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University commercialization policies and their implementation in the Netherlands and the United States

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The article explores how the US and Dutch governments have attempted to bolster research commercialization in their respective research systems and discusses the institutionalization of linkages between universities and industrial firms. First, the article shows how the institutional framework conditions compare in national systems of innovation (NIS) in the Netherlands and the USA with a special focus on regulatory and funding policy instruments. Second, it examines the influence of institutional framework conditions on the linkages that exist between universities and industrial firms in the two countries. Third, the article investigates how the institutionalization of university–firm linkages compare in the two countries. The findings suggest that path dependencies partly shape the process of research commercialization in terms of the timing and the types of policy instruments forming the institutional framework conditions in the two countries. The creation of university–industrial firm linkages is a challenge for governments irrespective of the type of NIS in question partly due to organizational inertia and informal institutions.

RESEARCH ON KNOWLEDGE commercialization and entrepreneurship has recently shown a greater interest in public policy that parallels the current interest governments worldwide have in building innovation capacity and competitiveness. This perspective centres on the development and promotion of national instruments and frameworks that foster public–private partnerships by increasing cooperation between universities and industry (Link and Siegel, 2007). Interest in understanding university–industry relations has accordingly intensified. For nearly two centuries now, European companies have collaborated with university scientists, and the practice-inspired basic research of some of these scientists has led to the development of new types of industries (Stokes, 1997).

However, in an era of open innovation (Chesbrough, 2003), collaboration between university scientists and industry goes beyond the outsourcing of research activities from firms to universities. Nowadays, collaboration means creating linkages of various shapes, including networks of strategic partnerships between firms, suppliers and universities (Borrell-Damian 2009). In this context, the deeper understanding of the policy mechanisms shaping certain types of linkages between universities and industrial firms is paramount.

In this article, I analyze how the US and Dutch governments have attempted to bolster commercialization of research in their respective research systems, and the extent to which they have created linkages between universities and industrial firms. I address three related questions:

1. Drawing on a national system of innovation (NIS) approach (Nelson, 1993), I show how the institutional framework conditions compare in the Netherlands and the USA, with a focus on regulatory and funding policy instruments.
2. Following North's model of institutional change (1990), I examine the influence of institutional framework conditions on existing linkages between universities and industrial firms in the two countries.

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3. I compare the institutionalization of university–firm linkages in the Netherlands and the USA.

This study specifically focuses on vertical linkages between universities and industrial firms (Balzat, 2006). These are formal and informal cooperation arrangements between two different types of organizations. Vertical linkages are pertinent to this study since they have been the focus of research commercialization policies in various countries for the past two decades (Dill and Van Vught, 2010).

Policy frameworks in countries of different national research governance and NISs are likely to vary significantly (Nelson, 1993). However, presuming that different governments are trying to achieve the same goals, namely research commercialization and a creating of functional linkages in their respective NISs, comparison of those governments is pertinent. The focus on the Netherlands and the USA is relevant because of differences in their research governance models and R&D-funding intensity.

The USA represents the Anglo-Saxon research governance model, with its emphasis on competitive science funding and university budgets that are highly reliant on third-party income, with a considerable R&D contribution coming from the private sector (gross domestic expenditure as % of GDP (GERD), 2.77% in 2008; OECD, 2010). The Netherlands follows a 'Continental' research governance model (Clark, 1983), in which science funding and university budgets have traditionally been determined on a historical rather than a competitive basis (GERD as % of GDP, 1.75% in 2008; OECD, 2010).

Moreover, while US universities have traditionally faced competition for resources, and research has been more geared towards commercial opportunities (Mowery, 2009), Dutch universities have been 'steered' by the state due to their high dependence on public money. Despite these differences, the two systems have the similar goal of research commercialization behind their governmental funding schemes.

To illustrate each country's implementation of research commercialization policies, two research universities that reported high performance on entrepreneurial activities as measured by third-party income, number of patents and spin-offs, were selected. Both universities are known for excellent science and engineering and have been actively pursuing external public research funding that is geared towards commercialization, and have similar structures in terms of the division between departments and research institutes.

A variety of sources inform my work. To study research commercialization policies at the national level, I use secondary sources (governmental reports, evaluations of research systems and other relevant literature). I also analyze written documents (reports, web-site descriptions, mission statements) for the two universities. Finally, national statistics of R&D funding using data from the National Science Foundation (NSF), the Ministry of Economic Affairs (MEA), and the Netherlands Research Council (NWO) are analyzed.

At the institutional level, data was gathered on university funding and staff evaluation criteria. I also interviewed scientists actively collaborating with industrial firms, scientists working in spin-off companies, technology transfer officers, and managers responsible for research at the case-study universities. A total of 20 interviews was performed from 2009 to 2010.

2. Conceptual considerations

Public policy in recent decades has focused on the growing role of knowledge in the economy and in society. Policy-makers believe that university collaboration with industry is important to fulfill the university's so-called 'third mission' (entrepreneurial mission) (Mowery and Sampat, 2004). The role of universities in open innovation is crucial given that the locus of innovation has changed; innovation is no longer restricted to industry but takes place at the nexus of academia, state, and industry.

