), or various [paths in-between. In addition, shifts in strategy of collaborating firms may have an impact on attention for an invention at university. Firms may, for example, lose initial attention if they gain easy access to a competing innovation, as a result of the strategy of merging or acquisition. Similarly, spin-off firms may become less focused on an invention if they move attention to consultancy, e.g. as a strategy of internal investment or merely of survival.

A further relevant body of theory is organizational learning, telling for example that collaborative learning in innovation is only possible if organizations are sufficiently different in particular expertise such that they can learn from each other, but not too different in culture that they risk failure in understanding (e.g. Nooteboom, 2009). In addition, in regional innovation studies ideas have been forwarded on factors that hamper or stimulate knowledge creation and learning, and market introduction of inventions. Among these are studies emphasizing agglomeration economies of large cities (Feldman, 1999; Capello, 2006), particularly knowledge spillovers, presence of pools of specialized workers and other creative people (e.g. Florida, 2002), as well as access to global traffic nodes. From a somewhat different perspective - the global city thesis - advantages of a large metropolitan area refer to proximity to major decision-making units, mainly private ones (corporate headquarters), a highly specialized service sector, and strong presence of high level professionals (e.g. Sassen, 2005). However, there is also an increased attention for diseconomies in large cities, like scarce land and high rents, and shortcomings in the traffic system.

Other schools in regional innovation studies emphasize benefits from a common regional culture, trust and social networks facilitating knowledge exchange, among others facilitating the use of concepts of open innovation (Keeble et al., 1999; Maskell and Malmberg, 1999; Cooke et al., 2004). In more practical approaches attention is drawn to advantages of specific support infrastructure and policy, including the supply of incubators, business accelerators and support packages for spin-off firms (Hannon and Chaplin, 2003; Hackett and Dilts, 2004; Soetanto and Van Geenhuizen, 2007; Van Geenhuizen 2003, 2009).

This section can be concluded with the remark that there are two potential ‘sources’ of regional differences in knowledge valorization. First, external conditions that favour or hamper valorization may be different between regions, like the labour market and networks within the region that enhance open innovation. A second source of regional differences is a different choice of research projects at university, e.g. research projects in medical life sciences and biology (genetical engineering) and research projects in electrical engineering, the first facing larger risk.

3. Regional Systems of Knowledge Valorization

The previous section indicates that many factors work directly and indirectly in influencing processes of valorization of knowledge (Figure 1). Important direct factors (within the
university) are the type of inventions being brought to market (e.g. incremental or more radical ones), the size and composition of the teams that work on the development towards market, and atmosphere and institutions supporting transfer and commercialization. With regard to teams at university, Etzkowitz (2003) views 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 skills 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. Also, the orientation of the team might be more on the fundamental side of science and technology facing a lower affinity with valorization.

A main factor directly at work is interaction between university and the business sector (Figure 1). The term interaction is used in this context, not transfer, because increasingly university research is triggered by questions from the business sector, making the development process of an invention a two-way (interactive) process instead of a one-directional linear process. In the interaction between researchers and firms, learning in bringing an invention to market may follow different models dependent on the types of technology involved. A distinction can be made between science-based learning including laws of nature (know-why), like in life sciences and nanotechnology, and problem-based and engineering type of learning with new applications (combinations) of existing knowledge (know how), like in medical instruments and automotive (Asheim et al., 2007; Tidd and Bessant, 2009).

Relatively few studies have investigated the nature of hampering, or conversely, converging factors in university-industry relations, but attention is increasing (e.g. Bjerregaard, 2010; Bruneel et al., 2010). Two common origins of hampering factors are orientation-related and IP (intellectual property) and university administration related. This may be explained as follows. Due to different systems of knowledge production, there is generally a weak attitudinal alignment between university researchers and private firms. Time lines in most firms are shorter than in university research, and firms need to adapt quickly to changing circumstances in the market while universities can remain quite stable in their choices. In addition, while researchers are keen to disclose information (in journals) as quick as possible, firms often prefer to keep the new knowledge secret or to appropriate the new knowledge (Westness and Gjelsvik, 2010). IP and university administration related obstacles also include different capabilities of university and industry in handling patent applications and licensing, and different strategies in making most benefit from patents, particularly when these are owned by both.

