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The role of patents in university-industry knowledge transfer
the case of Eindhoven University of Technology

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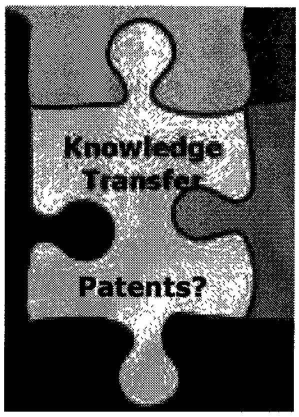

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Executive summary

Introduction

Innovation is a significant point in the policy agenda in The Hague and becomes a more and more important requirement for economic growth. The knowledge generated by universities is an essential ingredient in the innovation process. For the good performance of our economy it is very important that this knowledge flows into business. Policy makers are concerned that the knowledge produced by universities does not find sufficient commercial application. They complain that too much university knowledge remains on the shelf. University patenting may be a way for providing incentives to universities to address this issue.

The goal of this research is to better understand the mechanisms of university knowledge transfer and, in particular, the influence of patents as facilitator in these processes. This report examines the knowledge transfer process by a survey of scientific- and grey literature research and policy activity relevance. Case studies are carried out to gain insights on the relationship between patents and University-Industry knowledge transfer.

Literature- and policy framework

The first topic concerns university knowledge and innovation. The Dutch government led a common innovation policy for decennial years. Motives as creating secondary conditions, market imperfections and European objectives legitimize government's intervention. The present policy considers the improvement of the interaction between public and private institutions as a solution for innovation. University generated knowledge has to flow into business. These universities traditionally produce fundamental research. In case research nature is more fundamental, the results will pay off economic profits considerably slow. Nevertheless, the production of fundamental knowledge is important to the long term growth of a knowledge driven economy. The fact that university knowledge can not be converted directly into applications and economic profits is accepted by firms. Consequently, firms have another attitude towards collaborations with universities comparing to collaborations with other firms. The set up of connections with universities to transfer knowledge is a learning process from firms' perspective.

The second topic concerns the knowledge transfer to industry. It shows that university transfers knowledge through a variety of possible channels (eleven). This is because of the diversity of knowledge and the way it interacts with economic processes. Moreover, the knowledge transfer channels effectiveness is argued to be dependent on the knowledge- and research characteristics. For instance, the fundamental research does not have the aim or the prospect to result in commercial profits on the short term. The protection of IP rights (patents) may stimulate a firm to exploit this knowledge. The firms state protection from imitation as the most important motive to patenting. Nevertheless, some researchers are sceptical to the desirability of patenting by universities. Very little theoretical and empirical evidence supports the view that university patenting would accelerate commercialisation.

The third topic discusses the Dutch policy towards knowledge valorisation. It shows that the government employs three categories of instruments (i.e. stimulating collaborations, applied research and knowledge diffusion) to connect universities with business. The present policy is mainly thinking in terms of patenting to stimulate the university knowledge transfer into business. It is a response to Bayh-Dole Act in the US. It was introduced to facilitate and accelerate the transfer of technologies resulting from federally funded research. Consequently, the US universities patenting activity increased significantly.
Following government's example, radical changes can be observed in the patenting policy and behaviour of the Technical University Eindhoven over the past years. The TU/e as well as the 3TU believes there is a technological opportunity by patenting (i.e. knowledge transfer improvement, enrolment of income facilitation, research opportunities, etc.). The university researchers are stimulated by financial incentives on patenting since January 2006.

The fourth topic elaborates the patent issue. It shows that the three sub-topics 'the value/ quality of patents', 'the efficiency/ effectiveness of patenting' and 'the effects of patenting on academic research' make it possible to determine the importance of (university) patents. The first one can be assessed by the patent's estimated monetary value which is an important direct measurement. Moreover, the value/quality is explained by the importance of monetary rewards and career advances to researchers, the used source of knowledge for the development of innovations, the patents distribution by technological class and the characteristics of the individual inventors. The second one can be assessed by checking two developed economic research models which suggests that patenting is a bargaining game. Nevertheless, another third research model invalidates this by indicating that the effects of university patent ownership are insignificant. The final sub-topic can be assessed by the consequences of university involvement in -and institutionalisation of patenting. Nine possible (negative) impacts are defined.

Case studies - Discussion

The findings from the five case studies show a number of interesting insights. These insights can be categorised to the level of the national policy and the individual university policy (i.e. TU/e) towards knowledge transfer.
The patenting of university produced knowledge seems not to be linked with the acceleration of commercialisation. First, the firms and the university find each other rather well through other channels of knowledge transfer than patents. Second, the knowledge need appears to come from industry because they are the origin of the research idea. The subsequent patented inventions find its origin in cooperative research (i.e. master thesis, PhD thesis or consultancy). Moreover, the findings show that patent applications are only made on inventions that (might) have an application to a specific technology and/or are considerably economic valuable for the firm. Finally, the cases indicate that the initial aim to develop something (economically) useful that can be patented is important to industry.
Furthermore, the importance of the cases (university) patents, which is deduced from the patent issue topics, suggests that patents as facilitator are unimportant to universities. The two topics 'value/quality of patents' and 'efficiency/ effectiveness of patenting' did not show considerably positive findings in support of the university. The final third topic on 'the effects of patenting on academic research' did not indicate exceptional negative impacts as a consequence of patenting. However, it may change in case the university is drastically involved in patenting activities as a result of the new policy. The university patenting activities are significantly modest at this phase of time. Hence, the exception can be made to three impacts so far. It indicates that it has <u>no</u> significant negative impact on the 'publishing vs. patenting' issue on the one hand. I.e.

publishing seems to go together with patenting. On the other hand, the patents impact on the 'IP rights interference' and the 'patent absence' indicates to be negative. I.e. patents seem to break up informal connections as a consequence of interactions formalization and patents seem to be significantly important to embryonic inventions.

Conclusion and recommendations

This finally leads us to the answer on the main question of this report: What's the role of patenting in university to industry knowledge transfer in particular, considering the TU/e case?

The patents appear to be important to the industry. The assurance of exclusivity to pick up an invention that requires additional development for future application plays a prominent role. However, the patenting activities seem to be a task of the industry. Patenting by the university itself (i.e. university owned patents) seems to be an activity of minor importance for the TU/e. Therefore, any policy should allow the university to apply a variety of knowledge transfer channels. It makes little sense to try to bend or to increase university knowledge transfer in the direction of university patenting. Moreover, the financial incentives seem to be pointless to stimulate university researchers' effort to invent and patent significantly more. The researchers indicate that their involvement to the research results impact/ outcomes on inventions gives them satisfaction. Therefore, the management of knowledge transfer at the level of the individual university may (re)consider the use(fullness) of this policy. Any (new) policy may concentrate on the fulfilment of this satisfaction.

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List of figures and tables

List of abbreviations

3TU	Three Technical Universities: TU/e, TU Delft and University Twente
AWT	Council of Advice for Scientific- and Technology policy
DPI	Dutch Polymer Institute
EA	Economic Affairs
EC&S	Education, Culture and Science
ECN	Energy Centre of research Netherlands
EET	Economics, Ecology, Technology
EPO	European Patent Office
ETP	Expanding Thermal Plasma
IOP	Innovation driven Research Program
IP(R)	Intellectual Property (Right)
MIMO	Multiple-Input Multiple-Output
OFDM	Orthogonal Frequency Division Multiplexing
PhD	Doctoral degree
PMP	Plasma and Materials Processing
PT	Polymer Technology
R&D	Research and Development
SER	Social and Economic Council
TNO	Dutch Organisation for applied Research
TT	Technology Transfer
TTI	Technological TOP Institute
TTO	Technology Transfer Office
US	United States
WLAN	Wireless local area network

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This report presents the thesis of my final project. Here I would like to thank the people that helped me in finalizing this project. First of all the supervisors, Alessandro Nuvolari who guided me during the project and was my main contact person, Victor Gilsing who was my second contact person and Isabel Bodas de Araújo Freitas who guided me during the case studies. Special thanks goes to all the persons I was allowed to interview to carry out my case studies.

Last but not least I would like to thank my parents who always have supported me in finishing my study.

Wouter Smid

Eindhoven, August 2007

1 Introduction

1.1 Background

Innovation is a significant point in the policy agenda in The Hague and becomes a more and more important requirement for economic growth. The Netherlands have the ambition to lead the European knowledge driven economy in 2010 since the Lissabon top meeting in 2000 (Ministry of Economic Affairs, 2003)[1].

Innovation creates products and services with an increase of added value resulting in a rising labour productivity per employee[2]. At macro level this is visible in an increase of national income linked with economic growth. An economy dependent on innovation is called a 'knowledge driven economy' because knowledge is an essential ingredient in the innovation process.

In principle, the role of Universities is to produce fundamental scientific knowledge. Therefore, universities are at the start of the innovation process and create a "breeding" place for innovation. For the good performance of our economy, it is very important that knowledge generated by universities flows into business. The business sector has the task to transform this knowledge into innovations.

The most recent policy literature suggests that, at European and national level, policy makers are concerned that the knowledge produced by universities does not find sufficient commercial application. Since the introduction of the Bayh-Dole Act in the US, a dramatic increase in university patenting activity has clearly taken place (Colyvas et al., 2002). On the contrary, in the Dutch case (and also in the European case), university patenting seems to be a much more restricted phenomenon. Several policy documents (e.g. AWT, 2001) are unanimous in complaining that too much university knowledge remains on the shelf and that university patenting may be a way for providing incentives to universities to address this issue. On the other hand, some researchers (e.g. Verspagen, 2006; Geuna and Nesta, 2006) have argued that university patenting may create dangerous tensions within the University system (e.g. conflict between patenting and publishing, reorientation of University research towards "applied" research, etc.)

1.2 Research design

This research is set up by the methodology according to the book "Het ontwerpen van een onderzoek" (translated: The design of a research) by Verschuren and Doorewaard (2000). This methodology defines a research design that can be divided into two groups of activities. The first group is the conceptual design; the second group is the research technical design. Figure 1 shows a representation of this research design.

[1] An agreement was signed to make Europe the most competitive- and dynamic knowledge driven economy on the world with the contribution of all EU member states.

[2] Innovation results on the one hand in products and services with increasing profit margins and on the other hand in improving production processes, organisations, marketing processes etc. resulting in management efficiency and effectiveness.

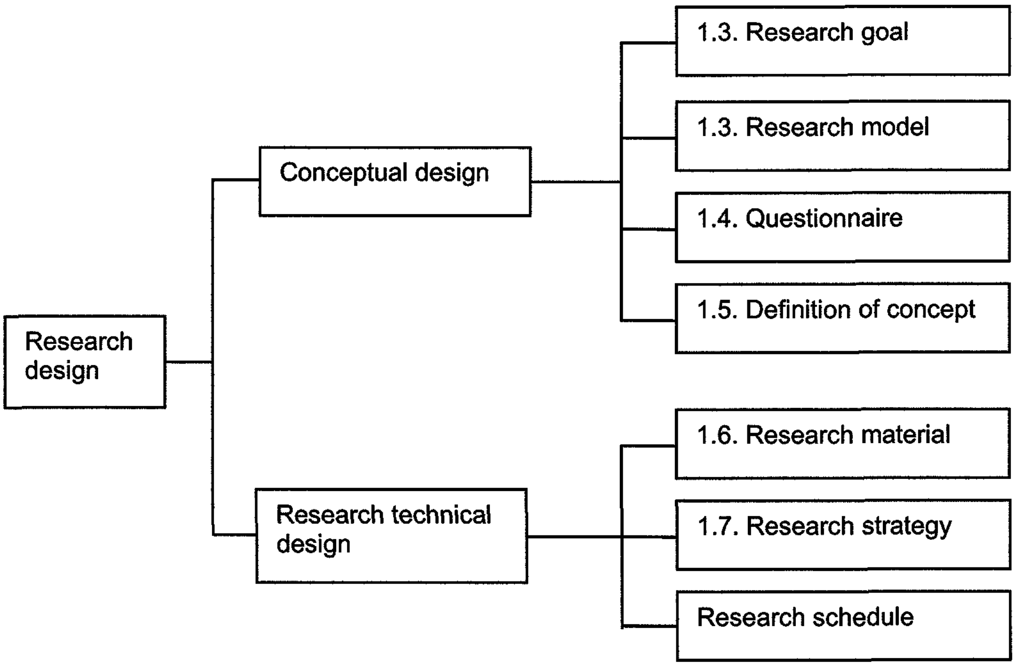

Figure 1: Representation of the research design

1.3 Research goal -and model

Preliminarily explanation shows that this report discusses the transfer of university knowledge into business in which patents are granted. This transfer process is linked with two other important processes. The processes knowledge generation and knowledge exploitation respectively take place before and after university knowledge transfer.

The goal of my research is to better understand the mechanisms of university knowledge transfer and, in particular, the influence of patents as facilitator in these processes

The research model consists roughly of four parts: (a) A study on knowledge transfer topics based on a survey of scientific- and grey literature research and policy activity relevance, providing the central points (b) to analyse five case studies in which patents were granted. (c) The findings to the case studies knowledge transfer issues lead to insights (d) that contribute to the discussion of my research goal.

Figure 2 on next page is a translation of parts (a) to (d) into a visual research model.

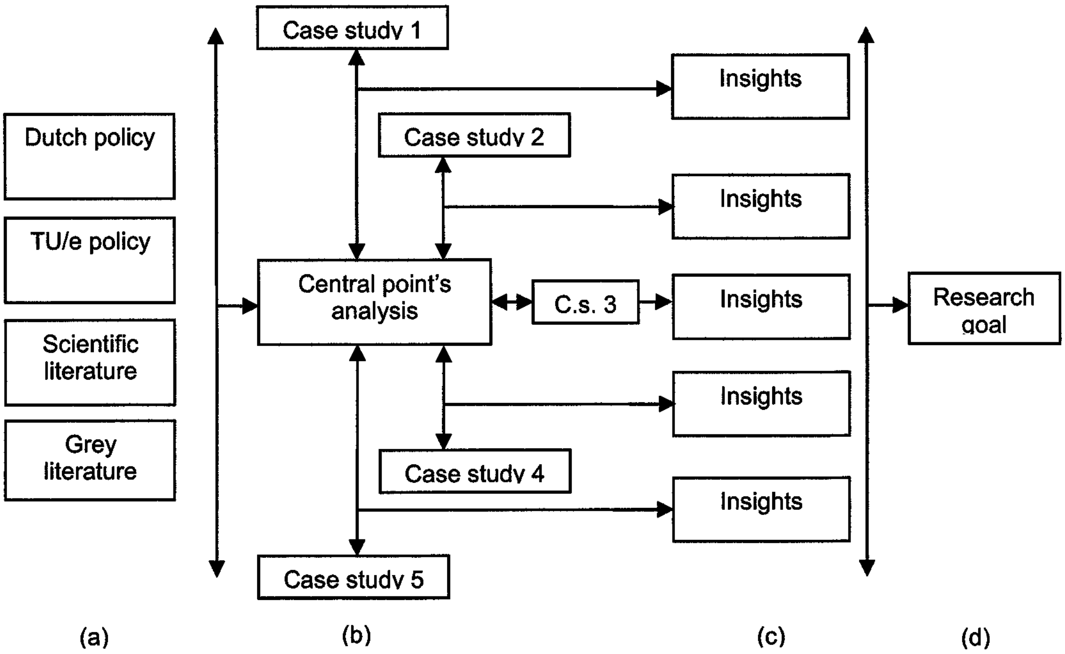

Figure 2: Visualization research model

1.4 Questionnaire

A central research question has to be explored to be able to achieve the main research goal. This question runs as follows:

What's the role of patenting in university to industry knowledge transfer in particular, considering the TU/e case?

I will carry out five case studies of university-industry knowledge transfer at the TU/e in which patents were granted to tackle this question. The case studies deal with different departments of the TU/e. In this way, I will be able to identify key differences in the attitude towards knowledge transfer and patenting between the departments (and the related scientific disciplines).

In each case, I will consider the following issues:

i. The nature of innovation and its origins;
ii. Development project;
iii. Involvement of university researchers, university departments, organisations and firms;
iv. Forms and implications of knowledge transfer process.

In particular, in each case, I will focus on the role played by the patenting decision (e.g. who took the initiative of taking the patent? how did the patent affect the knowledge transfer process? was there a conflict or other tensions between taking the patent and publishing the results of the research? did the patent create a more favourable context for the investment of private actors in the knowledge transfer process?).

1.5 Definition of concept

Some definitions in this report need to be explained more specifically in advance to prevent misapprehensions. These ones are:

Knowledge valorisation:	Stimulating innovation, knowledge- and technology transfer and business development
University:	Public institution at the start of the innovation process producing (fundamental) scientific knowledge or technology
Industry:	User of scientific knowledge or technology transforming it into innovations
TTO:	Office (of the university) that is responsible for university patenting and licensing activities.
University owned patent:	Patents assigned to a university
University invented patent:	The inventor of the patent is at least one (staff) member of a university, independent whether the university has assigned the patent

1.6 Research material

The research material consist the following sources:

- Persons (Academic and business actors involved in the link: face-to face interviews according protocol, individual or group)
- Literature (scientific books and articles: content analysis)
- Internet (official websites government, ministries, advice centres, university, firms etc.: content analysis)
- Media (newspapers, magazines, journals etc.: content analysis)

1.7 Research strategy

The research strategy is a mixture of desk research and empirical case studies. The desk research consists both of scientific and grey literature. All the case studies will be conducted using the same protocol developed for the NWO research project "The diversity of knowledge transfer in public-private knowledge networks" coordinated by Bart Verspagen.[3]

In all the five case studies, at least part of the knowledge involved in the technology transfer was covered by one or more patents. By comparing systematically the case studies I hope to gain a number of new insights on the relationship between patents and University-Industry knowledge transfer. These insights will be discussed and used to formulate recommendations both for the management of knowledge transfer process at the level of the individual university and for the national policy. I also hope to provide some recommendations for future research in this field.

1.8 Content

This report consists of 7 succeeding chapters beside this introducing chapter. The next chapter will first discus the innovation context. The innovation policy, the economic value of university research and public-private knowledge interaction will be taken into consideration.

[3] http://www.nwo.nl/projecten.nsf/pages/2200128111

Chapter 3 will explicate the process of knowledge transfer into business. The connection of knowledge transfer to knowledge- production and exploitation, the different transfer channels and the motives to IP protection will be discussed.

Chapter 4 discusses the Dutch policy towards knowledge valorisation. It respectively surveys the governmental- and the TU/e policy. The involved actors and the applied policy instruments are elaborated.

Chapter 5 is the theoretical part of this research that focuses on the patents issue within university to industry knowledge transfer. Three different subjects are elaborated concerning this issue.

Chapter 6 is the empirical part of this research. The case studies results are worked out in line with the knowledge valorisation- and, in particular, the patent issue debate.

Chapter 7 will be a discussion on the basis of the findings and insights to foregoing chapters.

Finally Chapter 8 will give the conclusion by answering the research question of this report. Moreover, recommendations are formulated both for the management of knowledge transfer process at the level of the individual university and for the national policy.

2 University knowledge and innovation

2.1 Introduction

The aim of this chapter is to provide a broader view on the innovation context. Innovation has to be effected with generated knowledge by universities by flowing it into business. First the Dutch innovation policy (policy context) will be discussed in paragraph 2.2. It's important to know more about the government's approach concerning innovation. Secondly an interpretation is made of the value of universities knowledge to innovation and the economy in paragraph 2.3. The final paragraph considers the nature of public-private knowledge interaction and prejudges to next chapter.

2.2 Policycontext: the innovationpolicy

Innovation has to contribute to economic growth as already mentioned. The Netherlands has designed a particular policy to stimulate innovation. This innovation policy is part of the economic policy. This paragraph shed lights on the backgrounds and aims of this innovation policy.

It is difficult to speak in terms of 'present or actual' governmental innovation policy because policy is continuously in development and mechanisms are regularly crossed off and introduced.[4] It is neither simple to formulate "the" innovation policy. The Dutch policy has considerable common grounds with educational- and scientific policy and can be characterised by the involvement of several ministries and regulations. This situation is known as 'sleeved'[5] and fragmented as a result of disordered policy (Ministry of Economic Affairs, 2002/I). Despite this the main lines of the innovation policy activities are orderly described in the following three sub-paragraphs.