Researchers have used different approaches to examine these complex relationships (e.g. Etzkowitz and Leydesdorff, 1997; Gibbons *et al*., 1994; Rip and Van der Meulen, 1996). The NIS conceptual framework (Lundvall, 1992) helps particularly with understanding of the complexity of the governance of industry linkages with universities and the government. The framework considers the role of both formal and informal institutions in diffusing innovation, the path dependencies of different countries, and the role of universities in innovation (Dill and Van Vught, 2010).

The structure of an NIS is made up of actors, institutional framework, conditions and linkages between the different organizations, and institutions (Metcalfe, 1995). Institutional framework conditions can impede or enhance technological change; institutions themselves are 'the rules of the game in a society … the humanly devised constraints that shape human action' (North, 1990). In North's model, the institutional context is dynamic, path-dependent, and consists of formal institutions (e.g. economic rules) and informal institutions (e.g. socially sanctioned

Studying the institutional framework conditions of a national system of innovation is crucial to understanding changes that occur in organizations, and the success (or failure) of policy implementation

norms of behavior). North believes that the level of inertia depends on the relationship between formal and informal institutions; he proposes that informal institutions are much harder to change than formal constraints, even as reforms are mostly attempted through formal institutions such as laws and regulations. Hence, studying the institutional framework conditions of an NIS is crucial to understanding changes that occur in organizations, and the success (or failure) of policy implementation.

Further the links between different organizations are crucial for NIS since they foster and disseminate innovations. Actors seek to enhance their capabilities and their economic success with these linkages. The NIS approach distinguishes between different linkage types based on the formality of arrangements or on the types of interacting organizations. Balzat (2006) distinguishes between horizontal linkages, where actors belonging to the same organizational category cooperate in their R&D efforts (e.g. researchers from different universities), and vertical linkages, which refer to the linkages between actors from different types of organizations (i.e. university–industry collaboration). This article examines vertical linkages between universities and industrial firms, since vertical linkages have been the focus of research commercialization policies in the NISs of both the USA and the Netherlands.

Vertical linkages can further be distinguished based on the level of formality and contractual arrangements. ‘Formal’ or ‘hard’ linkages take the form of cooperation agreements or new organizational structures. ‘Informal’ or ‘soft’ linkages emerge spontaneously, and their stability may depend on the shared values of the partners involved. These linkages can take the form of personnel mobility, scientific conferences, scientific publications, and trade fairs (Dill and Van Vught, 2010). Knowledge transfer in informal linkages may occur incidentally, while it is predetermined in formal linkages.

Based on the above discussion two propositions are put forward:

1. The influence of formal institutions on vertical linkages between universities and industrial firms will be shaped by path dependencies in both NISs.
2. The institutionalization of the vertical linkages between university and industrial firms will depend on the persistence of inertia in organizations due to informal institutions.

3. Actors in Dutch and US national systems of innovation

Governments, ministries, and funding agencies that foster innovation can be characterized as the key policy actors who set national framework conditions in NISs. Key research performers (research institutions, universities, and private sector R&D companies) are vital to vertical linkage creation in NISs.

3.1 Governmental funding agencies of R&D in the Dutch and US national systems of innovation

In the Dutch system, education, research, and innovation are divided among several ministries as shown in Table 1. Traditionally, R&D policy falls under the realm of the Ministry of Economic Affairs (MEA), while higher education and research belong

Table 1. Actors in Dutch and US national systems of innovation

NIS actors	National innovation system	
	Dutch	**US**
National level	Ministry of Education, Culture and Science; Ministry of Economics, Innovation and Agriculture; NWO, Technology Foundation (STW)	Department of Education; NASA; NIH; NSF; Department of Health and Human Services; Department of Agriculture; Department of Defense; Department of Energy
Universities	14 doctoral-granting research universities; 8 medical centres	170 doctoral-granting research universities
Research institutes	Approximately 30 state-funded research institutes	38 federally funded research centres
Business firms	In 2003:	In 2003:
	8% small R&D-intensive firms	9% small high-tech R&D-intensive firms
	19% medium R&D-intensive firms	21% medium–low R&D-intensive firms
		37% medium–high R&D-intensive firms

Source: Moncada-Paterno-Castello (2010); MEA (2006) to the Ministry of Education, Culture, and Science (MECS). Other ministries related to research are those dealing with agricultural and healthcare issues, with the caveat that the boundaries between policy arenas are increasingly blurring. Besides the ministries, funding for research has been provided by various intermediary agencies. The Netherlands Organization for Scientific Research (NWO), together with its semi-independent divisions, is a very important source of peer-review, competition-based funding. The role of NWO has been strengthened by the MECS since MECS moved its program-funding instruments there in the 1990s. Other ministries participate in common initiatives to finance certain priorities under the auspices of NWO.

In the USA, the federal government provides support and funding for R&D through its different research agencies (Duderstadt, 2005). From World War II, when Vannevar Bush advocated for a governmental role in funding basic research, the Department of Defense became a major source for science and engineering funding. In the 1980s and 1990s, the National Institutes of Health (NIH) became an important research funder (Slaughter and Rhoades, 2004). The NSF is another major source of federal dollars today; it funds about 20% of federally supported basic research at US higher education institutions (US$6.9 billion in 2010) (NSF, 2011).

