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Master thesis –

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The real reasons of sleeping patents owned by universities

A case study of Dutch universities

Master thesis Innovation Sciences
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Abstract

Since the initiation of the Bayh-Dole Act in the 1980s in the United States (US) of America, patenting at universities gained ample attention. Since then patenting activities are continuously increasing in both the US as well as in Europe. However, universities do not only hold patents which have been successfully exploited, but also patents which remain unused, also called sleeping patents. The aim of this thesis was to discover *reasons why some universities' patents remain unused while others are being commercialized.* Hereby, the two sub-questions, "*to which degree do universities hold sleeping patents?*" and "*what factors explain that university patents remain unused?*" were created to help approach this phenomenon in more detail. For this, the patents of three Dutch universities, namely (1) Utrecht University (UU) and University Medical Center Utrecht (UMCU), (2) Leiden University (LU) and University Medical Center Leiden (LUMC), and (3) Groningen University (GU) and University Medical Center Groningen (UMCG), were analyzed to gain insights of this phenomenon. To this end, a quantitative method approach was chosen, whereby an online survey was sent to 1000 inventors. These were analyzed with a regression analysis, which is designed to show the influence of the four potential characteristics that were deduced from the eight categories of the institutional readiness (IR) framework. The results showed that some patents owned by universities remain unused, while others are commercialized, could be explained by the fact that some inventions from a university are too radical in character since inventions are more likely to be used when building upon previous technologies. Also, the importance of the economic use of patents must be perceived high by the inventors in order to attain commercial use of the patents. Thus, universities' actors must have the capability to assess these two factors in advance in order to facilitate innovations. In light of this, this study is particularly interesting for universities to increase the commercialization rate of their patent portfolio. The researcher aimed not only to provide interdisciplinary knowledge, but also that this topic will receive attention, so that further research can be done in the future.

Table of content

List of figures

List of tables

List of abbreviations

CVs	Control variables
DV	Dependent variable
EPO	European Patent Office
GU	Groningen University
IPCs	International Patent Classifications
IPRs	Intellectual property rights
IPs	Intellectual properties
IR	Institutional readiness
IS	Innovation system
IVs	Independent variables
KTO	Knowledge transfer office
LU	Leiden University
LUMC	University Medical Center Leiden
OECD	Organization for economic co-operation and development
PA	Patent Act
PCT	Patent Cooperation Treaty
PROs	Public research organizations
R&D	Research and development
TR	Technology readiness
TT	Technology transfer
TTOs	Technology transfer offices
UICs	University-industry collaborations
UK	United Kingdom
UMCG	University Medical Center Groningen
UMCU	University Medical Center Utrecht
US	United states
UU	Utrecht University

1. Introduction

The phenomenon 'Valley of Death', which is the gap between a newly created invention and a marketable innovation, is well-known globally (Klitsie et al., 2019). An invention is defined as the process whereby a novel idea is identified or even established, whereas innovations are combinations of inventions generating monetary success (Roberts, 2007). Inventions are not only developed by companies, but also by public research organizations (PROs) and universities. According to Andrews (2017), there are several aspects whereby universities guide their actors, helping to increase the number of inventions created through knowledge production as well as dissemination. For example, academic institutions provide students with skills on the one hand. On the other hand, knowledge from alumni or a faculty itself can spillover over to individuals which are geographically close to the university (Andrews, 2017). Further, not only employees, but also students generate new ideas during their research and studies. However, ideas from both employees and students are often not further followed since their advancement is too cost intensive or inventors cannot or do not want to be entrepreneurs. Hence, the new invention, created by universities' employees and students, will not be commercialized resulting in an invention-innovation gap. Nevertheless, newly created inventions can be protected against others from the imitation by filing a patent at the patent office (Bessen & Maskin, 2009).