2.2.1. Policies philosophy

The philosophy beyond the Western Europe innovation policy is developed during the last decennials. The led defensive industry policy can be characterised by support to unprofitable firms in the seventies. The switch to an offensive technology policy can be characterised by support to strong growing firms operating within new production sectors in the eighties. The nineties were particularly led by a clustered policy. This policy took exceptionally care of particular fields in which national companies were powerful. Its rationale was to build a competitive economy. The Netherlands has also been part of this development although this clustered policy has not been effectuated at all (AWT, 2003).

The policy development is also noticeable concerning the role of universities. The law to higher- and scientific education lays down the assignments of the universities and academies. One of these assignments consists of the transfer of knowledge in favour of

[4] For instance it was decided by the new formed cabinet Balkenende IV (formed on February 22, 2007) that the governments council of advice 'the Innovation platform' continuous to exist, but its contents will be re-formulated. Ministry of General Affairs (2007)

[5] "Verkokerd" (translated to English: sleeved) according to Dutch dictionary Van Dale: "the phenomenon that different institutions interfere with a certain policy field and furthermore work alongside, without crossway connections and therefore operate uncoordinated".

the society.[6] This assignment is not formulated concretely into regulation but is traditionally performed by education (i.e. human capital) and the publication of research results. Both knowledge transfer channels are passive. A more active knowledge transfer takes place by channels as cooperation with business, patent applications and the establishment of spin-off enterprises since the (late) nineties. The active knowledge transfer is essential to innovation.[7]

The question that can be raised is to what degree universities are also responsible for taking care of an active knowledge transfer. The national government formed the opinion that universities have to contribute to a civilized society by performing society relevant research at the beginning of the eighties.[8] Most university research is financed by public funds after all. Since a few years their opinions are also changed to the belief that universities have to contribute to economic valuable developments (e.g. by carrying out commercial interesting research). The belief that universities should directly contribute to economic growth will be the point of departure in this report.

2.2.2. Why does government intervene?

Nowadays scientists and politicians are convinced of the insight that innovation interacts in a system of actors. This is called the innovation system. The innovation process is not considered as just linear anymore and it is recognised that a high degree of interaction (i.e. cooperation, knowledge transfer, supply articulation, etc) between actors (i.e. companies, knowledge institutions, government, intermediary) have to take place to innovate effectively. The government can play an important role to the innovation system. It can create the secondary conditions to stimulate innovation (e.g. a favourable regulation, an optimal infrastructure, the best possible educational system). Moreover, the government has several motives to intervene into the innovation process.

The first motive to justify the government's intervention is because of market imperfections (see e.g. Ministry of Economic Affairs, 2002/I). The first market imperfection may be the existence of a significant difference between the private and public value of innovations. An innovation which is not valuable (i.e. making profits) to an enterprise may in contrast be one to social welfare. The rationale might be that innovating organisations are not able to appropriate the positive external effects (e.g. positive effects for the environment). The second market imperfection may be incomplete information. Small and medium size businesses do not have sufficient insights to potential technological developments. This type of imperfections also arises from deficient interactions between actors into the innovation process.

The second motive is the necessity of the innovation process to be slow down (i.e. decrease of competition). On the contrary it may also be encouraged (e.g. by granting temporary monopolies on an innovation that becomes interesting) with economic power of control. The government, intervening in public interests, is the only actor which can regulate power of control legitimately.

[6] See the regulation on academy education and scientific research from 1992, article 1.3, paragraph 1: "*Universities [...]. At the least [...] they transfer knowledge for the benefit of the society.*"

[7] In the course of this year (2007) a new regulation on academy education and scientific research will be introduced by the government.

[8] This view can be retrieved into the public funding of universities and research in particular. A separated funding for education and research only just exists since 1983. From that moment the amount a university receives for doing research is also dependent on the scientific and societal relevance of research. Nevertheless the assessment on societal relevance has never been grounded well. See Jongbloed and Calerno (2003).

The final motive to justify the Dutch governmental intervention into the innovation process is to keep to the Lissabon agreement which is signed in 2000.

Governmental intervention may have positive effects on innovation but marginal notes have to be made. Regulation and encouragement signifies additional implementation costs. The government can not command over all perfect information and therefore is unable to govern optimally. Moreover, civil servants manage their own agenda (Viscusi, Vernon and Harrington, 2000). Policy makers have to take this kind of governmental failures into account to stimulate university knowledge transfer.

2.2.3. Policy aims

The innovation policy during Balkenende II (and III) raised three general aims (Viscusi, Vernon and Harrington, 2000). First the sub conditions for innovation have to be arranged. Significantly sub conditions are a fiscally attractive atmosphere, adequate knowledge protection, a good (ICT-) infrastructure, rivalry legalisation for permitting R&D cooperation and a sufficient number of educated employees.

Second aim is to reach a top position for the Netherlands on breakthrough technologies. The innovation policy can be divided into the stimulation of general as well as specific (e.g. ICT and biotechnology) technology areas. The Netherlands feels forced to devote to a number of breakthrough technologies to be competitive into the international area. The government is willing to stimulate this.

The above mentioned aims have to contribute to a good reference point for reaching the third and final aim: Increasing the number of innovative firms and an increasing innovation by firms. The innovation policy attempts to achieve her aim by stimulating respectively innovative entrepreneurship (e.g. techno starters) and private R&D.

The interaction between public and private parties is considered as an important bottleneck. Nevertheless, the interaction improvement is not a common goal but more considered as a direction of solution (Ministry of Economic Affairs, 2002/II).

2.3 The economic value of university research

Science has significantly contributed to the improvement of prosperity last centuries. This is beyond all doubts although the social- or economic value of scientific research on universities is difficult to quantify. Different methods are used to analyze the impact of university research as for instance analyzing to what extent patents refer to scientific articles. In order of the ministry of OC&W such a study has been carried out for the Netherlands in 1998.[9] This research shows that the university can be indicated as the initial source for a significant number of patented inventions by the firms (see Figure 3).

[9] See Tijssen and Buter (1998). The authors also notice themselves that the used method of research indicates limitations. One of these limitations is the existence of much more channels of technology transfer beside scientific publications.

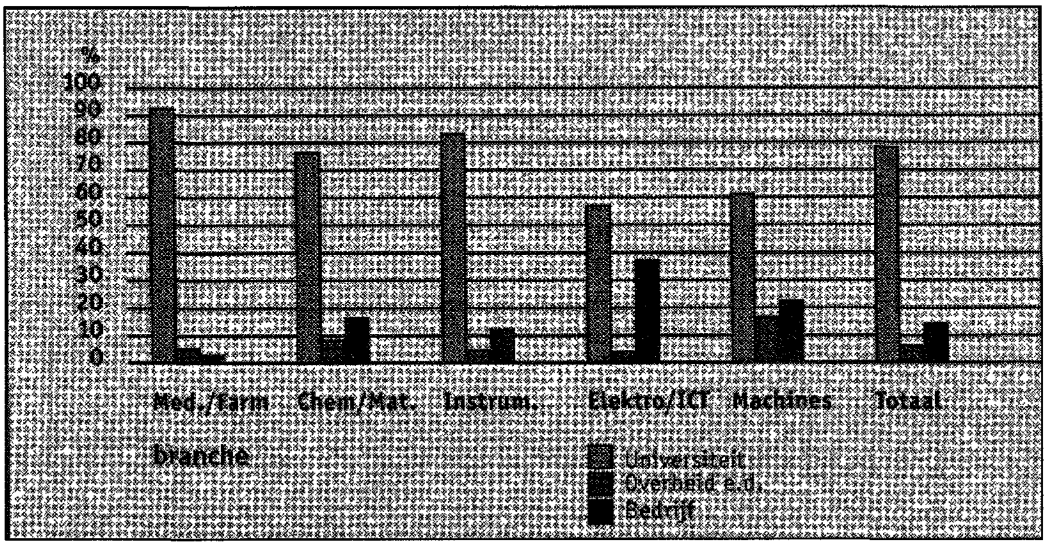

Figure 3: The University as source for patenting in 1996.* [9]

(*Translation: Med. /Farm = Medical/ Pharmaceutical; Totaal = Total; Branche = Branch; Universiteit = University; Overheid e.d. = Government and suchlike; Bedrijf = Firm)

The fact that universities are often indicated as the initial source for patenting explains nothing about the final social value of university research. The study by Venniker and Canton (2004)[10] shows that less and sometimes contradictorily empirical evidence exists to the social returns of public financed scientific research. It is too exhaustive to debate the public interest/ benefit of university research in this report. The reliable assumption is made that a considerable economic- as well as social benefit exists.

2.4 The nature of public-private knowledge interaction

Universities traditionally produce fundamental research. On some of the Dutch universities (e.g. the three TU) applied research is carried out as well. The results will pay off economic profits considerably slow in case research nature is more fundamental. Nevertheless, the production of fundamental knowledge is important to the long term growth of a knowledge driven economy. It appears that universities more and more have to take care of producing fundamental knowledge. The trend line shows a dropping line to the produced quantity of fundamental research at firms[11]. This emphasizes the importance of public-private knowledge interaction or in other words the transfer of university knowledge into business.

The fact that university knowledge can not be converted directly into applications and economic profits is accepted by firms. Consequently, firms have another attitude towards collaborations with universities comparing to collaborations with other firms. These firms have no definite objectives on the basis of connections with public institutions in general. On the contrary to public institutions the firms have these objectives to connections with private institutions (Poot and Brouwer, 2001).

[10] This literature study concerns a survey of macro economic studies to the returns of public financed scientific research.

[11] See Netherlands Bureau for Economic Policy Analysis (2002), p.151. People are speaking about a paradox: Dutch businesses are more and more dependent of knowledge but are producing decreasing fundamental knowledge themselves.

The set up of connections with universities to transfer knowledge is a learning process from firms' perspective because of above mentioned indirect benefit. The extra occupation of the firm's employees is underestimated in particular to the short term connections with universities (Poot and Brouwer, 2001). This complaint decreases as connections stands firm over time. Accordingly, the government may aim her support to public-private connections at the first period of existence to stimulate knowledge transfer connections effectively. This may facilitate the firms' investment costs to maintain the knowledge connection. Consequently, the firms become the possibility to obtain better insights to the added value to the firm as a result of the connection.

Furthermore, it is proved that a knowledge connection with a public institution is seldom at small size firms (Poot and Brouwer, 2001). Accordingly, this group shares relatively less benefits of public knowledge acquisition. Stimulating the start of such a connection may have a positive effect to this group. Nevertheless, the small remark has to be made that a significant part of small- and middle size businesses have less need for collaborations with universities. In this case possibly a role for the academies can be appropriated because they mainly produce practical knowledge.

Beside the different need of knowledge interaction to firm size it also differs to each business sector. Empirical research (Schartinger et al., 2002) shows among other things that the intensity of knowledge interaction differs to each sector significantly. Some sectors collaborate intensively with particular fields of science (e.g. the agriculture sector). Other sectors obtain knowledge from a wide range of scientific fields (e.g. the chemicals industry). In general the sectors have intensive knowledge interaction with the scientific fields close to their core business/ activities.

Finally, the knowledge transfer channels relevancy within the knowledge interaction process is different to each business sector as well. Policy activities concerning university knowledge transfer have to take these different channels into account. Next chapter will focus on this issue in detail.

3 Knowledge transfer to industry

3.1 Introduction

This chapter describes the university knowledge transfer to industry. First of all the process to knowledge exploitation is discussed in paragraph 3.2. It shows how produced knowledge leads to knowledge exploitation by knowledge transfer. Subsequently the different forms of knowledge transfer and its effectiveness will be clarified in paragraph 3.3. Finally paragraph 3.4 concentrates on the issue of Intellectual Property protection to stimulate knowledge transfer.

3.2 The process to knowledge exploitation

This paragraph explains the selected approach concerning knowledge exploitation within the innovation framework. The exploitation of knowledge is strongly correlated with knowledge- transfer and generation. Figure 4 shows a schematic representation of the knowledge process.

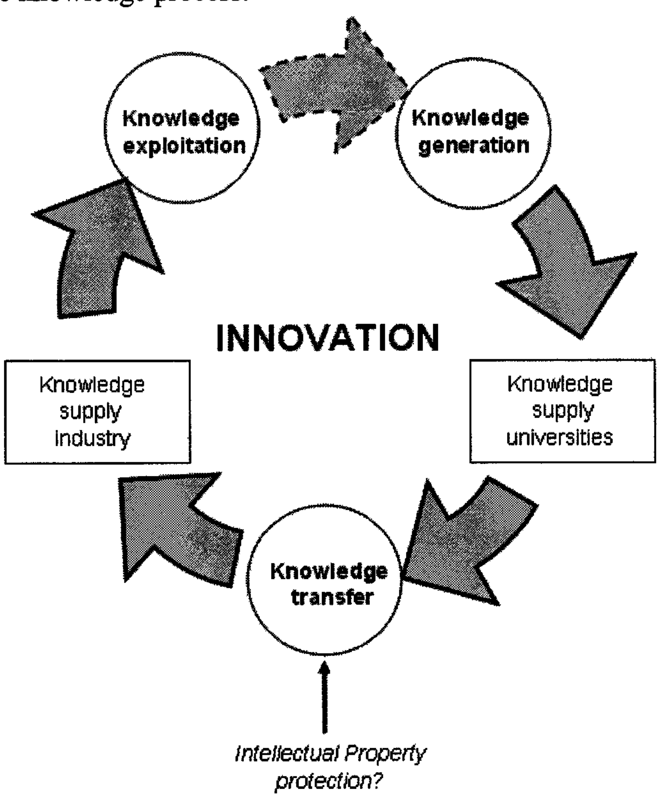

Figure 4: The knowledge process within the innovation framework

Firms manage commercial activities and want to make profits. The larger part of these firms is forced to innovate and exploit available knowledge to accomplish this goal. It is important this knowledge flows into business in case it concerns university produced knowledge. Accordingly, the aim of university knowledge transfer is knowledge exploitation in this process. Knowledge exploitation is the transformation process of knowledge into products, services, product processes, etc. The knowledge transfer can be defined as communicating the knowledge from an organisation to another.

Knowledge production consists of generating new knowledge by carrying out research. The different types of university produced knowledge are not all appropriate to transfer for exploitation. The applicability of research (results) plays a significant role to the exploitation possibilities. Fundamental research does neither have the aim or the prospect to result in commercial profits on the short term. Applied research possesses a significantly higher chance to be exploited because of the research results improved application. The exploitation of knowledge may be stimulated by emphasizing on applied research. Accordingly, the (short term) collaborations between universities and business may be more attractive in perspective of the firms.

Furthermore, the subject of the produced knowledge affects the transfer. If new knowledge optimally fits to business present knowledge/technology it will improve the knowledge transfer.[12] This establishment is linked with the policy themes like focus and masses to the research and firms clustering.

3.3 Forms of knowledge transfer

Knowledge is transferred through a variety of possible channels. This is because of the diversity of knowledge and the way it interacts with economic processes. For that reason a marginal note has to be made about the absence of a clear clarification between the channels of transfer and continuing new created channels. This paragraph shows an overview of the main mechanisms of knowledge transfer divided into two forms: The traditional forms and the more recent classified forms respectively discussed in sub-paragraph 3.3.1 and 3.3.2.[13] Subsequently the different channels effectiveness of knowledge transfer is discussed in sub-paragraph 3.3.3.

Traditional forms:	
(1)	Education
(2)	Publications
Recent forms:	
(3)	Mobility of people
(4)	Cooperation in R&D
(5)	Contract research and advice
(6)	Cooperation in education
(7)	Spin-offs and entrepreneurship
(8)	Sharing facilities
(9)	Participation in conferences, professional networks and boards
(10)	Informal or personal contacts
(11)	Intellectual Property Rights

Table 1: Forms of knowledge transfer

3.3.1. Traditional forms of knowledge transfer

The two knowledge transfer channels education (1) and publication (2) are nowadays known as the 'traditional' forms. These get along with the origin of the traditionally objectives of universities: taking care of education and carrying out scientific research. Knowledge becomes public and easy accessible by writing down and publishing research. The knowledge stored into this channel of knowledge transfer is mainly explicit due the nature of publications. The performance of the universities on the

[12] The knowledge fits better to the absorption capacity of firms, see Cohen and Levinthal (1990).

[13] The 'recent' classified forms are obtained using an elaborated list by Bongers et al. (2003).

traditionally forms of knowledge transfer can be measured successively by the number of graduates and publications as well as the number of citations to these publications.

3.3.2. Recent forms of knowledge transfer

By mobility of people (3) researchers with a particular internalized knowledge can transfer their knowledge from university to industry. A well known example of mobility is a university student carrying out his master thesis or promotion research at/ for a firm. The student transfers knowledge into business obtained during his study. Other channels of mobility are university researchers working both for the university and industry, consulting university employees, student trainees or exchanges.

Cooperation in R&D (4) is an important forth channel of bi-directional knowledge transfer parallel to mobility of people. It's an intensive knowledge transfer because of the joint ambitions to the main targets, the frequently contacts and often long term relationship.

The essence of the fifth channel contract research and advice (5) is to reply to particular questions of the industry. The university may possess specific knowledge to this demand. The academy carries out research individually (no collaboration) for a certain compensation of this knowledge flow to fulfil tasks for the firm.

The industry and university can transfer knowledge bi-directionally by cooperation in education (6). Training taken care by universities can be used to educate employees of the industry. Furthermore, firms can influence the curriculum of university education as an approach of cooperation. In this way university comes in touch with economy developments. It also creates an educated labour market in favour of the industry.

The seventh channel of knowledge transfer is spin-offs and entrepreneurship (7). This is a unique channel of knowledge transfer because the commercial firm is originated by public institutes or companies generated knowledge. In this sense not the firm but the knowledge transfer was present first. The used knowledge is often handed over in the form of licenses or full transfer of patents. One of the characterisations of a spin-off is the practical type of the knowledge transfer and the advanced stadium of the exploitation process comparing to earlier mentioned collaboration forms.

Particularly facilities as laboratories are sometimes needed for the developments of new technologies. Advantages (e.g. saving costs) exist by sharing facilities (8) because university and industry both do not need to buy or maintain the facility. On the other hand, a bi-directional knowledge transfer between the facility (-management and) users is created.

Participation in conferences, professional networks and boards (9) by academic researchers and the industry can be defined as an eight channel of knowledge transfer. Visiting conferences, congresses and workshops the academic researchers are able to communicate directly with other actors into the specific science/ technological field to exchange knowledge. Moreover, this participation can also create- and strengthen social networks.

Knowledge exchange also occurs on informal or personal basis of contact (10). This contact between universities and industry often originates from personal networks (Bongers et al., 2003) and is the most common way of bi-directional knowledge transfer (Poot, Brouwer and Zijnderveld, 1998). Professors and other researchers on universities having commissions into business play an important role. They obtain a significant amount of information about the dynamic economy because of their double function which can play an important part in their work on the university. Likewise firms come in touch with university developed knowledge and can enter the university generated knowledge resulting in an adaptable created knowledge transfer.

Finally knowledge can be transferred by intellectual property rights (11). New knowledge is temporary monopolized and can be published by applying IPR's (e.g. patents, design- and model rights, registered trades etc.). It can be made public without risks of third parties having unintentional aims.

Some researchers (e.g. Cohen, Nelson and Walsh, 2002; Agrawal and Henderson, 2002) found that patents (channel 11) is one of the least important knowledge transfer channels of universities. Publications (channel 1), meetings and conferences (channel 9), informal contacts (channel 10) and consulting (equal to specified channel 5) were all ranked as more important mechanisms concerning the most effective channels through which firms benefit from university research.

3.3.3. The channels effectiveness of knowledge transfer

The presence of sufficient tacit knowledge is a significant condition for innovation.[14] Empirical research turns out that seventy-one percent of the inventions in the US require a close commitment of the academic inventor to achieve successfully commercialisation (Jensen and Thursby, 2001). Accordingly, stimulation of the initial researcher's involvement and the transfer of tacit knowledge play a significant role in policy. However, not every channel of knowledge transfer is appropriate for transferring tacit knowledge. Channels consisting regularly personal contact (e.g. part-time commissions of researchers, PhD or master thesis's and joint research) are most appropriate to transfer tacit knowledge. Channels consisting no or relative less personal contact (e.g. patents, publications but also contract research and consultancy) are less appropriate.