Regarding indirect factors, Figure 1 pictures the regional ecosystem of firms, including customers, contractors, competitors, and collaborators. If well-developed, this ecosystem provides supportive services, potentials for subcontracting, knowledge collaboration and collective learning, aside from ‘bridges’ to knowledge sources in the country and abroad. These kinds of benefits have been indicated in the literature on regional innovation systems and on clusters (Porter, 2003; Cooke et al., 2004; Bathelt et al., 2004). The size of the business ecosystem and the presence of large (global) players herein seem important, not only to develop economies of scale and scope but also to create a ‘critical’ mass above which growth starts to develop as a self-propelling mechanism and the region can compare with other technology regions in Europe.
The figure also shows importance of organizations of applied research, of financial incentives and of the regional labour market. The latter not only refers to specialized academic knowledge workers but also to skilled practical workers, like technicians and laboratory analysts. Similarly, an adequate supply of business accommodation, land on industrial parks and science parks (e.g. Van Geenhuizen and Soetanto, 2008), university campuses and new large firms’ campuses where some forms of open innovation can be practiced, provide important conditions. Quality of life (housing and facilities) in the region and city is also important. This refers to attracting and keeping knowledge workers (graduates) in the region, in particular international top scientists from abroad (Florida, 2002). This is a matter of improving the housing stock but also increasing quality of life, and partially of creation of a metropolitan atmosphere, including high-level cultural amenities and a sphere of tolerance.

What has increasingly attracted attention is the ‘organizing capacity’ of the municipal and regional authorities (Van den Berg et al., 2003; van Geenhuizen and Nijkamp, 2007). This quality characteristic of governing refers to the capacity of local/regional political actors to achieve and maintain consensus and a sense of urgency on the direction of knowledge-based development in the city/region in the near future, and to gain sufficient commitment for policies that support this development direction. More specific it refers to the capacity to connect university, public policy actors and the business sector, to gain benefits from collaboration and activities in each other realms (Triple Helix) (e.g. Etzkowitz, 2008). The need for such capacity and the potentials to build it may differ between local situations, like polycentric city systems home of various different universities and monocentric cities with one university.

**Figure 1 A simplified model of a regional valorization system**

*Source: Van Geenhuizen (2010).*
The national innovation system should also be mentioned, as it influences for example how science and technology policy, particular public R&D spending, is organized, and how entrepreneurship and knowledge commercialization are valued in society (e.g. Edquist and Johnson, 1997). Moreover, knowledge commercialization is also influenced by manifold regulation, like concerning R&D and market access (testing rules, quality control, ISO standards, avoiding genetic manipulation, etc.) but nowadays national regulation partly originates from European Union regulation (Rathenau Institute, 2009).

4. Methodological Aspects

The analysis of results of valorization involves two steps. First, a broad scan of the outcome of almost 370 research projects financed by Technology Foundation STW (STW, various years) in terms of market introduction, continuation and failure, and secondly, an in-depth study of approximately 35 projects representing these different outcomes.

Technology Foundation STW (note 2) in its annual Utilisation Reports provides for each project a short description and evaluation of results at 5 or (if appropriate) 10 years after take-off of the project. This information, in some cases together with web-based information, enables us 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 through firms or to use in society, like in health care and environmental fields. The label is also given if software (as main part of a project) was brought to market. This quite strict definition is adopted to identify the ‘success stories’. However, this does not mean that projects not labeled like this have been useless. On the contrary, in the course of time these projects often have led to research contracts with potential users, patent applications, and they have gained investment money and have led to clear-cut products, processes or methods, but they have simply not reached the stage of market introduction or application in society. Of course, the knowledge developed in such projects may still be partially used in other ways, like in particular branches of the original research at university, and in research at firms where PhD graduates formerly engaged with a project found a job.