An important aspect of the way NSF functions compared to other funding agencies is the peer-review system. Similar to the Dutch NWO, the involvement of academic communities in the decision-making at NSF has been very strong in maintaining its mission of funding basic research over years (Stokes, 1997).

3.2 Research performers in Dutch and US national systems of innovation

As shown in Table 1, in 2010 the Dutch public research sector comprises 14 universities, including an open university, one agricultural university and three technical universities. In addition, there are more than 30 public research institutes of various sizes and shapes. Most are financed by the MECS, but other ministries finance ‘their’ sector institutes. Contract revenues have risen for research between 1990 and 2004. As reported by the MECS, the private share during this period rose from 22% to 32% (MOCW, 2008). According to the NWO figures, 74% of R&D funding for universities comes directly from the state, 13% from NWO, 7% from the private sector, and the rest from abroad or from the non-profit sector (NWO, 2010).

Research performers in the US higher education sector are first of all major research universities. In 2008–09, the USA had 165 public and 105 private doctorate-granting research universities (NCES, 2009). The R&D system also includes 38 federally funded research centres that are administered by universities, non-profit organizations, or industry. These are usually funded by specific funding agencies (NSF, 2009). In 2006, more than 61% of university research funding came from the federal government. In 2006, the private sector accounted for 20% of university R&D funding; it has generally increased (with some fluctuations) over the years.

3.3 Business firms in Dutch and US national systems of innovation

The Dutch business firms’ R&D intensity is rather low; this could partly be attributed to the low level of high-tech industry in the country, as Dutch industry is dominated by the manufacturing and services sector and the share of high-intensity R&D for this sector is low (Table 1).

Eight major multinational companies are responsible for roughly 50% of the business enterprise research and development conducted in the Netherlands. The R&D intensity of Dutch industry depends heavily on R&D expenditure in these companies. Although the Netherlands has a couple of multinational giants and a well-developed industrial base, and is well-placed to compete with other countries, the research commercialization possibilities have been perceived as limited due to the lack of venture capital and business angels (Van Vught, 2008). The barriers to research commercialization are to some extent related to industry and business capacities.

The US corporate R&D effort is dominated by the high-tech sector (Table 1). It is a dynamic economy with a lower share of medium–low R&D intensive sectors (Moncada-Paterno-Castello, 2010). As noted by Foray and Lhuillery (2010), the peculiarity of US knowledge transfer is the involvement of high-tech service firms as knowledge brokers between universities and industries. Industrial funding of R&D is rather high compared to that in the Netherlands. In 2004, 64% of the nation’s total expenditures on R&D was spent by US industry, mostly oriented towards development (Geiger and Sá, 2008).

4. Institutional framework conditions

The institutional framework conditions (both formal and informal institutions) may converge for different NISs due to isomorphism, or remain different due to historical path dependencies. Dutch and US R&D-funding and research governance models diverge due to the orientation toward market-driven competition in the USA, and the orientation toward ‘state steering’ in the Netherlands.

In this context, I now discuss intellectual property, research-funding policies, and incentive mechanisms; this will help establish the similarities and differences in the institutional framework conditions. Then I will discuss the role of these conditions in the creation of linkages in the Dutch and US NISs.

4.1 Research policies in the two countries – towards the contribution of universities to society

Traditionally, technology transfer was not perceived as an important task of universities by the Dutch Government. In the 1970s, the aloof attitude of both government and society with respect to research was changing, and the Dutch Government made its first real attempts to intervene in the world of university research. The first White Paper to have a serious impact was published in 1979 (the Policy Document University Research, or BUOZ-paper). The BUOZ-paper identified several problems, such as the university being an 'ivory tower' and the shortcomings of academics in accounting for public money (De Boer *et al.*, 2006). Since the 1979 BUOZ-paper, several initiatives have been taken during the last 25 years to increase the internal efficiency of science production.

First, in the 1990s, knowledge production at universities was specifically defined as contributing to the benefit of society. The Higher Education and Research Act of 1992, amended in 2002, then noted that universities are responsible for the provision of education and research for the benefit of society (MOCW, 1992: art. 1.3).

The Dutch Government strove to promote excellence and relevance in university research and to bring efficiencies into the sector. These efforts continued in the 2000s with the recognition that knowledge production was vital to the economic well-being of the Netherlands. This ambition was defined by the government's 2004 science budget, titled 'Focus on excellence and added value'. The central policy themes of the science budget (MOCW, 2004) were focus and concentration, human resources, and quality. Increasing the relevance of university research was also a prominent objective. To overcome the underlying concern about the gap between the discovery and use of knowledge, the government proposed enhancing the scale of research activities (clustering, concentration, and consortia) and increasing the relevance of pure knowledge to industry and society (Leisyte, 2007).