Generally, over the last decade, European applications for patents rose by 17%. In total, the European Patent Office (EPO) received more than 181,000 applications in 2019 (EPO, 2020). When it comes down to the commercialization rate it is difficult to mention exact numbers as researchers do not agree on it. However, the results of the PatVal-EU survey indicate that around 36% of the examined European patents are never commercialized or used for industrial purposes (Giuri et al., 2007). Further studies found a similar outcome for the US and Japan, namely that more than 30% of patents are unexploited for various reasons (Walsh & Nagaoka, 2009; Walsh et al., 2016). For instance, for the strategic non-use whereby actors block comparable inventions from their competitors to be patented (Cohen et al., 2002a) or sleeping patents which *"[…] remain unused for nonstrategic reasons, such as the difficulty of turning the invention into a commercial application or the inability to find a party interested in licensing or buying the patent right."* (Weeds, 1999, as cited in Torrisi et al., 2016, p.1375). Such patents suppress research activity which is especially detrimental in the existence of spillovers from research and development (R&D) (Weeds, 1999).

Since the initiation of the Bayh-Dole Act, which allows universities to hold on to and license inventions that were financially promoted by the government (Thursby & Thursby, 2003) in the 1980s in the United States (US) of America, academic institutions obtained importance and expanded the role for university owned patents. In fact, US universities filed, after the new law, approximately 1,000 patents per year compared to the years before the Bayh-Dole Act where they filed less than 250 patents each year. However, in European countries this fast-growing trend could not be observed even though some European legislators followed the US by introducing similar laws (Mowery & Sampat, 2004). According to Lissoni (2012), university owned patents from the US and European countries cannot easily be compared, as inventors from European countries usually patent in their own name whereas inventors from the US patent in the name of their universities. Nevertheless, a few scholars point out that university patenting increased tremendously worldwide (Geuna & Nesta, 2006; Lissoni et al., 2008; Mowery et al., 2001). What is more, some academics debated the effects of the Bayh-Dole Act as it is stated that in order to ease technology transfer (TT) universities must patent their inventions (Cohen et al., 2002b; Jensen & Thursby, 2001; Verspagen, 2006). While this will help to link universities and industries together, scientists also pointed out that negative effects might occur by university patenting such as young researchers might publish less when operating patent activities, a decrease of teaching quality, an increase in secrecy which means that open science will be undermined, a greater focus on applied instead of basic research and future academic research might be more expensive than before (Geuna & Nesta, 2006).

Lissoni's (2012) APE-INV study (a project between 2009 and 2013 that aimed to create a harmonized dataset on academic patenting in Europe) determined the number of academic inventors from six European countries being, Denmark, France, Italy, the Netherlands, Sweden, and the United Kingdom (UK) in the years between 2002 and 2006 (see table 1 below). In France and Italy over 1,000 academic inventors were identified. In the other four countries, the average number of academic inventors was 570. Furthermore, he identified that university-owned patents in Europe do not exceed 30%. The Netherlands and the UK both had over 20%, in contrast to the remaining countries where the percentage of such patents was approximately 10%. The variance between these countries can be explained by the deviation of the degree of autonomy within the different countries (Lissoni, 2012). As in the Netherlands, for example, an essential goal of all public universities in 2005 was to valorize scientific knowledge as well as enhance knowledge transfer and focus on scientific and technical research. A few educational institutions are very fruitful in patenting activities, compared to other European universities (van Dongen et al., 2014). Lissoni (2012) further stresses that in the Netherlands various universities, amongst others Leiden, Utrecht, and Groningen are on the list of top ten owners of academic patents whereas in other countries mostly big companies are listed.

Table 1: Academic inventors in Denmark, France, Italy, the Netherlands, Sweden and the UK (Lissoni, 2012, p.199)

	Academic inventors (no.) [a]	Academic inventors (% of prof.) [a]	Academic inv. incl. unchecked (no.) [b]	Academic inv. incl. unchecked (% of prof.) [b]
Denmark	328	4.44	571	7.72
France	1205	3.99	1822	6.04
Italy	1353	4.29	1395	4.42
Netherlands	600	2.75	731	3.35
Sweden	725	4.55	773	4.86
UK	630	2.30	4826	17.66

[a] Data from confirmed professor-inventor matches (professors confirmed to be the inventors).

[b] All matches, either confirmed or not confirmed (professors either confirmed to be the inventors or could not be contacted/did not reply).