In line with this, failure is defined as ‘not having reached the stage of market introduction/use in society’. In a few cases this happens quite early with ceasing the project before the official end date or directly after the end, if no continuation is undertaken. In most cases however, it takes a longer time before the project is stopped. Aside from these two categories of end results, there is a category of ‘stagnation or development unknown’ (older projects) and a category ‘continuation’.

In view of the long-lasting nature of knowledge commercialization, two different periods of project take-offs are selected in the current study, i.e. the years 1995 to 1997, and the years 2000 to 2002. A reason for taking two periods separately is also the change in economic climate in the early 2000s which makes an aggregate analysis of all years dangerous. It is plausible that in the early 2000s firms have been reluctant in engaging themselves with valorization. In addition, there is a difference in awareness of valorization and requirements for success in the two periods: relatively low at the end of the 1990s and stronger since then. Further, 2002 is selected for practical reasons; this is the year of the most up-to-date evaluation information available at the time that the current study took off (2008). For the first period, STW provides evaluation information after 10 years, for the second period it provides
evaluation information after 5 years. In addition, each period covers a sufficient amount of projects representing the metropolitan core area and other areas in the Netherlands (note 3).

A scan of almost 370 projects is followed by an in-depth analysis of hampering factors in commercialization. This part draws on a selected sample of approximately 35 projects representing market introduction/use and failure (delay), and covering the two types of regions. To avoid the result of many different influences from technology and markets circumstances, the sample covers a limited number of technology segments, i.e. biotechnology (medical and industrial), medical technology (instruments/software), new materials (nanotechnology) and systems for sustainable energy, and automotive. The respondents in the in-depth interviews are the project leaders of the research at university.

5. Outcomes of Research Projects

The following outcomes could be identified. Failure is faced by a minority of the projects, 26% in both sets of cohorts (Table 1 and Table 2). On the other side, market introduction is 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 follow from the short time-period in consideration. With regard to the two types of regions, the results for the first period reveal a trend of a higher failure rate as well as a higher rate of market introduction in the core metropolitan area compared with adjacent regions (Table 1), witness shares of 28% vs. 18% and 29 vs. 20% respectively. These outcomes support the idea of higher levels of newness and creativity (breakthroughs) as well as higher levels of risk-taking in core areas, particularly Amsterdam and Utrecht, but also favourable conditions in bringing projects to market and use in society, like tighter connections with public decision-making in the national government (Delft University of Technology in Delft).

In the second period, the core has remained quite high in failure (29 vs. 20%) without a high level of market introduction (14%). This pattern suggests that core regions tend to remain ‘stuck’ in a high failure rate more recently. The causes of this shift may be first, a remaining high risk-taking such as in projects concerning genetic engineering (biology) and medical life sciences. What might also be behind this change is the principle of open innovation adopted in high-tech manufacturing in other regions, particularly the region of Eindhoven, thereby improving university-industry interaction and reducing failure.

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

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

Source: calculation based on information from STW and website information.
If we focus on the time needed for new technology to reach market introduction or use in society, it appears that knowledge valorization is a long-lasting process. In almost a third of the projects taken off in 1995-1997 (32%) R&D is still continued after 10 years (Table 1). The case studies indicate that in medical life sciences a total of 15 to 20 years is not an exception. In medical technology (instruments and software) the time is shorter if the invention deals with product improvement that can avoid time-consuming approval procedures. In general, time is shorter if the R&D is driven by demand from the business sector and takes place in close collaboration with a firm, and if the invention is a new application of existing (proven) knowledge. Valorization of projects of these kinds tends to take only 5 to 8 years.