Second, the university and industries attitude towards the fundamental-, applied- or experimental nature of research is also important factor for effectiveness. Although research leading to innovation can be defined/ approached as a linear technological development (see process figure 4), the different types of research can have an impact on each other.

Third, it is significant to multi- or mono-disciplinary research in what way the organised disciplines are combined to achieve the best possible knowledge transfer progress. Parallel to this constitution the effectiveness of particular knowledge transfer channels is also dependent per sector- and field of science. Technical sciences and R&D intensive industries generally have significant benefits by intensive joint research. The social- and economic sciences and the service industry on the contrary are increasingly using channels of person's exchange.[15] The importance of the service industry for the Dutch economy[16] shows that this distinction is a significant policy consideration.

[14] See among others Leonard and Sensiper (1998). Tacit knowledge is hard to capture but essential for the creative aspect of innovation according to these authors.

[15] Conclusions made by Schartinger et al. (2002) based on empirical research.

[16] The GDP share of the service industry in the Netherlands is approximately seventy percent.

3.4 The protection of Intellectual Property

Knowledge can be protected in different ways. In principle protection by secrecy is no real university option because this is in conflict with science and sharing knowledge. It is possible to apply legal protection by the patent law or copyrights depending on the specific case.[17] Patenting takes a significant position into knowledge exploitation but not all knowledge can be patented. The rigorous demand on inventions to be industrial applicable is a condition to apply for a patent.[18] Accordingly, a significant part of social- and linguistic scientific knowledge is excluded. Hence, knowledge protection mainly refers to knowledge originated from technical- and exact sciences.

The patent gives the patent holder[19] a temporary monopoly on its invention holding the exclusive right to exploit. If knowledge is protected by a patent it can stimulate a firm to exploit this knowledge. In a study with the broadest geographical coverage by Arundel et al. (1995) eighty percent of the enterprises stated that protection from imitation is very important considering patenting. Followed-up other empirical studies (e.g. Duguet and Kabla, 1998; Cohen et al., 2002; Pitkethly, 2001) confirmed the significance of this motive. Two variants are conceivable to become patent rights. The first variant is the patent will be applied and hold on the invention by the patent holder. Subsequently licenses can be granted to one or more firms. The second variant is the firm can be patent holder by buying it. The deduction can be made that improved patent applications by universities may be good for innovation. In exchange for the temporary monopoly the patented knowledge will become public. This way other parties get the chance to carry out further research in the same field without having to invent the wheel twice. The patent will function as a channel of knowledge transfer in this case.

The comment has to be made preceding perspective is just theoretical. In practice the motive for using patents can also have a strategic argument to the firm. This way they can block potential competitors by clever- or superfluous patenting behaviour. Consequently, the access to specific profitable technology fields is complicated. This strategic behaviour can serve two goals. In first place a good negotiating position is created to negotiate about cross-licenses (i.e. providing mutual access to one or more of the patented inventions) this way. The second goal is to prevent competitors to venture into a specific patented field by a so-called minefield of patents. The blocking strategy consists of creating a field around the innovation to prevent other firms to develop a competitive alternative (Clarkson, 2002). Hence, strategic patenting does theoretical not contribute to knowledge transfer- and exploitation and consequently hinders innovation.

The number of motives to patenting is considerable larger. Blind et al. (2006) elaborated a list of motives and its importance to firms across sectors in Germany. Beside the motives protection from imitation and strategic behaviour these researchers found that securing both European and National markets followed by improvement of technological image were almost of equal importance. Other motives as increasing company value and position improvement in cooperation scored average. The

[17] Beside the patent several other IP rights exist like design- and model rights or registered trade marks. However, these will be left outside of consideration.

[18] Article 2 paragraph 1 of the Dutch Patents Act of 1995 claims that *"In order to be eligible for a patent in the Netherlands, an invention must meet the three requirements novelty, inventive step involvement and susceptibility of industrial application"*

[19] Article 12 paragraph 3 of the Dutch Patents Act of 1995 claims that "*Where the invention has been made by a person carrying out research in the service of a university, college or research establishment, the university, college or research establishment shall be entitled to the patent*"

generation of revenues from licenses and influence on standardization is seen as least important.

It has been put forward that the number of patents applications by the European (and also Dutch) universities is insignificant comparing to both the US and Japan since 1981.[20] On the contrary the European universities scientific performance is good and even slightly better.[21] In literature this is suggested as a problem behind the so-called "European paradox": A gap between academic research and industrial innovation. Obviously the Dutch policymakers are nowadays concentrating on the patent issue after the Lissabon top meeting in 2000. The board of committees on European universities are also focussing on patenting concerning knowledge valorisation. It even turned out to be that these committees are mainly thinking in terms of patents although policy activities differ significantly at each Dutch university and its faculties (Poot, Brouwer and Zijnderveld, 1998). The motive that patent protection is important to firms to switch over to exploitation constitutes a significant consideration in perspective of university patent policies. Nevertheless, some researchers (e.g. Verspagen, 2006; Geuna and Nesta, 2006) are sceptical to the desirability of patenting by universities. They argue that university patenting may create dangerous tensions within the university system. The topic how universities should have to deal with patenting activities is part of a broad discussion on both National and European level. So far very little theoretical- and empirical evidence exists in support of the view that university patenting would accelerate commercialisation.

On the contrary to Europe much is known about patenting activities at American universities and has been analysed by several research studies (see e.g. Trajtenberg et al., 1997; Mowery and Sampat, 2001; Mowery and Ziedonis, 2002). Recent years a number of studies have been carried out for European countries. Cesaroni and Piccaluga's (2002) did research to the patent activity for France, Spain and Italy on 'university owned' patents for instance. Moreover, other researchers as Meyer (2003) and Saragossi and van Pottelsberghe de la Potterie (2003) empirically studied data on 'university invented' patents[22] respectively in Finland and Belgium. Next step ahead was the PatVal EU-survey finished in 2004. It collected detailed- and direct data on more than 9.000 EPO granted patents between 1993 and 1997 located in France, Germany, Italy, the Netherlands, Spain and the United Kingdom. This database feed several researchers on providing new information concerning the debate on (university) patenting.

In order to discuss the patent issue (see Chapter 5) in depth it is important to describe the Dutch picture towards knowledge valorisation first. Next chapter surveys the Dutch policy activity for respectively the Dutch government and the Technical University of Eindhoven.

[20] The US implemented a piece of legislation at the end of 1980: The Bayh-Dole Act or University and Small Business Patent Procedures Act gives intellectual property control to this particular group's inventions that resulted from federal government-funded research.

[21] Production results on scientific- and technological performance of the US, the EU and Japan. European Commission (1995), p. 6.

[22] The inventor of the patent is at least one (staff) member of a university, independent whether the university has assigned the patent.

4 Dutch policy

4.1 Introduction

The aim of this chapter is to provide an overview on the Dutch policy activity towards knowledge valorisation. First the Dutch governmental policy on university-industry knowledge valorisation is mapped in paragraph 4.2. Subsequently the policy of the Technical University of Eindhoven policy is mapped into this field in paragraph 4.3.

4.2 Dutch governmental policy

Several ministries engage in a certain extent to affect the university knowledge transfer into business and its exploitation. Policymakers with considerable influence are the ministry of Economic Affairs (EA) and the ministry of Education, Culture & Science (EC&S). EA conducts the innovation policy and EC&S conducts the scientific and higher education policy. Beside these other ministries are involved as well. They stimulate the development of a particular type of knowledge (e.g. in the field of durable technology like solar energy). Therefore firstly the involved parties will be reflected in an overview in paragraph 4.2.1. Subsequently the applied policy instruments will be discussed in paragraph 4.2.2.

4.2.1. Involved parties

The number of parties involved in the accomplishment- and implementation of policy concerning university knowledge valorisation is significant. Figure 5 on next page shows the main- and most important parties/actors. These will be discussed below. The overview of the government actor field into detail is enclosed in Appendix I.

The main government actors are the ministry of EA and the ministry of EC&S. EA has the task to create good sub-conditions for the Dutch economy and fulfils this by stimulating innovation. The stimulation of innovation is constituted into the innovation policy. EC&S is not engaged in innovation directly but contributes to two other essential ingredients of the innovation process: knowledge and human capital. Relevant policy activity can be recovered in the 'science budget', the 'higher education and research plan' and the 'delta plan beta technique' (Ministry of education, science & culture (2003/I, II, III).

Universities and firms are the target group of governmental policy. Firms have to innovate increasingly by among other things affectively utilizing knowledge produced by universities. Universities have to support innovation improvement by among other things developing essential knowledge and transfer it into business.

Universities have always had a considerable autonomy to commit science independently. This autonomy is for instance visible in the free expenditures of resources. On the contrary to its American counterparts the Dutch universities are not that independent yet. The Dutch are working on the basis of national equivalence comparing to the American universities which are highly decentralized and very competitive. This implies the American universities possess a high degree of autonomy. Accordingly, they seize the opportunities to tackle their own issues and built on their own unique strengths and aspirations (Goldfarb and Henrekson, 2002).

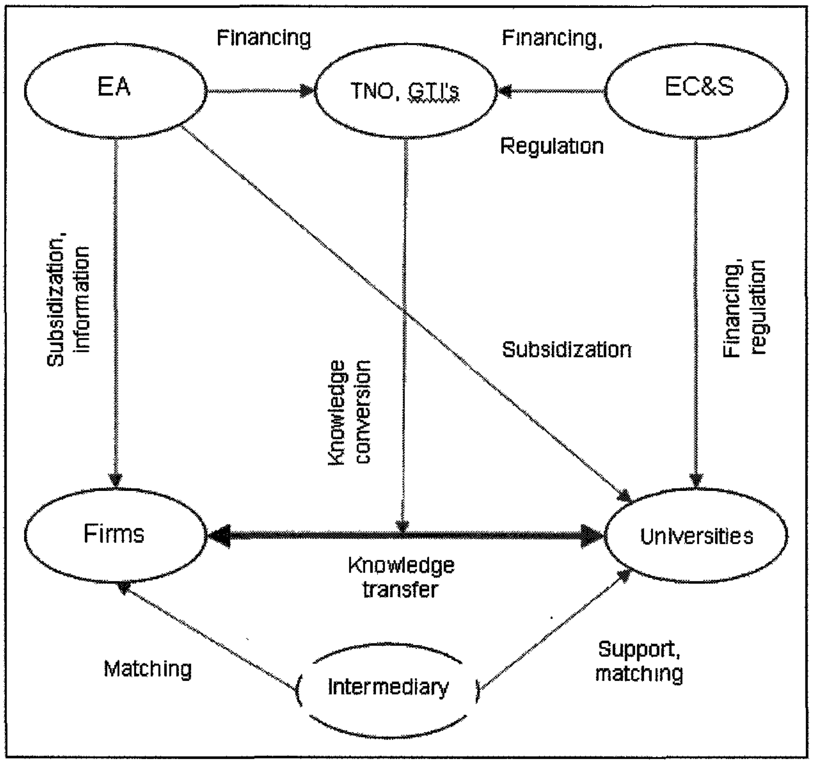

Figure 5: Schematic representation of the main actors and its connections.

The public institutes for applied research (e.g. TNO) fulfil a bridge connection by offering users (i.e. firms and the government) an advanced applicable form/ state of university produced knowledge.[23] The private intermediaries are knowledge brokers that look for customers of university produced knowledge. The institutes for applied research and the intermediaries constitute a connection between the universities and business.

4.2.2. Policy instruments

The new 2007 set up coalition agreement has decided to continue the Innovation platform by redesigning the platform founded in 2003. The government does their best to reach their innovation policy formulated goals (see paragraph 2.1.). They have implemented a number of policy instruments over the past years. These instruments to valorise knowledge are distinguishable into a set of three categories.

The first category of the policy instruments stimulates the joint development of knowledge by industry and knowledge institutions. Through collaboration knowledge is created for business that possesses an improved applicability as well as transferability. The industry close involvement to research is more or less dependent on the instrument. Nevertheless, cooperation with firms is already often on early stage. The second category consists of public research institutes for applied research fulfilling a bridge connection between universities and business. The knowledge transformation is increased by executing applicable oriented advanced research. The third and last category is the instruments that aim at the diffusion of knowledge (e.g. an intermediary like Syntens).

[23] TNO is active on the field of transforming (technological) scientific knowledge into practical applications. It constitutes the bridge between fundamental research and practical application aiming to strengthen the innovative power of industry and government.

Stimulating of collaboration (cat. 1)

The first category of instruments is financial of nature aiming to encourage collaborations between business and knowledge institutions by financial incentives. The collaboration has to lead to joint technology development. Recently some programs have developed their own set of rules and/or regulations with respect to intellectual property. Table 2 shows an overview of the instruments that can be put into category one (SenterNovem, 2006). Each instrument is elaborated in Appendix 2.

Instrument	Objective	Target group	IPR regul.?
IOP	*Innovation driven Research programs* Promoting scientific research projects at knowledge institutes, with firms	Knowledge institutes and firms	Yes
TTI	*(Eight) Technological Top Institutes* Promoting application of public knowledge and acting on research orientation	Collaboration connections firms – knowledge institutes	Yes, all 8 TTI's independently
Bsik (former ICES-KIS)	Strengthen the knowledge infrastructure by public-private collaboration	Collaboration connections firms – knowledge institutes	-
STW	*Technology Foundation STW* Stimulation of excellent technical-scientific research with utilization possibilities	Knowledge institutes	Yes
PSI (former EET)	*Economy, Ecology and Technology program* Promoting research projects contributing to sustainability of the economy.	Collaboration connections firms – knowledge institutes	-
PSI (former TS)	*Technological Collaboration projects* Promoting technological collaboration on the field of research and development	Collaboration connections firms – knowledge institutes	-
Smartmix	*Smartmix program* Promoting 'excellent' research to all possible (scientific) fields within all social sectors	Consortia of researchers and knowledge (end)users	Only rules
Practical research	Applied research within the agricultural sectors by co-financing firms	Collaboration connections firms – knowledge institutes	-

Table 2: Summary of the policy instruments aiming at collaboration between knowledge institutes and business.

Applied research (cat. 2)

This category consists of five sizable technical institutes (GTI's)[24] and TNO. These institutes, as already mentioned above, may be a connection between university and business by carrying out applied research utilizing fundamental university knowledge significantly. Besides fulfilling a bridge connection the institutes also develop knowledge themselves on customer's request. It is suggested these institutes should develop knowledge more demand directed instead of supply directed to business as well as the government. This way it may strengthen the connection according to research by the commission Wijffels.[25] The former cabinet has initiated a process to rearrange these organisations as response.

Knowledge diffusion (cat. 3)

The third category of instruments is focused on the diffusion of generated knowledge by public institutes into business by providing subsidy, information and consultancy. On the one hand, attempts are made to diffuse knowledge to existing companies. On

[24] The Dutch Energy Research centre ECN, Ground mechanics Delft, the Dutch Maritime Research Institute, the National Aerospace and Aviation laboratory and the Watercourse experts Laboratory.

[25] Ad hoc commission "Bridge function TNO and GTI's" (2004)

the other hand, the foundation of new firms (e.g. techno starters) which exploit university knowledge is stimulated.

One of the most well known instruments is Syntens[26]. This agency stimulates- and supports technology pursuing firms within small and medium size business on the field of innovation. They for instance give advice on product- and process development, strategy and marketing. They also fulfil a function as intermediary for small and medium size business by searching the right collaboration partner among knowledge institutes and firms.

4.3 University policy TU/e

The ministry uses mainly legalization, instructions and financial instruments as discussed in paragraph 2.2 and 4.2. Government conferences are held occasionally and the Dutch universities have a relatively high level of autonomy. In practice two visions for the hierarchy of Dutch universities exist according to the AWT Council of Advice for Scientific- and Technology policy. The first autonomy vision says the government owns the role of supplying funds as well as checking universities efficacy and legitimacy of expenditures. The government has no influence on the strategic policy. Justification for doing research is at the university board of supervision. Second vision says universities are objective organisations. The government designs a directive strategy and the universities can choose their own direction in the framework. The universities have to report their autonomy to the ministry. Beside these two visions the AWT formulates: *"Knowledge institutes serve public interests without being part of the machinery of government. Social enterprises serve to manage autonomy and to fulfill their tasks without intentions to make profits. Although they can and are allowed to develop market activities as long as it supports public activities."* Accordingly, universities have to act as social enterprises and have to justify their research activities to interested persons like citizens, companies and non-profit organizations (AWT, 2003, p.25-31).

The TU/e university policy covers a wide-ranged set of subjects.[27] The focus in line with this report will be the policy on university to industry knowledge transfer, and in particular the role of patents. Hence, below discussed policy only deals with the knowledge valorisation subject. The rest will be left out of consideration. First an overview of the important involved actors is reflected in sub-paragraph 4.3.1. Subsequently the applied policy instruments are discussed in sub-paragraph 4.3.2.

4.3.1. Involved actors

The number of actors involved to the accomplishment- and implementation of university policy on knowledge valorisation is significant. The main- and most important actors as showed and highlighted in Figure 6 will be discussed.

On top of the hierarchy the board of supervision supervises the entirely university management and its administration. The directors of CvB are responsible for the university management and administration. They take care of the strategic plan that is published every six years and constitutes the universities vision on policy for the period of four years. It is no blueprint but a time bounded and direction focused framework for policy. Additionally the institutional plan is a translation of the strategic plan. The CvB

[26] Other examples are Brainport and the former SKB and SKO regulations.

[27] The topics are education, research, student facilities, strategic collaboration (the Netherlands) and management. Knowledge valorisation and internationalization are two new topics within the new institutional plan 2006-2009.

is responsible for the policy intentions using this important document. It is published every two years by the TU/e and contains its core ambitions and policy aims for the period of three years.[28] The board of supervision has to approve the institutional plan and participation agencies have the right to give advice. The ministry gets an overview on the basis of the institutional plans as well as the administrative agenda's, annual-reports and accounts. It shows the institute's policy plans and to what degree it has been accomplished. The CvB manages following units:

i. The nine TU/e faculties. Each board of faculties is responsible for its own general management, organisation of education and execution of science. Although the faculty boards have to legitimize their tasks and authority they are having a high level of autonomy.
ii. TU/e Holding BV, founded in 1997. This holding consists of companies[29] exploiting university scientific knowledge into business commercially.
iii. The 3TU federation. This federation[30] consists of the three platforms '3TU Graduate School', '3TU Institute of Science and Technology' and '3TU Innovation Lab'. It was created by the three Dutch technical universities out of a common plan for science and technology to strengthen the innovation at the start of 2004. The 3TU is an extension to ambitions made by the Innovation platform as well as the letter of intent (het Hoofdlijnenaccoord) by Balkenende II. 3TU is directed by the three directors of the CvB with ambitions on education, research and knowledge valorisation for the period 2004-2010 (Stuurgroep Sectorplan Wetenschap & Technologie, 2004).

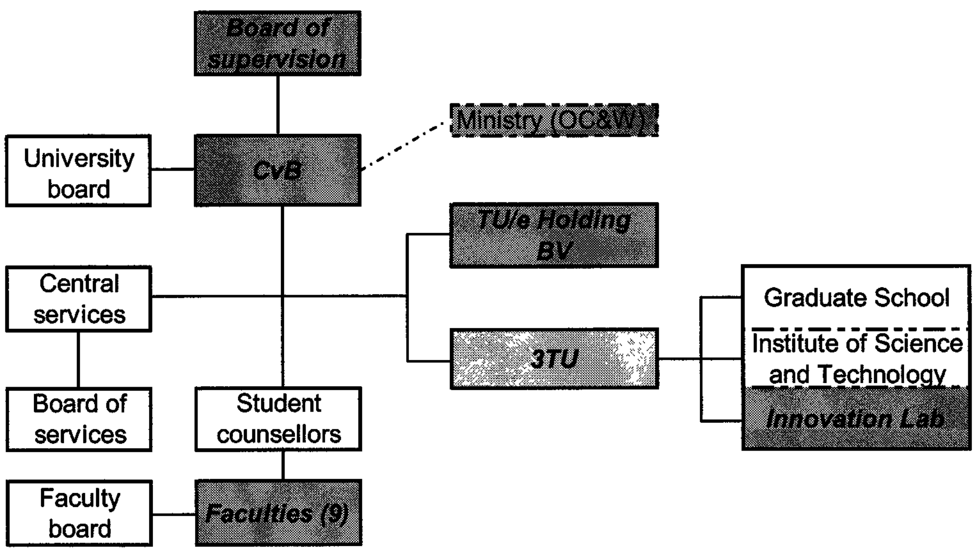

Figure 6: Schematic representation of the main actors and its connections

4.3.2. Policy instruments

Figure 7 shows a representation of the TU/e policy draw up to get a clear overview. In its (A) strategic plan 2002-2006 Eindhoven university has emphasized International competition and collaboration. The (B) institutional plan 2006-2009 defines the ambition within the knowledge valorisation framework. The aim is to invest in a

[28] Since 2006 it's for the period of three years. Former years it was for the period of 4 years.