Knowledge commercialization policies have also been complemented by initiatives from intermediary organizations and university representatives. Given the tradition of consensual democracy in the Netherlands, the role of these agreements should not be underestimated

Knowledge commercialization policies have also been complemented by initiatives from intermediary organizations and university representatives. Given the tradition of consensual democracy in the Netherlands, the role of these agreements should not be underestimated. For example, the Valorization Agenda (2008) agreement to promote research commercialization was signed by a range of stakeholders. The agenda shows the willingness and the commitment of different stakeholders within the Dutch NIS to contribute to knowledge valorization (utilization of the results of scientific work). It includes a joint vision on how to approach knowledge transfer, concrete actions for each stakeholder to take, and joint knowledge targets for all stakeholders.

This document demonstrates the 'steering' of the Netherlands Government to further investment in knowledge commercialization, while also monitoring progress with metrics and introducing it into research evaluation at universities. Professionalization of staff through training and development of technology transfer facilities by both public research organizations and industry are other instruments set in the agenda. Universities commit themselves to further institutionalize knowledge transfer through developing integral knowledge transfer policies within organizations and by continuing to develop knowledge-transfer facilities (Innovation Platform, 2008).

University research was brought to the front of US federal policy much earlier, during and after World War II (Geiger, 1993). Science and technology policy during the post-World War II period in the USA was led by uncoordinated action in different policy areas designed to further the missions of individual federal agencies. National security at that time was the most important mission, and this is reflected in the policies and strong investment in this area (Mowery, 2009).

This policy first led to competitiveness concerns in the USA in the 1970s. Therefore, the 1980s was an important period for putting major legislation and incentives in place to promote university knowledge commercialization. Both industry and universities have been targeted either through regulatory changes, such as the introduction of new laws, or through targeted financial programs for certain technological sectors. As noted by Krücken *et al*. (2007), the Stevenson–Wydler Act Technology Innovation Act of 1980 called for renewed cooperation among academia, federal laboratories, and industry, requiring federal laboratories to establish technology transfer offices (TTOs). This document was the first in a series of legislative steps to enhance the service orientation of US universities, including renewing university–industry links.

A further policy area that has been used to help promote commercialization of research in the USA has been the taxation system. One huge step forward was the use of tax incentives to encourage industry to collaborate with universities. In 1980, the

Economic Recovery Tax Act provided tax breaks for university research supported by industry; in 1984, the exemption of industry-research consortia from antitrust laws was passed. As a result of the above initiatives, different consortia and licensing of university intellectual property (IP) increased rapidly and became institutionalized (Geiger and Sá, 2008).

4.2 Intellectual property regulation in both countries

IP regulation is crucial for research commercialization. In the Netherlands, the Patent Act was passed in 1995. It followed the Copyright Act of 1912 to protect IP rights. Its Article 12 (3) stated that if the invention is made by an employee of a university or research institution, the employer is entitled to the patent. Parties may withdraw from this provision by agreement (MEA, 1995*)*. Traditionally, the IP rights in jointly developed research are owned by the industry partner, or jointly by the university and the industry partner. Currently, universities are more aware of their position and the importance of the protection and exploitation of their IP rights as observed by the Biolegis, a European group of lawyers specializing in life sciences. Dutch universities own their patents and, up to 2004, when the Innovation Charter was signed by all universities and medical centres, had their own rules about knowledge commercialization procedures.

IP rights legislation in the USA was passed much earlier than in the Netherlands. The 1980 Bayh–Dole Act allowed universities to own IP arising from federally funded research. The uptake of this policy has resulted in a variety of institutional and organizational changes in universities. Some authors describe this process as ‘revolutionary’ (Etzkowitz *et al*., 1998), in part because they have changed the understanding of a university’s academic mission. Other authors see it more as a ceremonial process among the universities (Greenberg, 2001; Krücken *et al*., 2007). It has also been seen as:

> an endogenous response to the patenting and licensing increase that had already begun rather than an exogenous cause. (Foray and Lhuillery, 2010: 403)

4.3 The funding mechanisms to support the above policies in both countries

The above-described policies have been facilitated through funding policy mechanisms aimed at promotion of entrepreneurship in universities. In the Netherlands, the government has initiated a number of grant schemes through the MEA and the MESC’s Technology Foundation (STW) to foster science–industry linkages. STW’s funding schemes have been strongly geared toward the potential real-world applications of their proposals.

Some of the programs were designed for specific sectors, such as nanotechnology. Others had a more general focus. For example, to promote the commercialization of life-sciences research in the Netherlands, MEA put forward the Life Sciences Action Plan of 2000–2004 and launched the BioPartner entrepreneurship promotion program in 2000. Its objective was to contribute to the entrepreneurial culture of the Dutch academy and to help establish 75 new life-sciences companies. Despite the policy imperatives for research commercialization, the main funding mechanism to promote spin-off creation was only launched in 2000.

In the view of Hu and Mosmuller (2008), the BioPartner program has been the most important initiative to date for stimulating entrepreneurship in the life sciences in the Netherlands. The government invested €45 million to eliminate the identified obstacles of research commercialization. This money was filtered through life-science incubators, research centres, and as seed capital for start-up companies. From 2000 to 2004, 109 life-sciences companies and six incubators were created as a result of the program (Hu and Mosmuller, 2008). Since the program proved effective, the Senter Novem launched a follow-up Techno Partner program in 2006; this time to help spin-off companies in technology fields boost the NIS.