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

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

6. Hampering Factors

We distinguish between the following factors (Figure 1): (1) internal factors, including characteristics of the invention, the project/team and the broader organizational context at university, (2) interaction factors, concerning the relation between university researchers and firms, (3) external factors typical for the region, and (4) external factors typical for The Netherlands (national system). The results for older projects are as follows (Table 3):

- Broadly speaking, almost 60% of all factors reside in the ‘oval’ of the projects (Figure 1), including the profile of the invention, the organizational context (team and university) and university-firm interaction. By contrast, regional factors amount to almost 30% and national factors to almost 13%.
- Shortages in the organizational situation at university constitute the single most important hampering factor (29% of all factors). This concerns not only a lack of affinity of some researchers with valorization, but also a reward structure that does not encourage this activity. In addition, in some cases valorisation may suffer from reorganisation of faculties leading to closing down, regrouping of specialized research groups, and small capacity of transfer organizations.
- Next are limitations in interaction with firms (19%). This is concerned with sudden changes in preference of collaborating firms due to an emerging situation of high risks-high costs and emerging competing technology. It seems plausible that the high level of failure in the core area originates from the choice of projects, like in biotechnology (genetic engineering) and medical life sciences which are more than any other sectors vulnerable to failure. Changes in strategy of collaborating firms play also an important role, like closing down of R&D departments, and merger and acquisition coming with new strategies.
• Among regional factors, a lack of particular financial incentives hampers valorization most frequently (11% of all factors). This factor is concerned with investment subsidies to attract firms from outside the region and abroad (absent in part of the core area) and with easy access to regional venture capital and large amounts of such capital (absent in all regions). Second are shortages in the labour market and business accommodation. Labour market shortages (specialists) occur both in the core metropolitan area and other regions if inventions do not match with the industrial structure of the region. Further, shortage in business (incubation) accommodation holds only for the core metropolitan area (Delft and Amsterdam).

A factor worth attention is an unfavourable profile of the invention (11%). Inventions that have no outlook on mass production are too expensive for the extras they bring (no breakthrough). Similarly, inventions that bear strong technology risks in next steps of the research, often suffer from lack of interest from firms and investors from the beginning. Our guess it that an unfavourable profile particularly holds true for general universities in the core region facing a persistently high risk of failure, mainly connected to medical life sciences and genetic engineering (biology).

Table 3 Factors hampering valorization a)

<table>
<thead>
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<th></th>
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<tbody>
<tr>
<td><strong>Internal</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profile of invention</td>
<td>7</td>
<td>11</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Project/team and organisation at university</td>
<td>18</td>
<td>29</td>
<td>8</td>
<td>21.6</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>25</td>
<td>39.7</td>
<td>11</td>
<td>29.7</td>
</tr>
<tr>
<td><strong>Interaction with business world</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emerging high risk and high costs</td>
<td>4</td>
<td>6.3</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Change in strategy of cooperating firm</td>
<td>4</td>
<td>6.3</td>
<td>4</td>
<td>10.8</td>
</tr>
<tr>
<td>Emerging new technology</td>
<td>2</td>
<td>3.2</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Opportunistic behaviour by firm, investor</td>
<td>2</td>
<td>3.2</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>12</td>
<td>19.0</td>
<td>5</td>
<td>13.5</td>
</tr>
<tr>
<td><strong>Regional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business ecosystem</td>
<td>2</td>
<td>3.2</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Financial incentives</td>
<td>7</td>
<td>11.1</td>
<td>4</td>
<td>10.8</td>
</tr>
<tr>
<td>Labour market</td>
<td>4</td>
<td>6.3</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td>Business accommodation</td>
<td>4</td>
<td>6.3</td>
<td>3</td>
<td>8.1</td>
</tr>
<tr>
<td>Remaining region</td>
<td>1</td>
<td>1.6</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>18</td>
<td>28.5</td>
<td>14</td>
<td>37.8</td>
</tr>
<tr>
<td><strong>National factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation (e.g. prohibition of certain tests)</td>
<td>4</td>
<td>6.3</td>
<td>1</td>
<td>2.7</td>
</tr>
<tr>
<td>Culture/attitude (entrepreneurship, valorisation)</td>
<td>3</td>
<td>4.8</td>
<td>4</td>
<td>10.8</td>
</tr>
<tr>
<td>Remaining national system</td>
<td>1</td>
<td>1.6</td>
<td>2</td>
<td>5.4</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td>8</td>
<td>12.7</td>
<td>7</td>
<td>18.9</td>
</tr>
<tr>
<td><strong>Totals (number of factors)</strong></td>
<td>63</td>
<td>100%</td>
<td>37</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: interviews by the author.
The following factors can be observed among younger projects, but the small number of factors mentioned in the interviews (37) call for a cautious interpretation (Table 3):

- Direct factors (internal and university-industry interaction) have lost importance (fallen back form 60% to almost 43%), particularly due to improvement in the organisational context at university, but also due to absence of situations of high risk-high cost steps in valorisation and emerging new technology. It is plausible that this improvement rests on an increased learning experience and awareness among researchers and university managers. At the same time, new factors are forwarded as blocking factors at university (22%), like a low urgency of valorization and lack of a professional approach in valorization by TTO’s (all regions).