[29] The companies are TU/e Innovation Lab BV, Euflex Employment Services BV, Acctec BV, TM/cc BV, SyMo-Chem BV, HemoLab BV, Polymer Technology Group Eindhoven BV (PTG).

[30] TU Delft, University Twente and TU Eindhoven

substantial source of knowledge, technology and new activities within the national- and regional knowledge economy by five instruments (CvB TU/e, 2006). These instruments are:

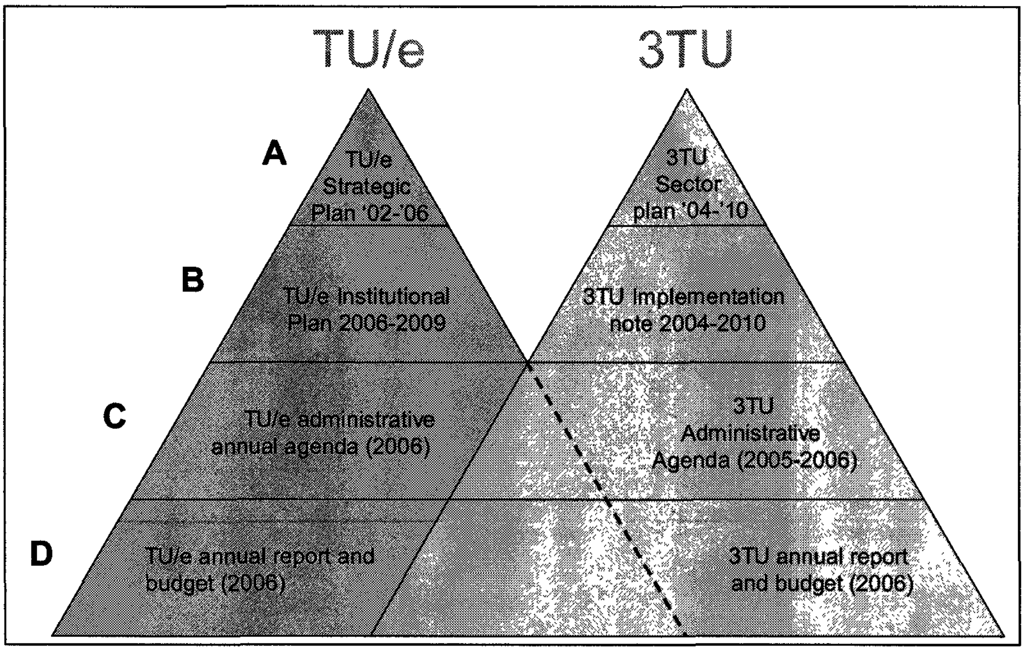

Figure 7: Schematic representation of the TU/e policy coherency

i. TU/e Innovation Lab. The lab has to play a significant stimulating- and supporting role to utilize university generated knowledge by business optimally. The main points are cooperation with large firms and industry, stimulating knowledge transfer to- and innovation projects with small and medium size business, and stimulation of entrepreneurship and innovation.
ii. Entrepreneurship education. Together with the Innovation Lab the faculty Technology Management has to take care of an attractive offer of education to stimulate- and support entrepreneurship to students and employees.
iii. Public private research- and technology institutes. Collaboration with business and other institutes within public private research- and technology institutes are important to obtain recourses for university research and to utilise economic & social generated knowledge optimally. Research priorities also have to be chosen on the basis of these collaborations.
iv. Brainport Eindhoven. The TU/e is involved actively to strengthen the cities and environs position as Brainport by participating on the strategic action program 'Brainport navigator 2013'. Eindhoven must grow into the European top technology regions by innovation.
v. Dynamism & Smartmix[31]. The universities target is to gain at least 6% of the yearly 100 million euros Smartmix divided on strategic government financing. The share will be based on former universities second and third cash flows. Hence, it is important that the share of at least 8% is maintained. The requests at NWO and SenterNovem should fit as close as possible to the university own policy on execution of research.

[31] See Appendix II for a specified explanation of the Smartmix program

The ambitions have to lead to at least 45 million euros of revenues by third cash flow on annual base and above noticed financial share of dynamism & smart mix funds. Moreover, 20 applied patents in the name of the university, 35 running licenses and last but not least 15 TU/e related start ups have to be effected each year.

Beside the institutional plan concrete policy points are mapped in an (C) administrative agenda each year. This agenda formulates the universities annual desired results. The Federation of Dutch Universities publishes, parallel to the TU/e administrative agenda, a common 3TU administrative agenda each two years. The 3TU agenda 2005-2006 overlaps the TU/e agenda on a number of points. The Innovation Lab constitutes the central instrument concerning knowledge valorisation according to the content of these agendas. The innovation activities of the three universities for knowledge- transfer and exploitation have to be combined in this institute. The cooperation has to lead to advantages of synergy, a transparent research supply and the creating of an increase into business sector collaboration and application. The lab had to fulfil among other significant objectives (CvB TU/e, 2004, 2005; Federation of Dutch Technical Universities, 2005):

- The implementation of a collective regulation to support starting entrepreneurs (so called TOP-regulation);
- Draw up agreements and collaboration arrangements about knowledge valorisation together with the five large enterprises (Philips, Shell, Akzo-Nobel, DSM, Unilever) and organisations as NWO, Syntens, TNO, STW and SenterNovem;
- The development of collective standard conditions, project templates, contract drafts, (corporate) agreements with regard to property rights within the contract research framework.
- The implementation of a collective 3TU patent strategy. The new IPR regulation of the TU/e is elaborated in Appendix III.

The ambitions were made respectively by the TU/e and 3TU to achieve the results reflected in Table 3.

	TU/e		**3TU**
Objectives:	**2005**	**2006**	**2004-2010**
Third cash flow (million euros)	35 (-)	36 (↑)	+ 20%
New techno starters/ spin-offs	15 (-)	10 (↓)	+ 25%
New patent applications	52 (-)	45 (↓)	+ 25%
New granted licenses	15 (-)	10 (↓)	-

Table 3: Knowledge valorisation ambitions of the TU/e and 3TU

The annual reports and budgets of the TU/e (D) are complementing policy by presenting the annual university results and finances to achieve the administrative agenda objectives. The annual report quantitative indexes of the TU/e for 2001-2005 (CvB TU/e, 2006) are reflected in Table 4.

	2001	**2002**	**2003**	**2004**	**2005**
No. of scientific publications (ref)	1944	1822	2247	2565	2692
No. of scientific publications (non-ref)	471	356	428	281	393
No. of start-ups in cooperat. with TU/e	11	10	7	16	16
No. of applied patents hold by TU/e	8	6	6	7	11
No. of new granted licences by TU/e	1	2	2	3	7

Table 4: The annual report quantitative indexes of the TU/e for 2001-2005

5 The patent issue

5.1 Introduction

The aim of this chapter is to provide a better insight on the patent issue. This issue will be discussed by applying the research framework on university patenting set up by Geuna and Nesta.[32] These researchers formulate three main topics on the basis of patent activity generated data about which very little is known in Europe. The first topic about 'the value/ quality of patents' will be discussed in paragraph 5.2. Subsequently paragraph 5.3 discusses the second topic about 'the efficiency/ effectiveness of patenting as technology transfer instrument'. Finally paragraph 5.4 discusses the third topic about 'the effects of patenting on academic research'. The exploration of these topics contributes to the analytical assessment of the carried out case studies on patenting in next chapter.

5.2 The value/ quality of patents

The significant part of literature has applied indirect measurements to estimate 'the value/ quality of patents'. Patent citations (Harhoff et al., 1999; Harhoff et al., 2003; Hall et al., 2005) forward as well as backward, patent claims (Pakes, 1986; Schankerman and Pakes, 1986), the number of countries registration for protection and the number of patent opposition (Harhoff and Reitzig, 2004) are the most common measurements to indicate its importance and value. Lanjouw and Schankerman (2004) applied all these indications to compose one index for the 'quality' of patents. In contrast with indirect measurements Giuri and Mariani et al. (2005) and Gambardella et al. (2005) applied survey based information to their studies. These researchers used detailed- and direct data from the large scale PatVal EU-survey (2005)[33].

Giuri and Mariani et al. (2005) results show the distribution of patent values is skewed left and a small number of patents yield large returns (see Figure 8)[34]. Only 7.2% of all the patents are worth more than 10 million Euros, 16.8% yields more than 3 million Euros and 15.4% have a value between 1 and 3 million Euros. The larger share of 68% has a value of less than 1 million Euros. There are no considerable differences visible to the patent values across the five technological classes, with the exception of 'Chemicals and Pharmaceuticals'.

[32] It was presented at the 4th EPIP (European Policy for Intellectual Property) conference, Paris, France in October 2004

[33] Data was collected on 9.216 responded questions by European inventors covering 9.017 EPO patents with priority date 1993-1997 located in France, Germany, Italy, the Netherlands, Spain and the United Kingdom.

[34] The values were estimated by the inventors. The logarithm scale of the variable is constructed by intervals.

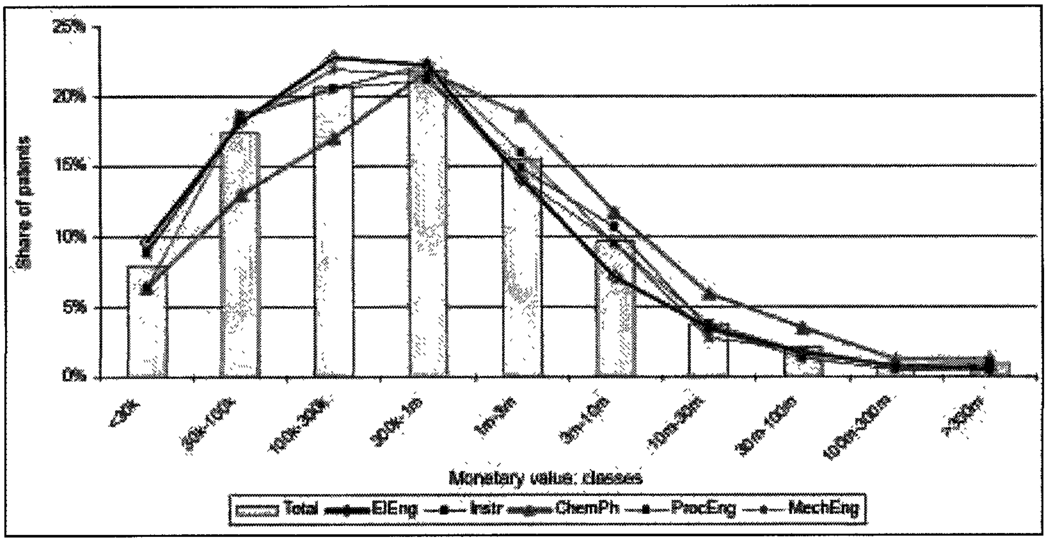

Figure 8: The value of European patents across macro technological classes (Source: Giuri and Mariani et al., 2005, p. 23)

Additionally their study shows the following three interesting insights. First of all, the importance of monetary rewards and career advances are found less important than personal and social rewards to inventors. Moreover, only a third of the patents appear to be developed by individual inventors. The rest of the patents have multiple inventors indicating inventions are a team activity. The second insight is that customers, followed by patents and scientific literature, are the most important used source of knowledge for the development of innovations. University and non-university are the least important source. The third insight is that half of the patents on the distribution by technological class are used internally by the firms for industrial and commercial purposes. More than a third of the patents are unused (i.e. blocking competitors and sleeping patents) and about one eighth is licensed.

Gambardella et al. (2005) explored four sets of determinants[35] to determine its importance on the economic value of patents by applying a regression method. They found that, other things being equal, the characteristics of the individual inventors (e.g. age, degree, past productivity, organisation employed years, money, career and prestige) are an important determinant. Beside their inventive experience the individuals' incentives play an important role. The researchers claim the individuals respond to monetary rewards and career advances to produce 'more' valuable patents. The valuable inventions appear not to be the result of prestige and reputation (i.e. academic motives). On the basis of these outcomes, compared to the other characteristics variables, the researchers suggest that the inventive activity is mainly the domain of talented individuals.

5.3 The efficiency/ effectiveness of patenting as TT instrument

The efficiency/ effectiveness of patenting will be discussed as one channel of knowledge transfer without comparing it to other channels. So far only two papers have been published on full economic models to assess the impact of university IPR (applicable within the European context) on the efficiency of the development process

[35] The determinants are the characteristics of 'the inventors', 'the patent', 'the organization' and 'the location' in which the patent was developed.

according to Crespi et al. (2006). These developed economic models by Hellman and Aghion and Tirole are successively discussed firstly.

Hellman (2006) focuses on the search process difference on patented and non-patented ideas to determine whether patents are efficient to transfer knowledge or not. He claims that *"since patenting affects the distribution of rents it has an effect on the relative search intensities of firms and scientists" (p.32).* He found two interesting findings about university researchers who develop ideas and subsequently seek firms for commercial development projects. Firstly, the researcher's incentive to invest in search is increased by university patents, but is decreased to firms. I.e. the researcher's position to 'push' their discoveries out to industry is improved. On the contrary the firms are discouraged to 'pull' discoveries out of researchers. The incentive to invest in search is dependent on the researcher's bargaining power strengthened by the patent. Secondly, the search efficiency rises if the control is taken over by the TTO on a university patented idea. The efficiency raise increases the probability of commercial application. The researcher's lose of control means he has to choose between disclosing and non-disclosing the invention to the TTO. The two-party (i.e. researcher and firm) or three-party (i.e. researcher, TTO and firm) bargaining game faces a different trade-off. Hellman's model concludes the matching process efficiency decreases in case the university owns the patent, but increases in case of the TTO involvement.

The model by Aghion and Tirole as cited in Crespi et al. (2006) analyzes the ownership of the patent within R&D collaborations between universities and private firms. Both parties have to make particular efforts to research and bargain about expected pay-offs which are related to the patent ownership. I.e. who takes (the initiative of taking) the patent? The pay-offs are compared to the firm in case the university or the firm will own the patent. Will the firm be better off if it shares the total pay off and receives the maximum effort by the university which owns the invention? Or shall the firm own the patent receiving the full amount of pay-offs but may having a discouraged effort by the university? Logically the higher university effort, the higher the pay-off will be for the firm in case the patent is shared with the university. The university effort is related to the willingness of the firm to leave the ownership of the patent to the university. The researchers Aghion and Tirole conclude that the final innovation will have a higher value if the university owns the patent. Accordingly, patents assigned to firms rather than universities may lead to market failure.

Crespi et al. (2006) themselves did an in-depth analysis to the need of a Bayh-Dole Act alike regulation for Europe. It was argued that universities need such regulation to make patenting more attractive. It may solve the patenting lack issue within the European paradox. Preliminary to the analysis the researchers found that patents are not statistically associated to university research because the firms are mainly applying for the patent. The data analysis from the PatVal EU-database (2005)[33] showed that at least one of the inventors was employed by a university in about 5 % of the total sample of EPO patents. The considerable high percentage of 80% and 82% of these university patents are 'not owned' by the university in respectively the Netherlands and the 6 EU countries. The researchers clarify the lack of patents to the fact that the patents office does not record university involvement. It is a lack of university-owned patents but not a lack of university-invented patents. They suggest the European patent output is not (that) far away from America in case the European-American ownership difference is corrected. Bearing these findings in mind the researchers analyzed the effects of university patent ownership on the rate of commercial application and on the commercial value. Bearing these findings in mind the researchers analyzed the effects of university patent ownership on the rate of commercial application and on the commercial value. The analysis was verified to the theory/ models by Hellman and Agion and Tirole. These models suggest that the economic efficiency of university to private knowledge transfer on patenting is a bargaining game. The analysis did not show statistically significant effects of university patent ownership both before and after controlling the different characteristics[36] of (non-) university ownership. Upon this the conclusion is made that *"no additional legislation is needed to make university patenting more attractive in Europe" (p.24).*

5.4 The effects of patenting on academic research

The current policy activity on patenting by the TU/e is grounded on the assumption that university patents may facilitate knowledge/ technology transfer and further invention development. Opinions against as well as in favour of increased university patenting exist to accelerate commercialisation to contribute to economic growth. Nevertheless, strong empirical evidence to the consequences of patenting is absent. The consequences of university involvement in-and institutionalisation of patenting[37] has to be determined to gain a better insight. Geuna and Nesta (2006) identified five main 'possible negative impacts' for analytical assessment. These are discussed with additional available literature in sub-paragraph 5.4.1. I added four 'other possible impacts' myself to complement the discussion in sub-paragraph 5.4.2.

5.4.1. The possible negative impacts

Publishing vs. patenting

The publication of scientific literature ranges from 3 to 18 months after initial submission to a journal. Its delay differs to each scientific field significantly. In particular the delays are longer (i.e. one to one-and-a-half years) in the fields of mathematics and technical sciences (Luwel and Moed, 1998). In contrast to publishing the patent applications are generally published 18 months after they are filed. The European Commission (2002) report has examined the public and private researchers' actual (and perceived) scientific publication delay due to the patenting of the invention. Figure 9 presents these results. It shows that a large majority of about 75% of academic researchers experienced some degree of delay. About 90% of industry researchers experienced a marginal- and no delay. This data suggests amongst other things that writing a publication is quite different from writing a patent application and the industry is more familiar to patenting.

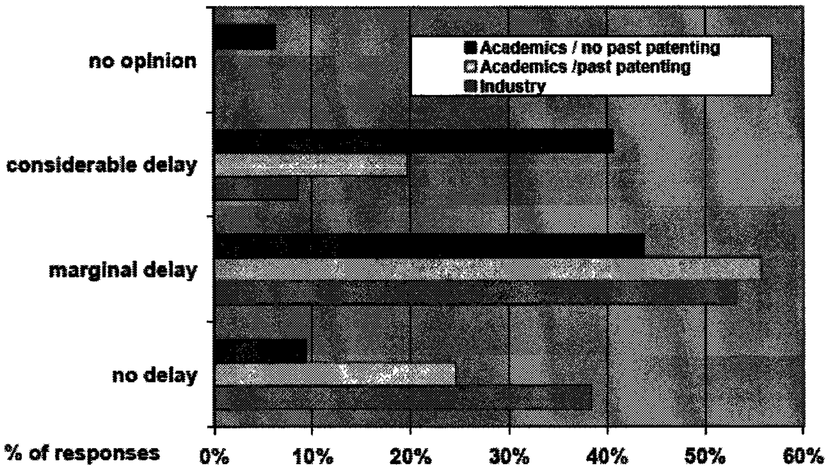

Figure 9: Actual (and perceived) delay of scientific publication due to the patenting of the invention (Source: EC (2002), p.12)

[36] Variables on Impact, Inventor- and Invention background, Technology -and Country effects.

[37] Institutionalisation within this context is the patenting as one of many activities

Geuna and Nesta (2006) argue the presence of complementarities between publishing and patenting for cross-sectional samples according to recent literature. Producing both patents and publications the age of the researcher is their subject for debate. Are younger researchers able to do both at the same time without a substitution effect comparing to their older colleagues? The older researchers already have built up an intellectual capital while the younger ones may have greater benefits by publishing to format an intellectual capital on the short term.