In the USA, funding agencies have devised funding schemes that increasingly promoted university–industry collaboration and research commercialization focusing on industry. This was especially so when US industry started to downsize its in-house R&D departments and outsource this function abroad or to other research institutions (Geiger and Sá, 2008). Moreover, in mid-1970s US universities increasingly needed to search for alternative funding sources among other things due to shrinking state budgetary allocations (Geiger and Sá, 2008). New initiatives to bring universities and industry together sprang up due to policy-makers’ perceptions of increased global competition, and desire to ensure economic viability of research projects (Slaughter, 1990).

In 1982, the Small Business Innovation Development Act was passed with the aim of promoting the role of small firms in the commercialization of new technologies. As a result, the Small Business Innovation Research program (SBIR) was established. Its goals have been to stimulate technological innovation, use small business to meet federal R&D needs, and increase private-sector commercialization innovations derived from federal R&D.

Since this program was positively received, a similar program that fosters cooperation between universities and small firms was created with the passage of the Small Business Research and Development Enhancement Act in 1992. This Act created small business technology transfer (STTR) grants aimed to stimulate scientific and technological innovation via cooperation between small firms and public research organizations and to foster technology transfer between research organizations and small firms. For a university–industry collaboration to qualify for a grant, the university level of participation must be at least 30% of the total endeavour; the industry/firm level of participation, 40%. Both SBIR and STTR are set-aside programs, meaning that each federal funding agency (in different sectors) sets aside 2.5% (SBIR) and 0.3% (STTR) of its yearly budget to provide funding to small and medium-sized enterprises (SMEs) on a competitive basis. The amount of grants, and the definition of priority topic areas and sector, has varied among the different federal agencies (Portnoy, 2010).

5. Types of vertical formal and informal linkages: evidence from the case studies

Although a number of the aforementioned programs have proved effective in the Netherlands and the USA over the years, success has been mixed in institutionalizing research commercialization at universities. I present evidence on formal/hard linkages created in the two NISs with examples from two pilot studies in universities that have significant funding from industrial partnerships and are active in knowledge commercialization activities.

The Dutch case-study university can be characterized as a highly entrepreneurial university with one third of its income generated from external contract funding. It is one of the most highly performing universities in terms of patenting and spin-off creation. A high proportion of its external funding comes from the national funding schemes promoting research commercialization.

The US case-study university actively promotes industry-funded research at the university and aims to contribute to economic development in their home state and in the country. Industrial support has been significantly increasing in the past 10 years. The university is one of the country's top public research universities and has the highest amounts of industrial research expenditures in the USA.

I present evidence on formal/hard linkages created in the two national systems of innovation with examples from two pilot studies in universities that have significant funding from industrial partnerships and are active in knowledge commercialization activities

5.1 Establishment of special structures to facilitate technology transfer

Varied technology transfer structures in the Netherlands Dutch universities typically create formal linkages with industrial firms and start-up companies via establishment of holding companies and technology-transfer offices. Since the 1990s, Dutch universities have promoted SME creation through their holding companies. The first university holding company was established by the University of Twente in 1985. Maastricht University and the University of Amsterdam followed suit in 1992, and seven others did so after 1995 (when the Patent Act was passed). The holding companies are private entities that are legally separate but owned by a university. The company holds shares in spin-off companies of the university, coaching those companies on IP, taxation and financial management matters. In addition, the holding company acquires and retains IP and may enter into joint ventures with private entities. The university receives dividends from the shares owned by the holding company. However, the range of holding activities varies across Dutch universities (Zomer *et al*., 2010).

The creation of formal linkages in Dutch universities has also been fostered through TTOs. Universities did not follow one structural template for their TTOs, and the institutionalization varies from one university to another. For example, in the case-study university, the industrial liaison office was already established in the 1980s (Zomer *et al.*, 2010). The technology transfer function of the university has become more important with the passage of time, and further decentralized technology-transfer structures have appeared.

Today the knowledge park (KP) is the main structure that manages most commercialization efforts for the case-study university. The KP handles technology-transfer activities on behalf of the university, manages facility-sharing between the university and industry (which amounts sometimes to around 50% of the recurring costs of the facilities), and runs the holding company in a fashion similar to that described previously. The university demands a share (usually 10–20% participation) of money or stock from a new company that is based on university-generated IP. At present, the university holds shares in some 20 joint companies through its holding company (university website). It also offers a coaching program for early-stage entrepreneurs and spin-off firms. However, the KP does not function as the single central office for knowledge transfer. Within most research institutes at the university, individual technology transfer officers are responsible for informing academic staff about IP procedures and scouting for commercialization opportunities. Furthermore, some of the incentive schemes used by KP require close collaboration between the managers of research institutes and the staff of KP.