- With regard to regional factors, lack of financial incentives tends to remain important on a modest level (11%), but shortage in the business ecosystem tends to increase in importance be-it on a modest level (8%). The absolute numbers are small in this segment. In another part of the study however – on key roles of the region in valorisation, not reported here - this factor is emphasized (Van Geenhuizen, 2010), reason why more attention is paid to this factor. Shortage in the business ecosystem refers to lack of ‘critical mass’ of the regional economy (and university). The regional economy cannot exceed a certain size limit before growth starts to propel itself and the region becomes attractive for large firms from abroad (outside the core region).

7. Policy Suggestions

Table 4 reports various suggestions following from frequently raised hampering factors. Note that these suggestions do not cover the whole spectrum of challenges, but is limited to those forwarded by respondents in our study (research managers). Note also that a distinction can be made between challenges that hold for all types of regions and challenges in one of them.

The challenge of a conscious valorization policy at university and a policy to better prepare researchers for valorization is important in all regions. This also holds for improving the financial system addressed to city/regional governments With regard to universities, the most significant change is concerned with the reward structure of researchers: there is a need to reward valorization in a manner similar to scientific publications. Currently the Ministry of Education, Culture and Science is performing experiments with a new reward structure at some faculties in The Netherlands. Working more indirectly, is the challenge to align the focus in research programs at university with local and regional cluster policies. Another challenge to be addressed to universities is to increase knowledge on marketing and market value of inventions, and to increase knowledge on strategic behaviour of collaborating firms among researchers active in valorization. This could be realized through extra training of university researchers, but also through detachment or part-time appointment of industry managers at university and of university researchers in industry. The previous policy also contributes to getting industry involved and committed early in time, particularly in testing pilots.

With regard to challenges for city/regional governments, improving the financial system responds to the need to create a level-playing field over all regions with regard to location subsidies in the core region. To create easy access to venture capital and sufficient amounts of
it (all regions) is another challenge. Pre-seed and seed capital seems to be sufficiently available but at the stage where huge amounts of capital are needed to scale-up production for testing while the outcome still faces large risks, venture capital is needed. Local and regional governments may be helpful here as they can initiate the establishment of funds together with local and regional banks, the universities and other research institutes. The Amsterdam Life Sciences Fund is a first example of such initiatives. Further, regarding the desire in non-core areas to increase ‘critical mass’, city/regional authorities may contribute in different ways. We mention enhancing alliances with other universities and universities of applied sciences in the region, as well as developing various models of attracting students (masters) from abroad. The latter means to respond to a higher claim on student housing and to create a quality of life that would increase the retention of these students in the area.

Table 4  Policy suggestions based on research managers’ opinion a)

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Suggestions addressed to</th>
<th>Details</th>
</tr>
</thead>
</table>
| Increase speed of valorisation and decrease failure (all regions) | University               | A conscious policy, including:
- organization of regular university-industry meetings, and of early involvement of industry
- appointment of additional (part-time) staff from business
+ introduction of reward structure favouring valorisation
+ selection of thematic areas in a common regional research agenda (coherence and alignment with regional cluster policy)
- selection of a balanced mix of type (newness) of inventions, increasing the share of user-driven inventions and of new applications of existing technology |
| Smoothen university-industry relations (all regions) | University               | A policy to better align researchers and business interaction:
+ increase knowledge on marketing and market value of inventions and on proactive and strategic behaviour
+ getting industry involved in and committed early in time, particularly in testing pilots
- increase knowledge on patenting and (strategic) patent use
- introduce transparent deals on ownership (patents and other ways of appropriation) |
| Increase ‘critical mass’ in business ecosystems (non-core regions) | City/regional government | A policy to grow selectively (‘critical mass’):
- support a stronger cluster specialization (niches) and stronger cooperation with other clusters
- support growth of university through various models (national/international subsidiaries; collaboration with other HEI’s) |
| Improve system of financial tools/ incentives, and first customer (all regions) | City/regional government | City/region as initiator of new tools and as co-investor:
+ create local/regional financial investment funds by bringing local actors together (province, universities, local banks, research institutes) and acting as co-investor
- act as buyer of innovative products (launching customer) |