Furthermore, Geuna and Nesta elaborated five motivations concerning the decision university researchers make whether to patent their invention or not (2006, p.799, 800). These are:

- *Curiosity: To gain pleasure from discovery process itself;*
- *Reputation: Peer recognition and prestige within the group of their fellow researchers;*
- *Career advancement: researchers aspire to professional security and advancement to positions of influence within their organisations and their profession;*
- *Augmented research resources to permit the building of a more effective, appropriately equipped scientific team under their direction;*
- *Personal financial gain* [38]

The TU/e is convinced the fifth motivation can play an important role to the decision of university researchers. It is questionable that this motive, comparing it to the other four noticed preferences, is actually (most) important to the functioning of the researchers.

Threat to teaching quality

Geuna and Nesta (2006) also argued the teaching quality may suffer from time- or commitment reductions by emphasizing on the patent output and its related activities. The output, as part of the new TU/e policy, will also be used to assess the performance of the university. Accordingly, patents may have a higher impact on the university person's careers than teaching. In the 21st Intermediair edition (2007)[39] Prof. dr. H. van Dijken, professor Industrial Biotechnology at the University of Delft, says: "*To be honest I don't like teaching that much. All those uninterested students*" He enjoys doing research with young passionate people. He only does research he likes to do using the generated patent incomes, being independent on financial support, to position a PhD.

Impact on the culture of open science

The open science is characterised by an atmosphere of openness- and sharing of knowledge, data and research results contributing to cumulative knowledge production. Patents may close this open culture because of different reasons. Patents may delay publication as already mentioned above. Additionally Verspagen (2006) indicates that the increase of patents may threat scientific progress on the long term. It may keep information and research related knowledge internal due confidentiality or secrecy. He also feels dubious whether possible financial rewards on patents are an important aim in research. It may create research operation to a more competitive rather than cooperative mode.

[38] In past the possible revenues for university researchers were negligible. The new patent regulation by the TU/e introduced a bonus to patenting and changed the profit structure as from 01-01-2006. Accordingly researchers may be more interested in patenting than publishing because of the link to potential revenues.

[39] A weekly magazine for high educated persons

Fundamental long term research

Whether fundamental long term research is appropriate for the development of patents or not is questionable and varies across scientific fields. In some fields (e.g. biotechnology or ICT) it is even difficult to make a good distinction between fundamental- and applied research. Moreover, it is debatable that patenting may become a distraction to scientists if it has effect on their efforts to engage in research. Universities are not able to commercialize their inventions directly and its exploitation heavily depends on the effectiveness of markets for knowledge. Therefore universities have to focus their patenting activities closer to business to patent and license more effective if policies give the IP rights on inventions to universities (Shane, 2004). Accordingly, university science may have to put a larger number of patents closer to industry request. Two reasons are possible to clarify. First, the returns are easier to fulfil to basic research than to applied research. Second, the industry may be reserved towards investments because basic research appropriation is difficult. Furthermore, patenting is more difficult for more fundamental/ basic research than for applied research (Arrow, 1962). Accordingly, the increase of university patenting may cause a shift of academic fundamental/ basic research in the direction of more applied projects over time.

Threat to future academic research

Patents may be a risk for academic future research. First, patents particularly have the potential to block research in the area of cumulative progress in which new results are built upon old research. This issue may have affect on new basic research discoveries and subsequent applied research. The appearance of many university discoveries are namely the results of basic research (Verspagen, 2006). The research results of Murray and Stern (2005) also show the citation rate to a scientific publication falls after the patent grant. Moreover, patented knowledge is allowed to be used for research purposes by many patent systems, but the patent holder is able to challenge it in court (Geuna and Nesta, 2006). Second, the strategic behaviour of universities may be a risk. They may have an incentive to carry out research in areas where patents are easily obtained and consequently behave more like firms (Verspagen, 2006). In addition Geuna and Nesta (2006) warn for the long term consequences of patenting. Most inventions are not sufficiently profitable because its value is a skew distributed (see Figure 8 on page 25). The variation amongst technological classes is independent on university- effort or competencies. It suggests that some scientific fields will profit and the majority will become poorer.

5.4.2. Other possible impacts

Absence patent

It has been argued that university inventions will not get into practice in case patents are absent. Most university inventions are embryonic requiring additional development to make them suitable for application. Private firms may be induced to invest in further development and subsequently commercialize the invention by means of patent protection. The study based on eleven case studies by Colyvas et al. (2002) indicates that IP rights appear to be most important for the embryonic inventions. On the other hand, patents are suggested to be relatively unimportant for inventions requiring no (or less) follow on work by industry.

Firm size

In closing the innovation gap the large as well as the small and medium size firms have to innovate more. The survey on the PatVal-EU (2005) data concludes that large firms are in particular important to the production of innovations within the business sector. The sample on the type of organisation shows that these large size firms with more than

250 employees account for 69% of the patents in the Netherlands. The small/medium size firms account for 22% of the patents in the Netherlands. In comparison the EU-6 countries average is respectively 70% and 20%. This distribution clarifies the importance of patents to firm size. Given this fact, the increase of university patenting may have the consequence that universities will mainly collaborate with and transfer knowledge to the large firms. In that sense universities will exclude small- and medium size firms which are more dependent on publications or other channels of knowledge transfer.

Inventions final product

Universities are an important initial source of technology (Tijssen and Buter, 1998; Crespi et al., 2006). The private sector has to fulfil the task to further develop university generated knowledge and exploit it. The majority of the economic benefits of university research come from inventions in the private sector rather than from commercial inventions produced by universities. The subject for debate can be made that the university (increased) patenting activity may shift university research efforts in the direction of more commercial objectives. The question is whether future commercial technologies will become a more first product (i.e. led by industry R&D objectives) or will stay a secondary product of university research.

IP rights interference

Some researchers (e.g. Cohen, Nelson and Walsh, 2002; Agrawal and Henderson, 2002) found that patents are one of the least important knowledge transfer channels of universities. The informal channels are argued to be the most effective channels through which firms benefit from university research. Therefore it is arguable that formal property rights (patents) may interfere with informal knowledge transfer (i.e. the break up of informal organisations by formalization of interactions). The increase of university patenting may have an adverse effect on the innovation process. It may decrease the rate at which existing knowledge can be exploited in new innovation (e.g. decrease of non patent complementary knowledge access, blocking transfer through social networks and informal contacts). The former PhD student Markiewicz (2003)[40] carried out her research on this issue. She suggested that university patenting lengthens the time between patenting innovation and the patented innovation that follows from it in industry. Markiewicz explored the effect of university patenting on the rate of knowledge exploitation in industrial patented innovations in the US.[41] Her results showed that university patenting is slowing down the exploitation of existing knowledge by industrial researchers.

[40] The promoters were D. Mowery, B. Hall and C. Wolfram

[41] The data was taken from a database collected by Hall, Jaffe and Trajtenberg in 2000. The database consisted of patents with application dates between 1985 and 1995

6 Case studies

6.1 Introduction

The aim of this chapter is to provide empirically evidence to this report subject of discussion. The focus is restricted to a set of five inventions. In all inventions at least part of the knowledge involved in the knowledge transfer was covered by one or more patents. To shed some light on the significant factors for knowledge transfer - between the Technical University of Eindhoven and the industry - five case studies are carried out. The summary of the findings of each case study is provided in Appendix IV. Using the protocol all information is obtained in particular by conducting interviews, but also by consulting PhD theses, project reports, internet websites, journals, the European patent office etc. Table 5 shows the key features of each case. The subsequent paragraphs 6.2 to 6.6 work out each case study in line with the knowledge valorisation and, in particular, the patent issue debate.

Inven-tion/ case	Appl. year of first patent	Techno-logy class	Funding sources	Usable (no/ less further develop-ment)	Patent holder	License type	Licen-ses to new firms	Inter-action between Licensee - Inventor	TU/e reve-nues
A	2005	Mech. Eng.	Govt.	No	TU/e	In nego-tiation	NA	NA	NA
B	1996	Proc. Eng.	Industry , Govt., (TU/e)	No	Industry	NA	NA	NA	Yes[42]
C	1989	Proc. Eng.	Industry , Govt., (TU/e)	No	TU/e	Non excl.	Yes	Yes	Yes
D	2000	Elec. Eng.	Industry , Govt.	Yes	Industry	NA	NA	NA	No
E	2005	Chem. Pharm.	Govt., industry , TU/e	No	Public techn. institute	In nego-tiation	NA	Yes	No

Table 5: Summary of the cases key features

6.2 Invention A: Adaptive optics

The Adaptive Optics case represents a mechanical engineering invention. Its idea originated from the public technical institute TNO as a result of astronomy scientists and telescope owners' research request. The institute works on the field of adaptive technology since mid 2001. Moreover, they are already collaborating with the TU/e on the field of optical systems for about 15 years. Accordingly, TNO called for a student to develop a new type of mirror by consulting its personal contact at the university in 2002. This student developed a first concept of a deformable mirror including actuators for his master thesis in 2003. Subsequently the student his followed-up PhD research was funded by the government after a subsidization request. The government granted it as an IOP project for the term of 4 years in 2004. The aim of the R&D project is to

[42] Royalties as soon as the invention is commercialized as well is sold.

have built a prototype of the concept[43] in February 2008. Through TNO personal contacts with TUD another PhD student also joined the project at the start of it. TNO coordinates the project represented by an IOP board of commission. This commission consists of approximately 15 different firms and institutes close and less close to the application.[44]

6.2.1 The value/ quality of patents

The granted patents are so recent they have not been cited yet (EPO, 2007; Scholar, 2007). Initially the patent on the actuator has been applied by the TU/e Innovation Lab and the two inventors[45] for protection in the Netherlands only in July 2005. This decision was made in consultation with the IOP board and TNO. The IOP rules and regulation compel the subsidization receiver (i.e. the TU/e) to do the patent application and commit the IPR on its name on inventions within IOP projects. Subsequently the Dutch patent was granted on July 2006. Accordingly, they applied for a world patent the same month. It was already known serious interests exist in case the development of the adaptive optics system will be successful. Approximately 10 to 20 astronomy telescopes owners worldwide are seriously waiting on this technology. Next to telescopes the invention (its knowledge) may be applied to other technology instruments as well. Its monetary value is estimated on slightly 1 million Euros for astronomical applications (G. Verschuren, Innovation Lab, personal communication, July, 2007). Nevertheless, the researcher's initial motivational point to join the project was the challenge to innovate and no possible commercially financial gains. Moreover, the possibility to do both fundamental- and applied research was very important for the student's choice to do this PhD research project.

6.2.2 The efficiency/effectiveness of patenting as TT instrument

IOP developed a set of rules and regulation with respect to IP rights. The firms representing the IOP board are having an active input in ideas generalisation and accompany the project. In return they are the first ones who take cognizance of the research results. Reports are made to this board to justify research twice a year. The participating firms have the first rights to further develop and/or commercialise the patented invention. This priority is a kind of a reward for the investments they made. Briefly it comes down to technology transfer that is already mapped out in advance to the project. The project is a mono-disciplinary research including a bi-directional transfer of knowledge. Scientific research is close to business and technology can be transferred to participating firms possessing possible applications.

6.2.3 The effects of patenting on academic research

Publishing vs. patenting

The student (then 26 years of age) finished his master thesis project in March 2003. His thesis was kept confidential. The first paper on the invention was strategically published one year and three months afterwards by the TU/e on a conference in June 2004. The Dutch patent application by the Innovation Lab, the student and his co-promoter (then 48 years of age) followed in July 2005. The Innovation Lab had benefit by delaying the patent application to ensure future outcomes. The reason was to squeeze the patent costs as long as the publication difficulties were avoided (G.

[43] The prototype of the concept consists of a large adaptive membrane mirror with high Actuator density.

[44] Although the requirements of astronomical applications are leading the adaptive optics technique possesses an overlap with other technology applications.

[45] The PhD student and his co-promoter (associate professor)

Verschuren, Innovation Lab, personal communication, July, 2007). The inventor's principal motivation for this patent application was to strengthen the reputation of their group members and the university. It was granted by the patent office in July 2006 and published a few months afterwards. In the meantime the student has made 2 publications on his research progress at conferences and workshops each year. Both inventors have only patented one invention before in 2005. Their built up publication record covers only 8 refereed proceedings by the student and about forty refereed publications and proceedings by the co-promoter so far. Their department group counts 47 employees and has applied for 17 patents and published 62 refereed articles in the last five years (2002-2006).

Threat to teaching quality

The question whether patenting and its related activities threats teaching or not is difficult to quantify. The patent application on the actuator by the co-promoter - associate professor is just the second one as inventor. On the other hand, the IOP-PhD project its patent output and related activities is one of six other currently running PhD projects he contributes to as co-promoter. He also coaches numbers of other master student- and traineeship projects. He has been lecturing 2 curriculum courses for the past 8 years.

Impact on the culture of open science

The impact on the culture of open science shows that the secrecy on the thesis project results kept the invention knowledge internal for rather more than one year. The subsequent IOP project works within the triangle TU/e (& TUD) – TNO – IOP board of commission after the subsidization was granted. They all had to comply with secrecy agreements. The Dutch patent application 2 quarter year after the master thesis ending, the subsequent R&D progress publications and the patent publication itself made the invention finally public.

Fundamental long term research

The patent on the actuator is a result from an invention originated by research request from astronomy scientists and telescope owners. The student and his coach initially were faced with practical problems and were motivated to solve these but by a quite fundamental approach of research. The first deformable mirror developments are made at the start of the 90's. The fundamental knowledge on the subject already exists since the early fifties. The student developed the first concept of the deformable mirror including actuators by spending 4 days a week at TNO-TPD. The subsequent IOP-PhD project consists of about 50% fundamental and 50% applied research to develop the prototype.

Threat to future academic research

Firstly, there has been no forerunner of an incentive to the university researchers to choose for research in an area where patents may be possible to obtain. Moreover, the patent decisions are the outcomes of the new TU/e patent regulation as well as the IOP IPR rules and regulation. Secondly, the patented invention has no consequences for the TU/e concerning the profitability issue. Possible users were already known before the patent application was made. The aim of the university (i.e. Innovation Lab) is to transfer the patent on the short term to these users (G. Verschuren, Innovation Lab, personal communication, July, 2007).

Absence patent

The invention is embryonic. It requires additional development for future application. The IOP-PhD project has the aim to develop a prototype of the concept but already started before the invention was patented. The initial absence of the patent did not change the firms- and institutes attitude to participate to the IOP board of commission. First of all the scientific application was leading. Secondly the knowledge was initially kept confidential and IOP program rules can compel the inventors/ subsidization receivers to apply for a patent. Hence, the firms have the first rights to further develop and/or commercialise the patented invention.

Firm size

The IOP board of commission is represented by approximately 15 firms and (public) institutes. The firms consist of small and medium size business as well as large firms.

Inventions final product

The university researchers have their own objectives towards the research efforts to be made to develop the future technology innovation. The scientific astronomical application is leading in the IOP project but the invention also has an overlap with other (possible commercially more valuable) applications. Accordingly, firms (and institutes) close and less close to the application participate within the IOP board. They accompany the project and can have an input in ideas generalisation.

IP rights interference

Collaboration in R&D as well as personal contacts between TNO and the TU/e Mechanical Engineering department already existed. The initial transfer of the invention took place by mobility of people (i.e. the student carried out research for his master thesis at TNO). Subsequently the research is continued collaborating in R&D with several other firms and institutes as an IOP project. The IOP project and granted patent on the invention blocks technology transfer to third parties. IOP rules impose the TU/e to request an exemption for publishing or exploiting their patent. The interests of the Dutch economy and the involved IOP project members/firms will be deliberated firstly according to specific arrangements in advance.

6.3 Invention B: Flexible solar cells

This case represents a Process Engineering invention. Its idea originated from a Dutch entrepreneur who had seen the manufacturing of flexible solar cells in the US. He was introduced to possible interested firms after he had obtained advice at the Dutch Novem agency. The invention on a method to manufacture a flexible solar cell is finally born during this entrepreneur's meeting with firm B-1. Firm B-1 directly applied a patent on the invention in 1996. Subsequently the firm initiated the R&D project H* in 1997. It was followed up by collaboration with the TU/e and three other Dutch knowledge institutions in 1998. These 4 collaboration partners are part of a large Novem network having contacts on the field of solar cells. The H* research project was funded by the industry itself and the government. The government (Novem) has funded about 50% of two EET projects for both for the term of 4 years. The explicit aim at the start of the H* project was to develop a useful innovation for industry and basically involve design as contrasted with fundamental research. The project share of knowledge input by the TU/e is based on years of fundamental research on plasmas and the deposition of thin layers using a plasma technique.[46] Only a very small group of PhD students worked on several aspects of the university patented ETP technique before this Novem incentive arrangement. A national energy company (hereafter firm B-2) took over the H* project from firm B-1 in 2006. It was convinced the project could contribute to a serious profitability over the long run at least. It funds the project itself with the aim to commercialize the invention.

[46] Patent on The Expanding Thermal Plasma (ETP) technique: D.C. Schram and G.M.W. Kroesen, U.S. Patent No. 4,871,580 (1989); European Patent No. 0297637 (1992).

6.3.1 The value/ quality of patents

The world patent on the method to manufacture a flexible solar cell is cited 7 times by other patents (EPO, 2007) and 4 times by other publications (Scholar, 2007). The firm B-1 issued about twelve continuation patents on the patent so far. The patents have multiple inventors but no TU/e inventors are cited. The estimated monetary value of the patent is difficult to quantify but may be a golden egg assuming the market available data. The firm B-1/ B-2 have catered to the potential market for solar cell modules which have grown by 25 percent annually in recent years. The global market is already estimated at 3.5 billion Euros and can grow further enormously by decreasing the producing costs of solar-generated electricity.

The department group's motive to participate to the R&D project is their connection to the so called 'solar cell network' which is founded by Novem. The group carries out research within the framework of next generation solar cells. The new emerging subject showed their interests. The motivational point for one of the number of PhD students who participated to the H* project was doing research in a very competitive group within PMP. Moreover, the visibility of the research results impact and the final applications constitute a reward on the short term.

6.3.2 The efficiency/effectiveness of patenting as TT instrument

The fact the invention is patented (and owned) by the firm before any collaboration for further development was constituted changed the direction of relative search. Contacts were made with other players by the Novem solar cell network. Initially firm B-1 had interest to apply the TU/e patented ETP technology to its own invention. The firm refrained from it into later phase. Nevertheless, it could definitely use the university's generated knowledge into the field. The firm B-1 made an agreement to pay royalties to the TU/e as a reward for their effort and knowledge input as soon as the H* product is produced and sold successful.

6.3.3 The effects of patenting on academic research

Publishing vs. patenting

A number of PhD students between the age of 25 and 35 years have contributed to the H* project. At least 5 high impact papers are published in each PhD thesis. These reports are publicly available, but confidential parts are kept secret for one to two years. All the PhD students are assisted by the same two promoters of the PMP group. The full professor (42) and his assistant senior researcher (33) have published respectively almost 200 publications (2 patents, 10 co-inventor patents) and about 65 publications (2 patents) so far. Their department group counts 41 employees. It has applied for 4 university invented patents and published 74 refereed articles in the last five years (2002-2006). The researchers of firm B-1/ B-2 also published approximately ten publications for the H* project themselves so far. These were published in particular at (world) conferences beside papers and their own internet website.

Threat to teaching quality

Research at the PMP group is performed within a very competitive group. The two promoters (full professor and senior researcher) have significant experience in research abroad, consultancy and collaborative R&D projects as staff members. The ETP technology represents the research group's showpiece. Furthermore, the full professor is member of symposiums, served several program chairs, is on an editorial board and serves numerous scientific committees. The senior researcher is currently participating on four projects with several industrial partners. Both staff members respectively take care of teaching 5 and 3 education programs on the TU/e. Two of the programs consist of education on solar cells.

Impact on the culture of open science

The openness- and sharing of knowledge, data and research results that contributes to the cumulative knowledge production are kept to the collaboration and its contributors initially. Both industrial focus and scientific interest have been taken into account to transfer knowledge within the project optimally. I.e. perform scientific research, make results quickly understandable as well as useable to the firm and last but not least the ability to publish without hindering confidentiality (i.e. strategic publications by publishing the approach and not the results). Confidential parts of PhD thesis' are kept secret for one to two years.