However, the interviews with academic staff in one of the highly productive institutes with regard to commercialization reveal that most academic staff members do not use the services of these offices. And even if staff members use its services, the usefulness of the services is rather limited. The interviewed scientists find an easier way of connecting with industrial partners through individual networks, informal meetings or conferences, or by talking to senior colleagues and tapping into their industrial networks in order to apply for a grant. For cases in which there is an idea to be patented, staff members found it is better to hire an outside law firm to do the patent application faster and more efficiently, rather than navigate through the university bureaucracy. In the view of the institute director, the role of a technology-transfer officer is to raise awareness on technology transfer possibilities among the less active staff in research commercialization (interview data).

Central location of technology transfer offices in the USA Universities established TTOs in the USA right after or within 10 years of passage of the Bayh–Dole Act. The success of the technology-transfer activities of universities has been varied. Oftentimes universities mimicked leading universities that were successfully reaping the benefits from research commercialization by creating TTOs in their own institutions and setting up specific IP rules and procedures, even though they did not place a high priority on research commercialization, which would be a necessary first step in creating a successful TTO (Greenberg, 2001).

The literature suggests that many research universities in the USA professionalize TTOs and then face increasing competition for the occasional 'blockbusters' (Hatakenaka; 2003). Unlike the situation in the Netherlands, these technology-transfer structures are centrally located at the university level in the USA. For example, the US case-study university gradually established a university foundation, Innovation Park; a TTO; and an industrial partnership office in the 1990s. The university also created a few incentive programs to foster spin-off activities, all at the central-university level. The Innovation Park, a structure facilitating creation of formal vertical linkages, currently hosts 35 start-up companies. It offers discounted office facilities for lease and a number of discounts and services for its tenants, including professional training opportunities, conference facilities and hotels, and social and networking events. Additionally, the Innovation Park runs programs that provide seed capital for the start-up companies and coaching to entrepreneurs.

The university TTO consists of four different offices that specialize in IP, industrial partnerships, supporting start-ups by advising them and promoting technology transfer. Internally, the technology-transfer administrators organize meetings with directors from research institutes, and give lectures and information sessions. Externally, they market their IP to industrial companies as well as helping scientists establish contacts with industrial companies.

Over the years, the number of patents has been slowly increasing. In 2009, 34 patents were issued, and most of them have been licensed. As reported by the head of the industrial partnerships office, the office concentrates on patents that are likely to be licensed and bring a return on investment. This sometimes means that some patents are unlikely to be promoted, and corresponding spin-off activity is rather low. Royalty revenues in 2007 were about US$2.5 million — which is a relatively low income given the US$700 million total budget of the university. Given that all academic staff are required to file a patent via the TTO, this selective application for patents may be seen as a bottleneck if the office does not deem the patent to be profitable. The interviews with academic staff, however, suggest that major links with firms are established directly through personal contacts, personal networks, and collaborations with partners in other universities or conferences, rather than through the TTO. However, if they want to patent, they have to file the patent and get the approval of the TTO.

5.2 Spin-off creation

The less-targeted Dutch approach The role of governmental funding to promote vertical linkages via spin-off creation support schemes has been limited in the Netherlands. The notable exception has been universities and spin-offs tapping into BioPartner (since 2000) and Technopartner (since 2006) valorization grants; the case-study university being a recipient as well. Despite this rather limited, targeted support for spin-off creation, Dutch universities started creating support structures to promote spin-offs after 1996 (Zomer *et al*., 2010).

The case-study university established the Temporary Entrepreneurial Positions program in 1984. This program already provided basic funding and coaching for start-ups (rather early in the game for the Netherlands, which as I have noted got a late start with the concept of university–industry collaboration in comparison with the USA) with MEA funding of €2.3 million; at its later stages, the program was further supported by the European Social Fund. The result of these initiatives has been the creation of 700 companies originating at the university over 20 years, with a five-year survival rate of 70%, an above-average performance for spin-offs in the Dutch business landscape. The employees of the spin-offs are usually former students, with senior academic staff participating on the management boards. Mostly, they use university facilities for their work and are assisted in developing business plans through various funding schemes.

Tapping into government funding The spin-off companies collaborating with the US case-study university, as with the Dutch university, tap into various sources of funding and have been doing so for many years, making use of funds from different sectors (private and public). Among others, the STTR and SBIR funding schemes figure prominently. Spin-offs create partnerships with the university to use their facilities and also senior academic staff, who are usually the founders of these types of companies. As interviewees from one spin-off company indicated, venture capital funding has been scarce given the location of the university (agricultural region). The recession also contributed to the decrease in venture capital opportunities, as it was harder to persuade investors given the hard economic times overall in the USA in 2009. Thus, maintaining the linkages with the university academic staff and tapping into their professional networks to raise funds has been one of the solutions.

For the US university, the requirements for establishing a spin-off company are high due to internal university regulations. Among other regulations, the rules require a professional manager, since it is argued that venture capitalists will not invest in the company otherwise. Thus, although the spin-offs in the university are created by the university academic staff and run by their former PhD students, they often have hired professional managers.