Source: interviews by the author.

a) Managers of research projects as well as managers of research and knowledge transfer organisations.
b) + = relevant
‘Living Labs’ as a new concept

It is worth mentioning that new ‘generation’ of policy concepts is emerging aimed at an acceleration of knowledge valorization in more open networks of innovation. These concepts put emphasis on the capacity of the region and regional actors to perform as ‘testing beds’ or true ‘living labs’. The latter distinguishes itself by using experiments in real-life environments 24 hours around the clock in which inventions are interactively developed (co-designed), validated and tested with customers (LivingLabs, 2010). Much knowledge valorization lends itself to be accelerated in this way in healthcare, environmental protection, sustainable architecture, local safety, local transport issues and telecom and multimedia. In this context users are individual persons or households in their physical environment including houses, public spaces like railway stations and airports, and sport arenas, etc. However, users may also be companies, non-profit organizations and city/regional authorities, the last in e-government.

The aims of ‘living labs’ are still somewhat fluid and different for diverse parties (e.g. Dutilleul et al., 2010). This situation means that before cities/regions start to promote them and/or participate in them, it is worth to identify bottlenecks to their performance and disadvantages for particular parties involved. Note that the type of learning and interaction in valorization is different between user-centric inventions and science-based inventions, the last including life-sciences and material sciences (e.g. Asheim et al., 2007; Tidd and Bessant, 2009). The concept of ‘living labs’ so far is applied to inventions in fields that are close to customers (user-centric) but they may also be connected with more basic research in which resources are pooled in ‘open innovation’ projects between universities, research institutes, and large and smaller firms. In terms of geographical coverage, some ‘living labs’ are regional, but an increasing amount are national and European as well, connecting cities, major universities and multinational firms. Table 5 reports preliminary results on how ‘living labs’ could respond to the most important challenges identified in this study.

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

<table>
<thead>
<tr>
<th>Challenge</th>
<th>Potential contribution</th>
</tr>
</thead>
</table>
| Increase of speed of valorisation and decrease of failure | -Early interaction of university and firms with customers, including early testing and early insight into (changing) customer preferences  
-Synergy and serendipity stimulated by connectedness of a variety of partners  
-Investment - and venture funds stimulated by connectedness of a variety of partners that fuel these funds (a)  
-New models of financing through co-design |
| Smoothen university-industry relations        | -Increased knowledge at university on marketing, market value of inventions, and strategic behaviour of (larger) firms  
-Change of attitude at university towards industry  
-Reduced uncertainty for universities through co-design relations with firms |
| Increase ‘critical mass’ in regional business ecosystem | -Increased ‘critical mass’ for co-design, validation and testing (large and more varied knowledge bases) through linking ‘living labs’ nationally and internationally |

(a) For example, large firms, universities, financial institutes and local/regional governments.
We may conclude in a preliminary way that ‘living labs’ supply good potentials for speeding up valorisation and diminish failure, for smoothening university-industry relations, and ‘increasing critical mass’ in the regional ecosystem. However, ‘living labs’ so far are mostly dealing with user-centric innovations, whereas valorization covers a much larger area. How successful ‘living labs’ are in reality remains to be seen as documented experience is still scarce and ‘living labs’ by nature are also emergent in various aspects.