Fundamental long term research

The Novem financial incentive made it possible to format an established group working on several aspects of the ETP deposition technique in 1998. The PMP group carries out fundamental research on plasmas and the deposition of thin layers using this plasma technique. Only two PhD students worked sequentially on the area of solar cells before this incentive. The personal benefit for the involved university researchers in the process of collaborative research is in particular further research on fast deposition technologies. The H* product can be a price breakthrough for end users (i.e. business and households) at the market introduction mid-2009. It has significantly more application possibilities comparing to currently existing solar cells technologies. New research opportunities for the firm and universities will arise by the constructed principle of this innovation for coming five to ten years (i.e. innovation improvements and next generation technologies).

Threat to future academic research

The active proceeding of cumulative research progress, in which new results are built upon old research, took more than 9 years referring to the H* project start and the first ETP patent filed date. Only two PhD students were carrying out research on one aspect of ETP (i.e. on the area of amorphous silicon solar cells) before the Novem financial incentive in 1998.

Absence patent

N/A. The H* project initiator firm B-1 applied for the patent on the embryonic invention.

Firm size

The H* project initiator firm B-1 is an international multicultural organization specialized in human and animal healthcare products, coatings and chemicals. The firm possesses a R&D lab with 834 million Euros of R&D expenditures. It has approximately 1000 R&D employees of which respectively about 4 and 30 employees worked on the project in 1998 and 2005. Firm B-2 took over the H* project in 2006. It's a national energy company with a turnover of 5.017 million Euros and almost 10.000 employees.

Inventions final product

The PMP group contributes to the development of commercial solar cell technologies to be able to carry out further fundamental research on fast deposition technologies. The university royalty incomes on future productions and successful selling of the H* product will be used to finance PhD students in this field. The PMP group claims it has its own curriculum and keeps enough distance to R&D request from industry. They are able to combine both objectives although collaborations are restricted to a certain number. The arrangements and particular commitments are the main difficulties.

IP rights interference

In this case the firm is the patent holder on the method to manufacture a flexible solar cell. It did not apply ETP to its own invention. Hence, no licenses on the patent are issued to the firm by the TU/e. Nevertheless, firm B-1 obtained ETP complementary knowledge access. The university researchers mainly transferred their knowledge by informal personal contacts and (student) researcher's exchanges to the firm. In particular, students spent some days at firm B-1. In addition some students and supervisors informally used the firm's equipment to carry out some experiments and tests. Furthermore, all H* project participants reported their results to the project leaders during formal project meetings twice a year. The final formal transfer took place by means of the doctoral theses of a PhD student at the end. Firm B-1 and the TU/e made an agreement on universities effort and knowledge input.

6.4 Invention C: Machine for high deposition SiNx

This case represents a Process Engineering invention. The idea was adopted by the firm C-2. It was participating as an official sub-contractor to the EET- project collaboration S*. This collaboration between firm C-1, the Energy Centre of research Netherlands (ECN)[47], TNO and the TU/e was granted by the government (i.e. (Senter)Novem). It was initiated under the Novem framework programme 'next generation solar cells' at the start of 2000. The project was a split-up to research on amorphous silicon solar cells by the TU/e. The universities department group PMP carries out fundamental research on plasmas and the deposition of thin layers using a plasma technique.[46] The patent on the ETP technique is hold by the TU/e. Only a very small group of PhD students worked on several aspects of ETP before the Novem incentive. The aim of the EET-project was to develop a technology for solar cells and modules through decreasing it costs by increasing the cell efficiency. Small scale process developments were made at the ECN lab applying different deposition system types. These developments were subsequently evaluated on large scale at the firm C-1. The sub-contractor firm C-2 offered firm C-1 to develop and manufacture a production line machine at a certain moment in time. Firm C-2 had decided to base it on ETP and all EET- S* project acquired knowledge. The consequence was the firm was compelled to take a license on the ETP patent. Accordingly, an informal collaboration with the TU/e was originated initially at the beginning of 2002. Subsequently this collaboration led to a new four year EET-project granted by SenterNovem the same year. The accomplishment of the first machine[48] was according expected outcomes and sold to firm C-1 at the end of 2003. Improvements were made the subsequent years. The final machine[49] was sold as the firms (C-2) own product to other worldwide customers.

6.4.1 The value/ quality of patents

The European and U.S. patent on the Expanding Thermal Plasma (ETP) technique is cited respectively 7 and 11 times by other patents (EPO, 2007) and 31 times by other publications (Scholar, 2007). The patent is also licensed to General Electric in Schenectady beside the firm C-2 in 1997. These licensee incomes are of that high

[47] ECN conducts research under contract from the government and other entities in the Netherlands. Research areas include solar energy, wind energy, biomass etc.

[48] Machine and processes are covered by new patents and continuation patents on the ETP technique. They are hold by firm C-2.

[49] A fully integrated in-line solar cell manufacture machine for high rate deposition of SiNx (Silicon Nitride) for solar cell anti-reflection coatings and passivation layers.

amount the PMP group is independently able to finance a small number of their PhD student researchers at firm C-2 and/or other firms. The costs to finance a PhD position are on average 100k Euro each year. Moreover, the private funding creates the possibility and freedom for the group to choose their own direction of (new) research. The firm C-2 themselves sells twenty to thirty of the developed machines to solar cell industries worldwide each year since the market introduction in 2004. The machine's commercialisation has resulted to a yearly turnover of about 30 million euros. The general consensus is made by the firm and the TU/e that the photovoltaic market will be dominated by crystalline silicon solar cells for at least another decade.

The motive for the PMP group, in particular the professor and his assistant senior researcher, to participate to the first noticed EET project was to gain a good overview of the scientific problems to work on without losing their focus on its own curriculum/ agenda. The motive to the second EET project was to continue on the first one and the group's drive to use the patented technique for further research purposes. Furthermore, they are pleased to see their research results and its introduction to the market by applied research. They become enthusiast about the adopted technology methods originated by research. The publication of papers only, read by a limited number of people, does not give them (enough) satisfaction.

6.4.2 The efficiency/effectiveness of patenting as TT instrument

The patent on ETP is granted in 1989 (US) and 1992 (Europe). The PMP group licensed the patent for the first time to General Electric after consultancy in 1997. The Novem network and its incentive made it possible to finance collaborative research on the deposition technique, in particular on the field of solar cells, in 2000. The university (i.e. the department group itself) did not made pay off agreements with the involved firm before the decisive research stage of the invention's development. They first set up a convincing and trustworthy collaboration. The decision to commercialize the machine integrating the ETP technique as well as taking a license on the ETP patent was made by the firm C-2. It transferred the technology to this firm in 2002. The second effective transfer of the patented technology took more than 10 years referring to the filed dates.

6.4.3 The effects of patenting on academic research

Publishing vs. patenting

The full professor (42) and his assistant senior researcher (33) have contributed to the first EET-project started in 2000. The subsequent collaboration between the TU/e and firm C-2, which took a license on the ETP patent, was accomplished at the beginning of 2002. Two European patent applications were applied on the heart of the machine's system by firm C-2 in May 2002. One of these patents is a continuation patent on ETP. The participating university researchers are cited as co-inventor on the continuation patent. Their principle motive for patenting was the ability to create more research resources for the benefit of their department group.

The first publication on the specific application was published by both the TU/e and the firm inventors in September 2002. Subsequently firm C-2 applied for two patents on own inventions to accomplish the machine's commercialization respectively in May and August 2003. The first manufactured machine was finished and sold to firm C-1 at the end of 2003. Firm C-2 has published 14 papers and 2 posters related to the process of innovation development and diffusion, in particular on photovoltaic conferences, so far. The two TU/e PMP group staff members and their two PhD students participating to the second EET-project have published several papers related to their research and innovation development. Clear arrangements had to be made considering publications by the PhD students. Miscommunication had arisen now and then. The firm C-2 had not given permission to- or even was uninformed of released publications.

Impact on the culture of open science

The openness- and sharing of knowledge, data and research results on new process developments was kept to the players within the first EET-project collaboration initiated in January 2000. As already mentioned above the sub-contractor firm C-2 offered firm C-1 to develop a machine and choose for applying the process development of ETP to deposit SiNx for solar cells. Two patent applications were applied on the heart of the machine's system by the firm in May 2002. One of these patents is a continuation patent on ETP. Finally the invention was published by the inventors of the TU/e and firm C-2 in September 2002.

Fundamental long term research

The Novem financial incentive made it possible to format an established group working on several aspects of the ETP deposition technique in 1998. The PMP group carries out fundamental research on plasmas and the deposition of thin layers using this plasma technique. Only two PhD students worked sequentially on the area of solar cells before this incentive. The personal benefit for the involved university researchers in the process of collaborative research is in particular further research on fast deposition technologies. The two noticed EET-projects were two new opportunities for the PMP group next to the H* project initiated in 1998. The fundamental long term research as well as the exploitation of ETP by licensing appears to be dependent on the closeness of the related R&D activities to business. Firm C-2 stepped in as soon as the results on applied research (on small scale concepts) at the ECN lab became visible. Firm C-2 received input and feedback by the TU/e senior researcher on in-house applied research to develop the first machine during their informal collaboration. An agreement was made between the TU/e and firm C-2 in advance. The licensee fee firm C-2 had to pay would be used to finance PhD positions to continue further research on ETP at this firm. The subsequent applied continuation patents by firm C-2 are the outcomes of their R&D cooperation.

Threat to future academic research

The active proceeding of cumulative research progress, in which new results are built upon old research, took more than 10 years referring to the first EET-project start and the ETP patent filed dates. Only two PhD students were carrying out research on one aspect of ETP (i.e. area of amorphous silicon solar cells) before the Novem financial incentive in 1998. The fact firm C-2 and the TU/e are collaboration partners should not give any tensions in allowing university to use the patented knowledge for research purposes.

The university costs were significant to maintain the US and European patent rights on ETP each year since respectively 1989 and 1992. The Innovation Lab states that the collaboration generated licensee incomes have currently resulted in a break even outcome after all. Nevertheless, the PMP group claims that the patent created more than 6 million euros of granted government money to finance their research (G. Verschuren, Innovation Lab, personal communication, July, 2007)

Absence patent

The development of the best possible process did relatively require less follow on work by firm C-2. Most was already performed at the first EET-project. This project carried out applied research on different deposition types. Firm C-2 gratefully acquired 2 years of generated knowledge on proven different small scale concepts of this project. This enabled the firm to develop and commercialize their own idea in one year. The firm made the decision to apply ETP as the appropriate deposition type. The fact this technique was patented, and no other/ better options were obtainable, forced the firm to take a license on the TU/e patent.

Firm size

The firm C-2 located in Eindhoven is a company in design, engineering, development and manufacturing of tailor made inline production equipment. It constituted a separated business unit in solar technologies at the end of 2004. The firm has about 150 employees and possesses a R&D lab with approximately 70 R&D employees of which eight worked on the machine at the solar unit. Firm C-2 has high experience in using external sources of technological knowledge. It joins conferences every year, frequently visits universities on the field of chemistry, mechanical engineering etc. It also frequently checks patents considering its own strategy. The firm didn't have experience in collaborations with universities so far.

Inventions final product

The PMP group contributes to the development of commercial solar cell technologies to be able to carry out further fundamental research on fast deposition technologies. The acquired government subsidizations and licensee generated incomes on the ETP patent are used to finance PhD students' research in this field.

IP rights interference

The Novem network is a very active group of participants performing R&D on the field of solar cells. Novem had granted the R&D cooperation between the 4 parties as an EET-project at the start of 2000. Firm C-2 was just an official sub-contractor of this cooperation. They saw challenges during the project and its results. The firm made the decision to adopt the ETP technique and developed its own idea. They found out ETP was patented and its rights are hold by the TU/e. Firm C-2 had less contact with the TU/e at that time. Hence, they were forced to cooperate with the university to be able to develop their machine and contacted the TU/e. Initially the two PMP staff members provided feedback on OTB its objectives by informal contacts. The PMP group decided to collaborate with OTB at the start of 2002. An agreement was made the licensee paid fees on the ETP patent should be used to finance PhD students carrying out further research in this field at OTB. Subsequently the assistant professor- senior researcher frequently had short visits to their R&D lab to have a look at the development progress. He provided input and feedback to familiar R&D difficulties based on years of his group research on ETP. On some occasion's formal meetings were joined. The role of the university decreased as soon as the machine's development progress turned to more and more applied research. They played a significant role in knowledge input at the start of the development as well as to the fundamental research on next generation technologies. PhD- and master students are exchanged to firm C-2 within the collaboration agreement and the new initiated EET-project at the end of 2002. These students spend some days of the week at the firm.

6.5 Invention D: MIMO-OFDM

This case represents an Electrical Engineering invention. The idea originated from the firm's challenge of substantially extending the performance of wireless communication system behaviour. The aim was to develop new systems and basically involve design as contrasted with fundamental research. The Dutch facility of the American firm D-1 called for a master student by consulting its university personal contacts. It thought the TU/e could help them because of their knowledge to this technology field and acquaintance with developments. The student carried out successful research on site. He did research on wireless communication combining MIMO-OFDM technology for his master thesis in 1999. Subsequently he was asked to stay. The firm D-1 expected to have a high value in terms of market- and operation potential benefits with MIMO-OFDM at that time. The student became a company paid employee and also did his PhD research continuing on this topic on site. He had personal contacts with another TU/e student who also joined the firm for his master thesis and PhD in 2002. The second student did his PhD as part of the firm's involvement to the B* project. This project within the pre-competitive phase was part of the university-industry B* alliance granted by the government. It was initiated by the firm D-2 in close cooperation with the TU/e in 2001. Both students' functional goals were to develop required algorithm to analyze different scenarios of OFDM/MIMO-system behaviour. The combination of OFDM-MIMO techniques was seen as promising. The technology was a strong candidate for various standards. Unfortunately the American firm D-1 closed down its Dutch facilities after deciding to withdraw from the wireless communication business at the end of 2004. This decision was made because of market strategic motivations. The second student has continued the last 2 years of his research at the TU/e to finish his PhD. Making the inventory 10 patents on MIMO-OFDM technology related processes are granted so far. The American firm D-1 claims its rights to Europe, US, worldwide (and some in Japan). It will not produce wireless products but will try to claim the rights and gain incomes on its IP portfolio.

6.5.1 The value/ quality of patents

The 10 patents on MIMO-OFDM technology related processes are cited 8 times by other patents (EPO, 2007) but not cited by other publications (Scholar, 2007) in total. Whether these patented processes have been adopted in any wireless communication technology standard and/or sold or licensed by the American firm D-1 to another party is unknown so far. The firm was unable to maintain and improve its existing products as well as launching next generation products as former market leader. It had an annual turnover of about 300 million $ in wireless communication technology two years before withdrawal. If it had been able to adopt a number of patents from its portfolio into a standard, the monetary value of a patent may have been a golden egg.

Nine out of ten patents are invented by multiple inventors[50] and only one patent by the first student individually. The source of knowledge for the patented inventions is literature and patents. The first student's motive to join the firm was his enthusiasm about combining the opportunity to tackle a scientific subject thoroughly doing a PhD research and being employed at the firm on site. The second student also liked combining university-industry research. I.e. carrying out research on a subject without losing the academically freedom and work on product innovations for the long term of 4 years. Thus not only publish research on papers. The first student even won the second prize of a Student Paper Contest for a paper on his master thesis as well as an important price for his PhD work.

6.5.2 The efficiency/effectiveness of patenting as TT instrument

An agreement was signed all IP rights belong to the firm D-1 on all produced knowledge by the TU/e students. In return the firm financed the first student's research during his master thesis and PhD. The second student his PhD research was financed by the granted money within the governmental (B)TS framework for the B* project. Accordingly, knowledge was transferred by the channels mobility of people and cooperation in R&D. The students participated to the firms R&D project team on site.

[50] The inventors are the researchers of the firm and one or both of the university students.

6.5.3 The effects of patenting on academic research

Publishing vs. patenting

The thesis was kept confidential for the period of one year in October 1999. The first publication on the specific MIMO-OFDM topic was made on a conference by the first student and the firm D-1 in May 2000. Furthermore, the student researchers (30 and 28 years of age) did not have to delay their publication to avoid (patenting) difficulties with the firm. The agreement was made that the firm should take care of the possibility to publish research results within/ maximum 3 months. It never led to this circumstance. In most cases patent applications were made by the firm D-1 within a few weeks. The firm had a good and professional IP management. It was pro active not to disrupt the publishing process. The two students have respectively published 15 publications in the period 1999-2004 and 24 publications in the period 2002-2006. They figure in ten granted patents on MIMO-OFDM technology related processes as (co-)inventor so far. The student's department group (19 employees) has not applied for patents[51] and published 94 refereed articles in the last five years (2002-2006).

Threat to teaching quality

The students' promoters did not have to reduce time/ commitment to teaching because all patent output and its related activities were undertaken by the firm. In fact the research on MIMO-OFDM had a positive impact on the TU/e. It fitted to the group's research on broadband/ high data rate communication. Consequently, the research on "wireless" communications by the TU/e is one of the central subjects nowadays.

Impact on the culture of open science

The openness of science on wireless communication technology developments, in particular the MIMO-OFDM technology related process, can be called open. A significant number of publications are made public internationally in a significantly short time (i.e. conferences, papers, workshops). Moreover, formal meetings were organised 4 to 8 times a year within the university-industry B* alliance for the B* project. This project took place within the pre-competitive phase. Discussions in a very open atmosphere were held about each ones progress by showing presentations about the performed ideas and results.

Fundamental long term research

The Dutch performed most research on MIMO on the contrary to research on OFDM by the American last decennial. On the one hand, the principles and some of the benefits of OFDM were already known since the 1960s. On the other hand, the earliest publications on MIMO were made during the 70's. OFDM broke through with the publication of an US patent in 1994. The American firm D-1 has OFMD and MIMO related patents respectively since mid-1997 and mid-2001. Its first introduced wireless products (i.e. WaveLan) were based on OFDM in 1997. Consequently, with WLAN systems the OFDM technology was an adopted standard for data transfer. It was believed that the MIMO technology could improve data speed as reliability of WLAN systems.

Both students' functional goals were to develop the required algorithm to analyze different scenarios of OFDM/MIMO-system behaviour. Their share of research contributions consisted roughly 50% fundamental and 50% applied research. The technology transforms to applied research quickly. I.e. wireless communication developments are a fast moving field. The students participated to a R&D project group

[51] Next to this case applied patents by the two students.

and were often consulted for their theoretical expertise considering practical difficulties. Moreover, the first student demonstrated the feasibility with a proof of concept as part of his PhD research. He successfully demonstrated a MIMO/WLAN system test based on the IEEE 802.11a standard having a world scoop in 2003.

Threat to future academic research

Patents and publications are complementary into this research field. The cumulative progress in which new results are built upon old research indicates no disruption so far. Research on OFDM and MIMO has been carried out for more than 30 years. A large number of the patents have been applied on processes related to this technology. It is an area where patents are easily obtained. The inventions profitability depends on the adoption of patented processes into an international communication standard for a specific application (i.e. IEEE 802.11n, 802.16, UMTS HSDPA, 4G). It is a political game. Some patents can make significant profits but a majority will be worth none or less in this case.

Absence patent

The aim of the American firm D-1 was to patent potential successful wireless communication technologies/ processes and subsequently attempt to gain incomes out of it. The patented inventions require no to relative less follow on work by the industry.

Firm size

The American firm D-1 is a spun-off microelectronics division in semiconductors and software solutions for storage, mobility and networking markets. It has approximately 5200 employees worldwide with a $1.57 billion turnover (fiscal year 2006) worldwide. A small group of 8 employees of about 200 employees based at the Dutch facility carried out R&D on MIMO-OFDM. Publications by Bell Labs and literature research constituted the firms external used sources of technological knowledge. Furthermore, it had experience using university contact networks. In this manner papers constituted an important element of acquiring knowledge in particular to the master and PhD students who joined the firm.

Inventions final product

The students contributed to the firms R&D project team having commercial objectives. The students were able to combine university and industry objectives tackling a scientific subject thoroughly. They worked for the company on site but also kept their academically freedom on doing research.