5.3 Research institutes and centers as a policy-fostered vehicle to forge vertical partnerships

Changing role of research institutes in the Netherlands The creation of research institutes where research groups participate from various departments and interact with business is an example of the formal vertical linkages created at the universities in the Netherlands. By itself, research institutes are not a new phenomenon, but traditionally they have been umbrella organizations hosting different departments and have had basic research funding from the university to promote interdisciplinary research. In recent years, as in the case-study university, the idea of increasing research valorization via innovation-oriented collaboration of institutes with industrial partners has surfaced. Such collaboration would be facilitated by industrial funding or other sources, like STW; or by specific sector programs, such as the NanoNed Program, which was designed to expand knowledge and expertise in nanotechnologies and their applications (2004–2010, €235 million).

Given that the case-study university has an institute dedicated to nanotechnology, the NanoNed Program funding has been an important source of income for developing the state-of-the-art equipment the university needs, as well as for running flagship research programs in cooperation with industry. The industrial partners contributing substantially to the running costs of the facilities range from the big Dutch multinationals to the local spin-offs funded by the government. At the same time, the flagship nanotechnology institute receives substantial matching funds from university management.

Company participation in research centers in US universities In the USA NIS, the creation of special research institutes and research centres has been a distinct way of institutionalizing vertical formal linkages in US universities (Hutchinson, 2005). The NSF started with the Science and Technology Center in 1978. Later, a range of engineering centres became part of the NSF Industry University Cooperative Research Centers initiative (Croissant and Smith-Doerr, 2008). These centres are partially funded by NSF and by industrial firms' fees. In 2007, there were 38 active centres with NSF co-funding in US universities, and 14 centres without this co-funding. Universities were (and are) in the process of changing their internal policies to adapt to 'the team based, cross-departmental activities of scientists participating in these research centres' (Geiger and Sá, 2008: 74).

In the US case-study university, research institutes have their budgets and host a number of research centres which work with industrial partners and are also funded by external grants. Looking at the research centres within the research institutes, it is distinctive that infrastructure and administration in the centres are funded by the NSF. Firms pay membership fees to become members of the centres and use their facilities, as well as using the knowhow of the centres for their purposes. The research centres consist of academic staff, equipment, and company membership, where companies can put in bids and researchers can apply for and obtain contracts if they are deemed suitable to carry out the tasks. This formal linkage creates an opportunity for researchers to more easily establish contacts with firms and vice-versa. However, the types of agreements, and the procedures behind realizing the agreements, are centrally defined by the university. The industrial liaison office has an important role in partnership agreement negotiations.

6. Comparison

Comparing the national framework conditions for the Netherlands and the USA, we can see the expected differences, which are in part shaped by the

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path dependencies, such as the structure of the industrial base, and the traditional governance of research in a particular NIS. In particular, we can see how the traditional state 'steering' and intensive negotiation between the NIS actors in the Dutch case gradually inspired research commercialization policy processes towards concentration in the late 1990s. In contrast, spreading of research commercialization programs over the variety of sectors and agencies is characteristic of the US funding schemes. In the US case, path dependence may be traced in the competition-based schemes and strong orientation towards value creation in early 1990s in a variety of sectors.

Another difference which may be partly attributed to path dependence is the professionalization of the technology-transfer officials in the USA, as seen in their having their own organization and code of conduct. Their influence on institutionalizing the technology-transfer function centrally within the universities in the USA should not be underestimated (Benneworth and Jongbloed, 2010). In the Dutch case, agreement on technology-transfer practices has been reached by a range of university stakeholders, a state of being that again may be attributed to the negotiation culture in the Netherlands.

At the same time, it is interesting to see similarities, which may indicate a certain 'mimicking' behavior in the NISs for the Netherlands and the USA (Table 2). Since the 1980s, both governments have had commercial and social relevance in their policy imperatives for research organizations. Although the USA has been an obvious forerunner in the development of funding schemes that promote vertical linkages, the Dutch examples show a range of visibly similar schemes. The innovation vouchers used in the Netherlands resemble SBIR grants. But at the same time they are different, since in the USA they apply for a variety of sectors and are set-aside funds, while in the Dutch case they are separate funds targeted only for specific sectors. Thus it is possible to interpret the adaptation of schemes to local framework conditions on the part of the Dutch policymakers as a 'mimicking' behavior. Furthermore, the competitive nature of these schemes is similar, although it is not traditional in the Dutch NIS.

Table 2. Comparison of national framework conditions and vertical linkages in the Netherlands and the USA