8. Concluding Remarks

Drawing on an evaluation of 370 projects and a detailed analysis of some 35 projects in The Netherlands, this paper has brought to light preliminary results on the extent in which technology inventions are brought to market. The paper responds to two knowledge gaps in the current literature, first, a lack of knowledge on valorization on the project level and, secondly, a lack of knowledge of differences between various regions in valorization outcomes. The questions were as follows. (1) To what extent are research projects with potentials to bring knowledge to market successful in reaching this aim? How does this vary between different regions? (2) Which factors hamper a quick valorisation? (3) In which ways could ‘living labs’ respond to needs for a more comprehensive and quicker way of commercialization?

Failure is faced by a minority of projects whereas market introduction is also faced by a minority of projects. Older projects in the core metropolitan area tend to experience a relatively high rate of market introduction but also a relatively high failure rate. However, with regard to more recent projects the differences between core areas and other regions tend to change leading to a situation in which projects in the core area seem ‘stuck’ in failure without a high rate of market introduction. Factors underlying this pattern were found in a different choice of projects at university between the core area and other regions, i.e. more science-based and also more often technologies facing greater risk and consuming more time in the core area compared to other regions. Another hampering factor in the core area is the absence of location subsidies which makes attracting firms from other regions and from abroad more difficult. In general, the main hampering factors include circumstances in the organizational context at university and in the interaction between university researchers and firms, as well as shortage of (regional) financial incentives, particularly a shortage of (large amounts) of venture capital.

The work in this paper contains various limitations. The first one follows from the use of information from one particular source of financing technology research. It is possible that other financing programs in The Netherlands in which the business sector is stronger involved or involved in other ways, may produce a somewhat different picture. However, the in-depth interviews in the current study were structured in such a way that a broader picture of subsidies could be reached than merely the particular financing source. This situation suggests that the result of most important obstacles to valorization have larger implications. Secondly, this study had to narrow with regard to technologies and applications. Fields like microelectronics and information and communication technology, including multimedia and gaming for example, have remained beyond the study of hampering factors.

Given the previous results and implications, the following research avenues can be envisaged. First, in the current study the emphasis is somewhat on science-based research. Next part of the research will have a stronger focus on user-driven projects and add these to the database. Secondly, in the current study hampering factors have been presented ‘disconnected’ from the
individual projects. Next part of the research will allow for testing causal models on the individual project level, thus connecting characteristics of the projects with outcomes in reaching the market. Thirdly, one of the conclusions of the current paper is that industry needs to be involved in valorization at university much earlier than usual. In attempts to speed up valorization today, ‘living labs’ are mushrooming. However, there is a need to better clarify the concept and its practical applications, particularly which types of learning can be accelerated. Whether ‘living labs’ can really respond to challenges in knowledge valorization remains to be seen, because of their recent emergence and emergent character.

Acknowledgement
The study has benefited from a subsidy by NICIS (Netherlands Institute of City Innovation), four cities (Amsterdam, Delft, Eindhoven, and Maastricht), and TU Delft.

Notes
1. Compared to knowledge commercialization, the term knowledge valorization also refers to non-commercial applications, which is more correct. Therefore, we prefer using the term knowledge valorization.
2. STW has been funding scientific research at universities and institutes in The Netherlands since 1981. Its methods in organization of research bring together, immediately after start of the research projects, researchers and potential users of the results of these projects. The ‘users’ provide input and also financial or other contributions to the project. The consultations during the projects ensure that the research groups and users get as much as possible out of these contacts.
3. The study is restricted due to financial support. Therefore we could not include all research universities. We selected them as follows: (1) the core area and (2) outside this area at a substantial distance, in the eastern and southern part of the country. We included Delft University of Technology in Delft, University of Amsterdam and Free University (both in Amsterdam), Leiden University (Leiden), Erasmus University (Rotterdam) and Utrecht University (Utrecht) (all in the core area), and Eindhoven University of Technology (Eindhoven), Radboud University (Nijmegen), and Maastricht University (Maastricht) (other regions). With these nine universities, the coverage of research universities is almost 70%. The coverage of relevant universities (with bêta faculties and/or medical schools and academic hospital) in the core area is 100%. The coverage of relevant universities in the eastern and southern regions is 75%.

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