IP rights interference

N/A

6.6 Invention E: Novel nanocomposite

This case represents a Chemical invention. The invention was a serendipitous by product of fundamental/applied research by an Indian PhD student. The student came to the Netherlands and joined the Polymer Technology group for his PhD. This group intensively cooperates with other department groups of the TU/e within the PT program. It also has strong formal ties with several research institutions. Accordingly, the Dutch Polymer Institute (DPI) approved a formal research proposal set up by the PhD student and his co-promoter. The approval was made on a research on the field of nano composites as a DPI/PhD project in 2001. The DPI industrial partners choose and determine the research project programmes within the pre-competitive research phase. In principle the ideas and project proposals originate from the universities and the Programme Committee approves the projects according to specific conditions. This committee is represented by at least one representative per industrial partner. Approved projects are financed by the government (ca. 50%), the DPI industrial partners (ca. 25%) and the knowledge institute has to contribute ca. 25% itself. The TU/e had to provide information on its research progress and justify their PhD project to the other programme involved partners of DPI. On the original goal of the PhD student to learn more about the material properties he made a surprising invention mid-2004. Firm E-1, one of the non- programme involved industrial partners, was convinced the invention was also applicable to other materials and adopted the invention. The patent application on the invention was made in February 2005. Firm E-1 and the TU/e have continued to work on further product development together, but not as a DPI project anymore, after the student finished his PhD. The new initiated STW project[52] is partly in cooperation with other companies.[53] It is a long term 5 year project started on December 2005. Nevertheless, firm E-1 operated more on its own as the development came closer to production of its own material polyethylene. It will take a license on the DPI world patent on the Novel Nanocomposite if it decides to produce the new material.

6.6.1 The value/ quality of patents

The world patent on the Novel Nanocomposite is not cited by other patents (EPO, 2007) or publications (Scholar, 2007) so far. The invention can have an impact on the decrease of the processing costs (i.e. eurocents per kg produced material) and increase of the product demands. It has to be fit into an actual production process of existing standard plants for application. The plastics converting industry may benefit from it (e.g. the automotive -or pipe industry applying plastic processes to make their products). The firm E-1 has expended between 50k and 100k Euros to the first scale up. The costs for further development (i.e. up scaling to industrial scale) will multiply times 5 depending on the number of stages and its scale size. On account of above data the patent monetary value is estimated between 1 and 3 million Euros.[54]

The invention source of knowledge is scientific literature because the PhD project was initially designed as a model study to understand some observations from it. The patent has cited the student and his two co-promoters as the inventors. The former student is a talented Indian researcher who did his master study in Polymer Engineering at Akron University, USA. He subsequently worked 6 months on a R&D project for the Kawamura Institute of Chemical Research in Japan. It resulted to the citation of 3 Japanese patents as co-inventor. He decided to move to the Netherlands to do his PhD study at the TU/e having contacts with TU/e professors working on nano composites projects. His principal motivation was his interest in this specific research area.

6.6.2 The efficiency/effectiveness of patenting as TT instrument

Initially the DPI industrial partners choose and determine the research project programmes. Subsequently they approve ideas and project proposals originated from the universities. Inventions resulting from these research projects are presented to the industrial partners. They play a significant role whether or not to patent the invention. DPI developed a set of rules and regulations with respect to the IP rights. The industrial -or knowledge institute partners have the first rights to further develop and/or commercialise the patent. Accordingly, the technology transfer on possible patented inventions is already mapped out in advance to the collaboration. Scientific research is

[52] Project number epc7057. Polymer adsorbents: a breakthrough for polymer processing?

[53] Six unknown companies are involved. Some of these companies also participated to the DPI project

[54] The student inventor had no idea about the patent estimated value. DPI and the firm E-1 both keep information secret.

close to business and the technology may be transferred to the participating firms possessing possible applications.

6.6.3 The effects of patenting on academic research

Publishing vs. patenting

The former student, 30 years of age, made the surprising research findings mid-2004. He wanted to publish his results on a conference which potentially had tremendous consequences for the material processing conditions. His co-promoter, 37 years of age, advised to his disappointment to keep it secret for the time being and first discuss it with the DPI industrial partners. In this way the TU/e could have a look into the phenomena of the research results and have an input to the technology possible applications. The project involved industrial partners expressed interest when they heard about the results. The partner firm E-1 showed most interests and helped the researchers with the patent application. In a relatively short time this was completed so the student could complete his PhD thesis and make it public in July 2005. The student has made 15 publications and he figures in 4 patents as (co-)inventor between 2001-2005. His co-promoter has published 29 publications and 1 patent between 1997- 2007. Their department group (54 employees) has applied for 10 patents and published 197 refereed articles the last five years (2002-2006).

Threat to teaching quality

The industrial partner firm E-1 which showed most interest to the invention helped the TU/e inventors (i.e. the student and his co-promoter) with the patent application as already noticed above. It may have taken extra charge of them as well as time pressure if the firm did not have offered their assistance. Hence, the possible negative consequences stayed out. The student was able to complete his PhD thesis within one short year left.

The co-promoter is a lecturer of the Polymer Technology group. He is currently project leader of the new initiated follow-up project. The STW project continues on the invention research results. He spent a few months at the firm E-1 on site in Austria for this project this year.

Impact on the culture of open science

The student assisted by his co-promoter spent his research at the university (lab) full-time. His group intensively collaborates with other departments within the PT programme sharing each others facilities and expertise. The DPI/ PhD project was carried out within the pre-competitive research phase. I.e. science was carried out in an open atmosphere. This matter changed after the discovery was made. DPI has set up rules and regulation with respect to IP rights. The generated knowledge, data and research results will be shared with the participating DPI partners initially. They all have to comply with secrecy agreements. The industrial partners will make the decisions whether to patent it or not. Subsequently the institute will be the patent holder on the applied patents. Their participating industrial -or knowledge institute partners have the first rights to further develop and/or commercialise it. The patent application on the student his invention was applied within a few months time. Accordingly, the invention was made public without delay at the student his PhD defense.

Fundamental long term research

The PhD project was a mixture of fundamental and applied research. To gain a better understanding of the mechanisms (fundamental) the student did research on the effects of adding particles in standard polymers (applied). The invention surprisingly found results on one material (polypropylene) were directly applicable on small scale. The firm E-1 was convinced the invention could be applied to other materials because of its simpler molecules. Nevertheless, it was conscious of the significant amount of work that had to be done before their material can be used and finally fit in an actual production process. The subsequent STW project participated by six companies continuous on the product development by doing both fundamental and applied research on polymer adsorbents.

Threat to future academic research

The new STW project proceeds cumulative research progress. It was initiated half a year after the student finished his PhD. Two other TU/e PhD students work on this project. The use of the patented invention/ knowledge for research purposes is allowed because DPI is patent holder. Moreover, the participating firms to the project are also industrial partners of DPI.

Absence patent

The aim of DPI is to bring scientific research and industrial innovation together and valorize knowledge via patents. The industrial partners have an incentive to join programs they have interests in because of the DPI formula. Moreover, they have first rights to further develop and/or commercialise patented inventions. This case invention required additional development and significant financial investments to make it commercial valuable. Although it was directly applicable it had to be scaled up several times and evaluated by the firm to make it industrial applicable. Further development is required to make the invention also appropriate for other materials.

Firm size

The Austrian firm E-1 is an international industrial petrochemical company. It has 4,639 employees (year 2006). Their R&D activities, consisting of 45 million Euros of expenditures for the year 2006, are conducted at 4 European country Innovation Centres by around 400 employees. The firm has realized a turnover of five billion euros sales revenue in 2005. The customers represent about 60% of the used source of knowledge for the development of innovations. The customers constitute the back market. Approximately 70 to 80% is developed in-house and 20 to 30% by cooperation to come to innovative solutions. The firm has experience with universities in general. It only collaborates with the TU/e and no other universities in the Netherlands. These collaborations are also on polymer with other groups. It has financed parts of projects concerning PhD positions but also postdocs several times. The big company uses all kind of external sources. Conferences are just one aspect of many.

Inventions final product

The student researcher did not foresee he would find something interesting that could be patented for the beginning of the project. It was a serendipitous by product of his PhD research. This research consisted of scientific objectives only.

IP rights interference

Formal meetings were held with the industrial involved partners to discuss the DPI/ PhD project progress every three or six months before the inventive discovery was made. Informal meetings/ contacts were the initiative and responsibility of the student researcher himself. He frequently did this by phone and mail. On some occasions he visited the industrial partners, in particular firm E-2 located close to Eindhoven. His promoter had direct contacts with this company. These different ways the industrial involved partners could give feedback and input to have project progress control.

The patented invention became public at the end of the DPI/PhD project. Several other firms, which are no DPI industrial partners, also showed interest. They futile contacted university aiming at bilateral contracts. These firms have to inform the DPI firstly to be able to start collaborations and/or taking licensees on the technology. DPI holds and claims the formal patent rights on the invention. Their industrial partners have to give permission for technology transfer to third parties. DPI can only dispose of the patent (according to its own discretion) to third parties if there are no takers among their partners.

7 Discussion

The main goal of this report is to better understand the mechanisms of university knowledge transfer and, in particular, the influence of patents as facilitator in these processes. This discussion is aimed at providing some insights to this subject. This will eventually lead to the conclusion and recommendations in Chapter eight.[55]

The Dutch government are mainly using legalization, instructions and financial instruments to stimulate the innovation process. Universities are an important player for the government to contribute to economic and social welfare. The government employs three categories of instruments (i.e. collaborations, applied research and knowledge diffusion) to connect universities with business. On the contrary to the Netherlands (and Europe) the US has implemented a piece of regulation to facilitate and accelerate the transfer of technologies resulting from federally funded research. This Bayh-Dole Act has increased the US universities patenting activity significantly. Accordingly, the Dutch policy makers are responding by the development of policies to stimulate university knowledge transfer mainly thinking in terms of patenting. For instance, the IP rights on university research outcomes are already established in advance to most government financed collaboration programs nowadays. The IPR rules/ regulations to this collaboration programs differ independently. Nonetheless, the universities transfer knowledge through a variety of channels which effectiveness differs all as discussed in Chapter 3.

The question that arises is whether the government's emphasis on the patenting of university produced knowledge accelerates commercialisation. First, the cases findings show us that firms and the university find each other rather well through other channels of knowledge transfer (i.e. informal or personal contacts and mobility of people). These channels between both parties already existed before any collaboration was constituted as well as any patent application on university produced knowledge was made. Second, the case studies indicate that the firms have a significant influence on the patenting activity. The knowledge need appear to come from the industry because they are the origin of the research idea. Moreover, the subsequent patented inventions find its origin in cooperative research (i.e. master thesis, PhD thesis or consultancy). The findings also show that patent applications are only made on inventions that (might) have an application to a specific technology and/or is considerably economic valuable for the firm. The firm's decision whether to patent or not weights heavily. It suggests that it is important for universities to know what technical activities play inside a company. Universities on the other hand may apply patents on inventions because these are interesting scientific discoveries. Nevertheless, their objectives can differ significantly to the ones of the industry. Finally, the cases indicate that the initial aim to develop something (economically) useful that can be patented is important to industry. When this matter come into a play the university may significantly lose their autonomy to carry out scientific research and built upon its own aspirations.

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[55] Comment: The non-representative sample of the cases examined precludes the author from drawing quantitative conclusions or allows claiming generality for the insights drew from them.

Invention/ case	A	B	C	D	E
Existing KT channels?	Yes	Yes	Yes	Yes	Yes
Origin research idea	Industry	Industry	Cooperative research	Industry	TU/e
Inventions origin	Cooperative research	Industry	Cooperative research	Cooperative research	Cooperative research
Development aims	Yes	Yes	Yes	Yes	No

Table 6: Summary of the cases general insights

Following government's example, radical changes can be observed in the patenting policy and behaviour of the Technical University Eindhoven over the past years. They as well as the 3TU believe there is a technological opportunity by patenting (i.e. knowledge transfer improvement, enrolment of income facilitation, research opportunities, etc.). How the university will complete their ambitions to the presented 'quantitative numbers of patents' is obscure. The cases represent a significant number of 'university invented' patents. Accordingly, it is vague whether the university emphasizes patent applications on the results of 'offer' or 'demand' directed research.[56] On the contrary to this vagueness it is apparent that the university faculties and its researchers lose a share of their academic autonomy to research due to this policy. Nevertheless, financial incentives on patenting (i.e. small bonus for applying a patent and one-third of the profits made to the valorization of knowledge) are used to stimulate the researchers. Furthermore, the TU/e policy shows the draw up of all kinds of agreements and arrangements to valorise knowledge. The university may think to know 'how' to transfer knowledge effectively but the possible emerging of tensions within the University system with respect to patenting are neglected.

That brings us to a new question; what is the evidence in support to patents as facilitator on the university knowledge transfer process? Chapter 3 and in particular the theoretically- and empirically research in Chapter 5 and 6 have had a small contribution to the clarification of this broad subject of discussion. The answer to the question can be found in the three determined topics below.

The value/quality of patents

First, the cases indicate that the monetary estimated value on the patents is difficult to quantify (by the university inventor or university) and is widely ranged. Nevertheless, it becomes noticeable the industry itself, in contrast to the university, appears to know the possible value well. It can be deduced from the cases (B and D) because the industry had marked out the IP rights before it started the collaboration. All the patents in these cases are industry owned patents. Moreover, the patent value 'peaks' (i.e. the golden eggs) is dependent on commercial market in-transparent developments which universities do and can not have as a public institute. Second, the monetary rewards and/or career advances have not been a motive to the university researchers for inventing. It is evident the scientific objectives are the most important motive to them. Additionally the researchers' chance to combine university-industry research and see their research results impact/ outcomes makes inventing significantly interesting. Third, the fact that in 3 out of 5 cases the university inventors have an inventive experience and/or are talented individuals suggests that this is significant to the value/quality of patented inventions. It is questionable whether other university researchers are also able

[56] University research to industry request and/or its closeness to business (applications) or university research built on their own aspirations.

to enter this domain as a result of the new IPR regulation by the TU/e. Finally, scientific literature indicates to be a relevant source of knowledge for the patented inventions. This explains the importance of publications which is traditionally one of universities main channels to transfer knowledge.

Invention/ case	A	B	C	D	E
Total granted patents	1	1 + 12 cont. patents (so far)	2 + 2 cont. patents on ETP patent	10 (so far)	1
University owned patent	Yes	No	No, only the ETP patent!	No	No
University invented patent	Yes	No	Yes, 2 cont. patents on ETP	Yes	Yes
Number of inventors	2	Multiple	Multiple (cont. patents on ETP)	Multiple (almost all patents)	2
Estimated monetary value	< 1 million euros	Possible golden egg	Number of PhD positions	Possible golden eggs	1-3 million euros
Motives: monetary rewards/ career adv.	No	No	No	No	No
Source of knowledge for patented invention	Scientific literature, customers/ users	Competitors (in the US)	University	Patent –and scientific literature	Scientific literature
Inventive experience university inventors	-	-	Yes	-	Yes
Talented individuals	-	-	Yes	Yes (first student)	Yes

Table 7: Summary of the cases insights to the value/quality of patents

The efficiency/ effectiveness of patenting as technology transfer instrument [57]

No inventions or patent applications on inventions were made by the university before it started the collaboration in three cases (A, D and E). The patents indicate to be an effective technology transfer instrument as a result of the university-industry-(TTO) made arrangements in advance to the research collaboration. I.e. the university had benefits by financing their research and the firms by becoming- or having the privilege to the IP rights on university produced knowledge. The patent application decisions were the responsibility of the firms. The acquaintance with this collaboration arrangement suggests giving less tension to university-industry research efforts.

The other two cases (B and C) concern the transfer of a university owned patent. The university had to 'push' their discovery to industry as a consequence of patenting. The effectiveness of the transfer to industry[58] was considerable dependent on the network and financial incentive of the intermediary agent. The agent increased the matching process efficiency. Moreover, the taken attitude (i.e. building up a good connection, financial affairs and research efforts) by the university towards the firm indicates to be important. This suggests that the industry is cautious to university owned developed inventions and its transfer efficiency is a bargaining game.

[57] Patenting as 'one' channel of knowledge transfer without comparing it to other channels

[58] The firm obtained technology complementary knowledge in case B. This decision was made after it refrained from applying the patented technology to its own invention into later phase of the R&D project.

Invention/ case	A	B	C	D	E
Patent eff. TT instrument?	Yes	No	No	Yes	Yes

Table 8: Summary of the cases insights to the efficiency/ effectiveness of patenting as TT instrument [59]

The effects of patenting on academic research

The cases did not indicate exceptional negative impacts as a consequence of patenting. However, it may change in case the university is drastically involved in patenting activities as a result of the new policy. The university patenting activities are significantly modest at this phase of time. Hence, the exception can be made to three impacts on the basis of the cases findings so far. It indicates that it has no significant negative impact on the 'publishing vs. patenting' issue on the one hand. I.e. publishing seems to go together with patenting. On the other hand, the patents impact to the 'IP rights interference' and the 'patent absence' indicates to be negative. I.e. patents seem to break up informal connections as a consequence of interactions formalization and patents seem to be significantly important to embryonic inventions.

Invention/ case	A	B	C	D	E
Publishing vs. patenting difficulties	Dubious	No	No	No	No
Threat to teaching quality	Dubious	No	No	No	Dubious
Culture open science	Restricted	Restricted	Restricted	Open	Restricted
Fundamental (long term) research	Closeness R&D to business, mix of app. / fund. research	Closeness R&D to business, mix of app. / fund. research	Closeness R&D to business, mix of app. / fund. research	Closeness R&D to business, mix of app. / fund. research	Closeness R&D to business, mix of app. / fund. research
Threat to future academic research	No disruption cum. research progress, insignificant risks patent	Stagnation active research progress, patents may risky	Stagnation active research progress, patents may risky	No disruption cum. research progress, patents may risky	No disruption cum. research progress, insignificant risks patent
Absence patent	Embryonic, industrial/ scientific objective	Embryonic, commercial/ industrial objective	Embryonic, commercial objective	No/ less further development, commercial objective	Embryonic, commercial objective
Firm size	All sizes	Large size	All sizes	Large size	Large size
Inventions final product	Both university and industry objectives	Both university and industry objectives	Both university and industry objectives	Both university and industry objectives	Both university and industry objectives
IP rights interference	Yes	No	No	NA	Yes

Table 9: Summary of the cases insights to the effects of patenting on academic research

[59] Patenting as 'one' channel of knowledge transfer without comparing it to other channels

Publishing vs. patenting

All cases show complementarities between publishing and patenting. The inventions did not hinder publications although the student theses were kept confidential in some cases (A, B and D) for about one year at least. The numbers of publications are considerable in all cases. Strategic publications were made initially to avoid difficulties to patenting (case A and occasionally in case B). Furthermore, publications did not suffer delays as a result of the involved firms having a good IP management and/ or patenting experience (cases B, C, D and E).

Threat to teaching quality

No considerable time suffering and commitment on the patent output and its related activities are concerned in all cases (except case A) because most was taken care of by the firms. In some cases (B, C and D) the firm had its own professional IP management. In case E the researchers were assisted by the firm. The inventors are assisted on formal affairs by the Innovation lab in case A. It was just the second patent application by the co-promoter. Nevertheless, the cases suggest that the university is vulnerable without this support. Furthermore, the R&D projects had a positive impact on teaching in a number of cases (B, C and D). It contributed to educational programs.

Impact on the culture of open science

The openness of science can not be specified as closed but as restricted on the early stage of the science results initially (cases A, B, C and E). It can be attributed to the collaboration partners' first interests before science becomes public. Although the final constituted collaborations restricts access to other parties, the governmental programs makes it possible for them (e.g. other knowledge institutes) to join the collaborations by subscribing at the start of it. Nevertheless, the TU/e worked on a cooperative mode with other universities or departments of its own university in four cases (A, B, D and E). The culture of science can be called open in case D. The patent application and the publication of inventions followed upon each other quickly.

Fundamental long term research

In all cases fundamental (long term) research and its knowledge transfer is dependent on the closeness of the related R&D activities to business. The industry practical issues to specific technology applications play an important role. The researchers also engaged to a certain extent in applied research within the collaborations. In some cases applied- and fundamental research is narrowly connected. It suggests that applied research is a dependent factor for fundamental research in some technological fields to transfer knowledge (by patents) to industry effectively.

Threat to future academic research

The proceeding of cumulative research progress shows no disruption in three of the cases (A, D and E). In contrast to these cases the active progress has stood still in the other ones (B and C). The university patented invention was considerably dependent on financial incentives to be able to carry out further research on the patent as well as transfer it to the industry. Moreover, the cases B, C and D suggest that the patents may cause financial risks (i.e. its maintenance and the accomplishment of incomes) in case university apply for patents. The cases A and E show these risks are insignificant because technology transfer (to any firm or institute) is already mapped out before any patent application was made.