NIS dimension	Predicted differences in national system		Key findings from the analysis	
	Dutch	US	Differences	Similarities
National framework conditions	Intellectual property regulation passed in 1995 Less competitive funding for universities A small variety of external funding agencies A large variety of sector and other programmes Senter Novem, STW grants, vouchers, subsidies for specific sectors Innovation Charter – inter-university agreement on technology transfer	Intellectual property regulation passed in 1980 Very competitive funding for universities A large variety of external funding agencies Some federal sector programmes SBIR and STTR grants offered by a variety of funding agencies NSF programmes to promote partnerships; AUTM – a national professional agency of technology transfer	The timing of research commercialization regulation is different The spread of research commercialization programmes over sector agencies in the USA is larger than in the Netherlands USA has a professional association of university technology transfer with its code of conduct, while in the Netherlands the Innovation Charter sets the code of conduct for technology transfer	Since 1980s, governmental pressure for commercial and social relevance Some funding schemes incentivising university–industrial firm linkages look similar Agency funding programmes to foster partnerships are based on competitive bids in both countries
Vertical linkages	Universities traditionally are not accustomed to competing for external funding Technology transfer offices are decentralized and vary per university Research institutes increasingly are responsible for facilitating vertical linkages	Universities traditionally are accustomed to competing for external funding Technology transfer offices are institutionalized at the central administrative level of universities, with mandatory intellectual property procedures for scientists Research institutes and centres are an institutionalized form of creating vertical linkages	Technology transfer offices and intellectual property procedures are more professionalized in the USA than in the Netherlands Research institutes/centres with industrial partners are more institutionalized in the USA	Universities tap into funding schemes incentivising industrial firm linkages to earn additional income Creation of technology transfer offices Research institutes/centres structure is used in universities to facilitate the creation of vertical linkages

Exploring the influence of institutional framework conditions on the linkages that exist between universities and industrial firms in the two countries, we can see that the role of regulation and funding policy instruments has been substantial. This is attributable to the partial influence of IP regulation and the creation of holding companies in the Netherlands, as well as to TTOs in the USA. The role of research commercialization funding schemes has been significant when it comes to creation of new structures in universities, as exemplified by the creation of research centres and institutes.

However, the institutionalization of vertical university–industrial firm linkages has been varied in the two NISs as exemplified by the two case studies. In the Dutch university sector, the structures of TTOs have been more decentralized than in the USA, and the institutionalization of these vertical formal linkages remains ceremonial and varied; they are often negotiated on a university-to-university basis. Scientists in the Dutch case study, unlike their US counterparts, may patent and work with industry directly, bypassing the TTO (see also Colyvas and Powell, 2006). Thus, the role of informal institutions in establishing the vertical linkages in the Dutch case should not be underestimated.

Further differences in vertical formal linkages are seen in the institutionalization of research–industry institutes. The industrial funding in the research centres in the US case study is required by the funding agencies, and the industrial firms have already used their services for years, with clearly defined agreements negotiated via a central industrial liaison office.

In the Dutch case, the agreements with companies are mainly the business of the institutes and are not clearly defined. The organizational inertia of doing things informally and via personal networks seems to strongly manifest in the Dutch case (see also Jongbloed and Van der Meulen, 2006). At the same time, a number of cross-cutting similarities in the institutionalization of vertical formal linkages in the two case-study universities can be observed. The similarities include the opportunistic behaviour of the universities and scientists when tapping into research commercialization incentive schemes by forging real or ceremonial vertical linkages with industrial firms; the use of the research institute structure to facilitate the creation of vertical linkages as such; and the 'mimicking' of TTO structures across the universities.

7. Reflection and conclusion

Path dependencies partly shape the process of research commercialization in terms of the timing and the types of policy instruments forming the institutional framework conditions in the two countries. This can be seen from the main differences in framework conditions in the two NISs. The differences include the dispersal of commercialization funding schemes in the USA versus concentration in the Netherlands. Further, the definition of the code of conduct of technology transfer has been shaped by different actors in the two NISs.

Despite the expected differences, we find interesting similarities in the framework conditions of the two NISs for the Netherlands and the USA. The main similarities include policy convergence concerning promotion of commercial and societal relevance in research, structural similarity of certain funding schemes and the competitive nature of the overall process.

The creation of vertical linkages between universities and industrial firms as shown from the two studied universities has been institutionalized in both cases. The main differences have to do with IP procedures within the universities, the level of institutionalization of the technology-transfer function, and the level of institutionalization for the country's research institutes/centres. Organizational inertia is sometimes observable in these various structures. However, despite the differences in the NISs, the case-study universities show certain similarities in adopting the institutional framework conditions, and in creating vertical formal linkages.

As seen from this study, the creation of vertical linkages is a challenge for governments, irrespective of the type of NIS in question. However, it is possible to conclude that policy-makers should take the path-dependent features of the NIS into account while attempting to shape institutional framework conditions in order to boost innovation via the creation of vertical linkages between universities and industrial firms. But more importantly, they should not only concentrate on the opportunistic behaviour of the universities and foster only vertical formal/hard linkages, but also use policy instruments fostering informal/soft linkages in order to overcome organizational inertia at universities and to facilitate bottom-up processes that may mitigate the possible tensions between these new tasks for academics and professors' other activities (Krücken *et al.*, 2009). The success of this mixed approach may still depend on the extent to which universities depend on external funding, their autonomy in commercialization activities, and the industrial capacity of the NIS in question.

To conclude, the findings challenge my first proposition to a certain extent, since path dependencies could be only partially traced in shaping national framework conditions and the institutionalization of vertical linkages in the two NISs. The second proposition, however, can be reinforced, since as I discussed above organizational inertia can be seen in the creation of vertical linkages in the Netherlands as well as in the USA. This conclusion needs further empirical support through follow-up studies that focus specifically on the types of (and roles for) informal institutions in shaping institutionalization of vertical linkages within different NISs.

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