Absence patent

The patented invention is embryonic (i.e. requires additional development for future application) in all cases except case D. The assurance of exclusivity (i.e. patent or licensee) was important to the firm's commercial objectives to pick up the invention (case B, C, D and E). It is questionable whether exclusivity is needed to pick up the invention in case A. The scientific astronomical application is leading beside possible industrial applications for internal or commercial use. It suggests that the secondary application is the motive for the assurance of exclusivity. Accordingly, the cases indicate that patents and licenses are significantly important to embryonic inventions.

Firm size

The small and medium size businesses are not excluded as a result of patenting and also interfere with innovating (case A and C). Although in four (A, B, D and E) out of five cases the large international firms with high R&D expenditures and large number of R&D employees predominate.

Inventions final product

Some of the researchers contribute significantly to the company's commercial objectives (cases B, C, D and E)[60] although they have the academically freedom to carry out fundamental research. Both university and industry objectives are combined within the collaborations. This suggests that it is risky for university to patent own developed ideas because they may have to shift their research efforts towards more commercial objectives. In that case commercial inventions can become a more first product of university research. Moreover, the university may carry out researches that yield profits to be able to finance their research.

IP rights interference

University and industry find each other rather well through different channels of knowledge transfer before any matters of patents or licensing issues came up. In two cases (A and E) knowledge transfer is already mapped out in advance because of the collaboration IPR rules and regulations. The patents interfere with the university's other knowledge transfer channels to third parties (i.e. the patents have formalized interaction). In two other cases (B and C) the university group acted individually on all its research activities with regard to their own hold patent. They totally controlled the knowledge transfer process to industry itself as a pro-active managing entity. This suggests that the group's own management of a university patent does not have to interfere with informal knowledge transfer. It may change because the university has formalized its IPR policy since January 2006.

[60] The subsequent project collaboration (i.e. the second stage) referring to case E.

8 Conclusion and recommendations

8.1 Introduction

The conclusion is given in paragraph 8.2. It gives the answer to the research question as formulated at the beginning of this report. This is followed by recommendations for the management of knowledge transfer process at the level of the individual university and the national policy in paragraph 8.3.

8.2 Conclusion

The following conclusion can be made carefully on the basis of the policy activity relevance and literature- and empirical research as discussed in this report.[61]

What's the role of patenting in university to industry knowledge transfer in particular, considering the TU/e case?

Patents appear to be important to the industry. The assurance of exclusivity to pick up an embryonic invention that requires additional development for future application plays a prominent role. However, the patenting activity seems to be a task of the industry. Patenting by the university itself (i.e. university owned patents) seems to be an activity of minor importance for the TU/e. First, the university to industry transfer of knowledge through patents appears to be a secondary transfer. Its initial transfer of knowledge already takes place through other channels. I.e. the industry, institutes and intermediary agents are somewhat acquainted where to find their knowledge. Moreover, the knowledge need to the finally patented inventions appears to come from the industry. This suggests that the industry's request to university knowledge can be considered more important than the university offer of university knowledge. Second, the industry appears to be significantly more competent than the university to reduce negative outcomes of patenting on university research. The industries competence is distinguishable to among others things:

- Their patenting experience and/or the involvement of an IP management. Accordingly, publication delays as a consequence of patenting seem to be marginal or possible to prevent. Furthermore, the patent application by the firm deprives of (young or inexperienced) university researcher's time suffer/ commitment considerably.
- Industries better capability to determine the relevance to apply for a patent (e.g. usefulness to particular technology applications, the technological- and commercial value, and present market developments).

Thirdly scientific literature appears to be a relevant source of knowledge for patented inventions. This emphasizes the universities most important traditionally task: publishing. Moreover, the university researchers revealed that the scientific objectives to inventing are the most important to them. They attach no importance to financial gains. Nonetheless, the 'valuable' patents appear to be the work of experienced inventors and/ or talents.

[61] Given the fact that the five case studies represent a non-representative sample and so little is known about this issue its worth to pursue further University to Industry knowledge transfer studies.

8.3 Recommendations

The conclusions reveal that university patenting seems to be inferior to the university knowledge transfer process into business. Moreover, the patenting activities are the domain of the industry. Therefore, any policy should allow the university to apply a variety of knowledge transfer channels. It makes little sense to try to bend or to increase university knowledge transfer in the direction of university patenting.

The financial incentives seem to be pointless to stimulate university researcher's effort to invent and patent significantly more. The researchers indicate that their involvement to the research results impact/ outcomes on inventions gives them satisfaction. Therefore the management of knowledge transfer at the level of the individual university may (re)consider the use(fullness) of this policy. Any (new) policy may concentrate on the fulfilment of this satisfaction.

Furthermore, it is definitely worth to pursue further case studies on the patenting issue within University to Industry knowledge transfer. The collecting of significantly more data may give an improved clarification on this subject of discussion. In addition to the 'value/quality of patents' topic, it may be interesting to obtain data by raising the following questions:

- What was the inventions research origin of the patent? Did the research idea come from the industry (i.e. research request to university) or from the university (i.e. research offer to industry)?
- Did the transferred invention, in case the university made the invention and owned the patent, fit to business current technology (i.e. complementary) or was it an entire new technology?
- To what degree has the patent fulfilled both R&D objectives of the university (i.e. scientific) and the firm (i.e. commercial) in case the university owned the patent?

The answers to these questions contribute to the determination of the value of patents to universities and whether university-owned patents are important or not.

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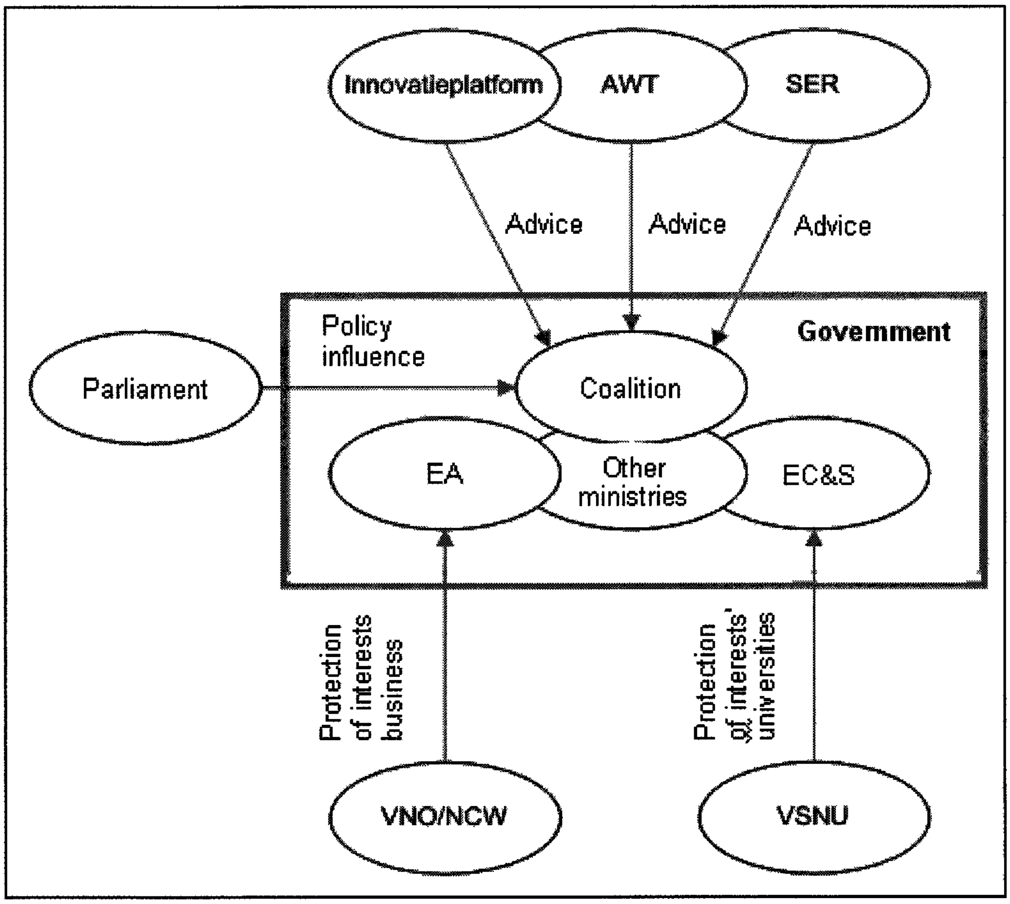
Appendix I: Detailed overview government actor field



Economic Affairs (EA) and Education, Culture & Science (EC&S) are the two ministry departments which are in particular involved in the innovation policy. The directives of their policy activities come from the coalition. The two ministries are influenced by interest groups. In this case these are the Confederation of Netherlands Industry and Employers (VNO/NCW) for EA and the Dutch Association of Universities (VSNU) for EC&S.

The governmental policy is influenced by the councils of advice like the Innovation Platform, the Council of Advice for Scientific- and Technology policy (AWT) and the Social and Economic Council (SER). The parliament checks the policy of the coalition. Moreover, it is slightly controlled by the approval of budgets and the proposal of motions.

Appendix II: Instruments stimulating collaboration

The governmental instruments to stimulate collaboration can be categorised to following six programs and arrangements (SenterNovem, 2006):

IOP

The ten innovation-driven research programs (IOP's) have the aim to harmonize the supply to- and demand of scientific and technologic research. Each IOP subsidizes public research institutes on strategic fundamental research, industrial research or pre-competitive research for the term of 4 years. An IOP subsidy application can be made by forming an IOP cooperation consisting of at least one Dutch non profit research institute and two Dutch firms. Firms can join the research actively by being part of an accompanying committee. The transfer of research results plays a significant role and takes place initially with the firms being a member of this committee. The technology transfer is regulated by IOP and the Dutch administrative Awb[62] law. If the receivers of the subsidization will patent their innovation they will be compelled by IOP to do the application and commit the IPR on its name. Subsequently the rights have to be maintained and the patent can be exploited. The interests of Dutch economy and the involved IOP project members/firms will be deliberated first according to specific arrangements in advance.

TTI's

The ministry of EA together with EC&S has established eight Technological TOP Institutes (TTI's).[63] Each institute carries out research on international significantly specific themes. Within this institutes framework business and knowledge institutions are collaborating on strategic fundamental research. Participating firms have to finance an established institute considerably (for ca. 25%). Each TTI has developed an own set of rules and regulations with respect to intellectual property. For instance, DPI will be the patent holder on applied patents resulting from research. It subsequently offers all industrial- and knowledge institute partners the opportunity to acquire these patents for further development and/or commercialise it. If there are no takers among the partners DPI can dispose of the patents (according to its own discretion) by transferring it to third parties (DPI, 2007).

Bsik

Through the inter-departmental arrangement Bsik (former ICES/KIS) investments are made to the research infrastructure on social relevant fields (e.g. ICT, utilization of space, sustainable system innovation, micro system- and nanotechnology and health-, food-, gene- and biotechnology breakthroughs). The program's motive is to bring

[62] Secrecy agreement on the basis of article 2:5 and article 14 paragraph 2

[63] The eight TTI's are the Dutch Polymer Institute (DPI), the Wageningen Centre for Food Sciences (WCFS), the Telematics Institute (TI), the Dutch Institute for Metals Research (NIMR), the Top Institute Pharmacy (TI Pharmacy), the Centre for Translational Molecular Medicine (CTMM), the TTI Green Genetics and the Technologic Top Institute Water technology (TTIW).

knowledge supply and demand together because research in this field is shred. Consortium establishments were only honoured if produced knowledge will be diffused. Moreover, preferences were made to private-public cooperation's. Within the ICES/KIS-3 program the government has subsidized 802 million Euros to 37 consortia for the term of 4 to 6 years at the start of 2004.

STW

The Technology Foundation STW supports technical scientific research and its application on universities with money of the Dutch organisation for scientific research NWO (60%) and EZ (40%). Participating firms to a STW research join a users committee and can profit on reasonable conditions first (and to significant occasions also a considerable time exclusivity by patents) to obtained knowledge. In return a firm has to pay a financial compensation. STW has developed a set of rules and regulations itself with respect to IPR's. All research results as well as (potential) IP rights are hold by STW and the involved public institutes at which the research is carried out.

EET

The subsidization programs Economy, Ecology and Technology (EET) and Technological Collaboration projects (TS) are merged to the Innovation subsidy collaboration projects (PSI) since March 2004. The arrangement subsidies collaborations between firms and public knowledge institutes as well as firms mutually on large-scale long term research projects. The sustainable projects are emphasized.

Smartmix

The new initiated program Smartmix promotes 'excellent' research to all possible (scientific) fields within all social sectors. It has the aim to create 'tangible' knowledge valorisation and the strengthening of focus and critical mass in outstanding scientific research by using the whole knowledge chain. Firms and/or social organisations have to work together with knowledge institutions to achieve these goals. On annual base an incentive of approximately 100 million euros is available for programs varying in costs of 3 to 10 million euros for the term of 4 to 8 years. The receivers of the subsidization are compelled by the Smartmix secretary to do the patent application on research results and commit the IPR on its name. Subsequently the rights have to be maintained and exploited by them. If the rights are not utilized by the subsidization receiver it has to transfer it to its consortium partners. In case these partners show no interest the rights can be transferred to third parties after exemption by the Smartmix secretary.

Appendix III: IPR regulation TU/e

The new patent regulation[64] has been introduced by the TU/e on 29 June 2006. This regulation has to harmonize the three Dutch technical universities' policies and to work on the ambition of knowledge valorization. The aim is to improve knowledge transfer, in particular into the business sector, and to facilitate enrolment of income beside the protection of knowledge. The new regulation has replaced the old one[65] with retroactive affect on 1 January 2006. The main changes are made to following aspects:

i. The Innovation lab has a mandate to be the administrative board of management within the TU/e concerning all arrangements regarding IPR.
ii. The commission of a patent committee aimed for professional advising the TU/e Innovation Lab in the field of patent applications.
iii. The costs of the patent application are financed central (i.e. by the TU/e) for a prolonged period. Thirty instead of twelve months will be financed obeying an active involvement of the Innovation Lab during the patent application.
iv. An incentive to stimulate inventors' patent awareness. A bonus of 1500 Euro is paid to the inventor(s) by the CvB for applying a patent on the invention.
v. A new arrangement on profits made to valorization of knowledge: One-third of the profits flow to the inventor(s), one-third to the involved department (group) and one-third to the central cashbox or the Innovation lab patent funds of the university after patent costs deduction. Accordingly, two-third of profits made will be kept by the university. In former arrangement the university had a higher share because the inventor was allowed to claim the maximum amount of 25.000 Euros.

The articles most important content covers following regulations with respect to patents and inventions:

<u>Article 3: Board of management TU/e Innovation Lab</u>
The Innovation lab has to report and justify their activities to the CvB. Decisions must be made in consultation, this means involving the Faculty board (or the inventor(s)). Final decisions have to be notified to both the CvB and the Faculty board.

<u>Article 4 and 5: Patent advice commission and its tasks</u>
The commission consists of min. 3 and max. 5 members appointed by the CvB for a period of 3 years. It gives advice to the Innovation Lab about various subjects of protection as well as exploitation which are related to research outcomes. The commission reports to the CvB via the Innovation lab.

<u>Article 6: The regulation effect</u>
The regulation covers all generated knowledge, developments and inventions made by scientific employees and students of the TU/e as well as involved third parties. An exception can be made, in particular if a project is financed by a third party, by a formally written agreement. This is the only way to deviate from the TU/e patent regulation. It is established that university employees, assistants and involved persons

[64] Regelingen octrooien en vindingen TU/e definitief Juni 2006

[65] Regelingen uitvindingen van TU/e-personeel -en studenten (CVB 99/2915)

have to abdicate possible IP rights. Students involved in projects also have to sign a statement for it.

Article 7: Secrecy
All named university persons in article 6 are compelled to keep an invention or protected research secret. The CvB can grant an exemption. Publications related to protection of IPR (e.g. patents) have to be submitted to the Faculty board first. The board immediately has to inform and consult the Innovation Lab.

Article 8: TU/e patent holder, rights on copyrights
The TU/e can claim the IP rights at all time. On the basis of article 7 on the Dutch copyrights regulation the TU/e can claim the rights. The person will not lose it rights on Personality according to article 25.

Article 9: Notification
One is compelled to notify his/her inventions on which a patent can be applied to the Faculty board/ Innovation Lab as soon as possible. All involved persons (incl. the advice commission) are compelled to keep secrecy.

Article 10: Patent application, increasing and maintaining a patent
The Innovation lab decides as soon as possible (i.e. within 6 months) whether or not to apply for a Dutch or European patent after notification. It can ask advice to a third specialist. The advice is publicly available according to article 5. The costs for the patent application, novelty check and continuation will be financed for 30 months by the Innovation Lab patent funds. The patent application has to be finished 6 months after notification. The inventor has the right to apply for a patent by private costs and to exploit the patent rights himself from that moment. The Innovation Lab, advised by the Faculty board and advice commission, decides the duration of maintenance as well as the responsibility for counting its costs after 30 months.

Article 11: Cooperation
The inventor is compelled to cooperate to the patent application and its maintenance.

Article 12: Exploitation
The Innovation Lab cares for a copy on the patent application for the inventor. Subsequently a plan is made with involved university actors for exploitation of the patent. They all have to make effort to find an interested third party for it (e.g. patent transfer, licensing, start-up, etc.). Its agreements are set up by the Innovation lab in advance and will finally be contracted by the CvB.

Article 12: Allowance
The bonus of 1500 Euro is paid to the inventor(s) by the CvB for applying a patent on the invention. This bonus is independent on exploitation effects. One-third of the profits flow to the inventor(s), one-third to the involved department (group) and one-third to the central cashbox or the Innovation lab patent funds of the university after patent costs deduction.

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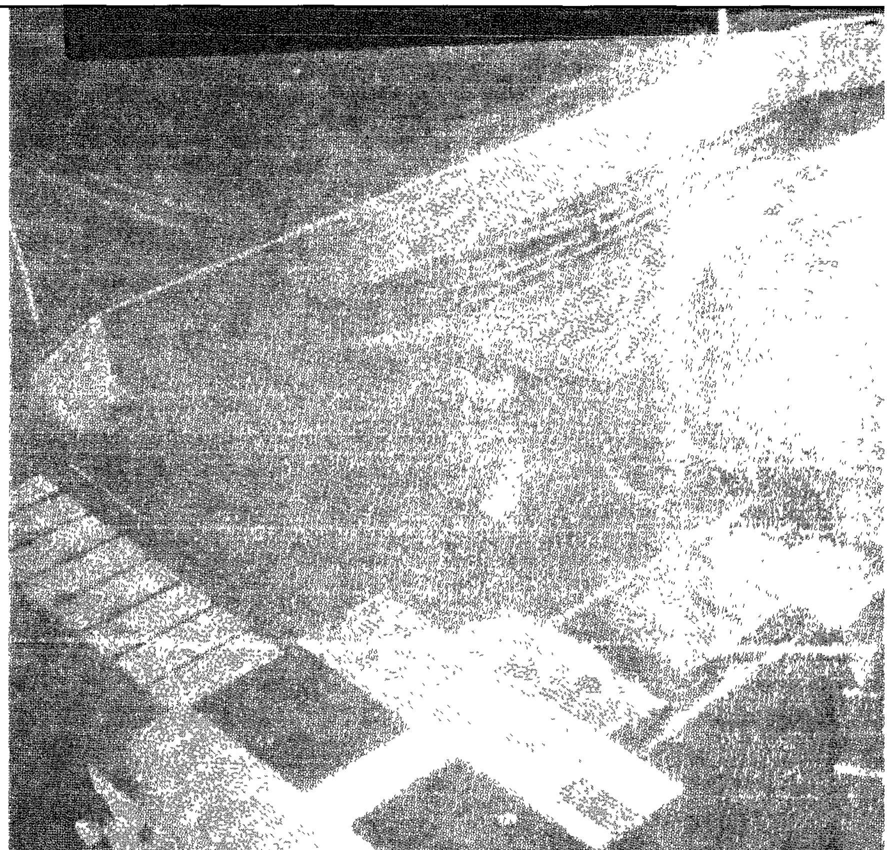

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