Concerning intellectual property rights (IPRs) in the Netherlands, patent law is grounded in the Dutch Patent Act (PA) 1995 (*Dutch: Rijksoctrooiwet 1995*). In general, applicants can choose to protect their invention for 6 years whereby no novelty search is compulsory or 20 years whereby such novelty search is mandatory (Netherlands Enterprise Agency, 2021a). During this time, the invention is protected from others who might copy that invention, giving the owner temporal monopoly (Netherlands Enterprise Agency, 2021b). As filing a patent is both complex and associated with high costs, educational institutions are there to help employees with the procedure. In terms of patent ownership, art. 12(3) PA states that universities are the owner of the patent if the invention has been developed by its employees and/or students. Thus, for inventions created by a university's employee or student, it is unnecessary to frame a contract to transfer them to the university (The Ministry of Justice, 2009). What is more, according to the Association of Universities in the Netherlands (2016) universities are the ones who are authorized in decision making instead of the inventor of the invention.

Patented inventions created by employees as well as students from the university, are, however, not all successfully exploited. The problem with these patented inventions is that they might block other researchers or companies from creating similar ideas. Hence, the phenomenon of sleeping patents (i.e. patents which remain unused) needs to be tackled as previous literature did not arouse much attention to it. While some researchers focused on unexploited patents from firms, little is known about sleeping patents owned by universities. In light of this above, this research aims to gain insights on sleeping patents owned by a university, thus, the following research question and sub-questions were addressed:

Why are some university owned patents being commercialized and others still remain unused?

Sub-questions:

- *To which degree do universities hold sleeping patents?*
- *What factors explain that university patents remain unused?*

In this research, the following three universities were chosen (1) Utrecht University and University Medical Center Utrecht, (2) Leiden University and University Medical Center Leiden , and (3) Groningen University and University Medical Center Groningen in order to obtain a greater understanding of sleeping patents owned by a university. These three Dutch universities were selected as they are among top owners of university patents in Europe (Lissoni, 2012; Reuters, 2019) as well as among the oldest and largest universities within the Netherlands. All patented inventions held by these three universities were first collected, followed by the identification of sleeping patents through an online survey which were then analyzed. Hereby, the institutional readiness framework, which was developed by Webster & Gardner (2019), was adopted. This relatively new approach helped to understand characteristics of sleeping patents which hinder the use of such patents.

This research contributes to the literature on the extent of the commercialization of IPRs by analyzing patents owned by UU and UMCU, LU and LUMC as well as GU and UMCG. Since the phenomenon of sleeping patents has only been studied in the private sector, the focus on university owned patents provides first steps to understand why some of these patents are being commercialized, whereas others remain unused. The used theoretical framework, institutional readiness, typically helps to review if an institution is ready to adopt and implement a specific technology. However, in this study it is a tool to help understand problems/ruptures of a specific phenomena in order to find out why sleeping patents owned by a university occur. Hereby, the categories of the IR framework provided potential characteristics which might influence/explain the underlined phenomenon. Hence, it provides a wider aspect on the IR of universities. Furthermore, the use of the IR theory gives a better understanding of the lack of social and physical structures in order to foster an effective innovation system.

Concerning societal relevance, it is essential to recognize the extent and reasons why universities hold sleeping patents in order to be able to exploit new inventions into marketable innovations, thereby filling the gap of the 'Valley of Death'. This is especially important as innovations contribute to the competitiveness of a country, thereby positively stimulating economic growth. Also, another important reason to identify potential characteristics of sleeping patents is that such patents are blocking the development of new knowledge by others which eventually lead to the underinvestment of R&D. Further, universities are also better able to utilize their resources more efficiently and also can significantly save costs. By determining boundaries in the process of the commercialization of patents, universities are able to take the right measures and as a consequence, the patented inventions can be exploited.

In the following sections, the thesis first presents the theoretical framework to answer the aforementioned research questions (section 2). This is followed by the methodology of this research (section 3) including its research design, data collection as well as its data analysis. Hereafter, the findings are presented in section 4, followed by the analysis of the results (section 5). Lastly, the conclusion (section 6) and discussion (section 7) are being presented.

2. Theoretical framework

The following section describes the theoretical concepts that were applied in order to conduct this study which is divided into two sections. The first (section 2.1) outlines the concept of the institutional readiness framework which gains insights into impeding characteristics and their accompanying institutional ruptures. In the second subsection (section 2.2), the conceptual framework of this research is introduced by first stating reasons why universities file patents, followed by reconciling connections of unused patents and institutional problems with IR criteria for ease of understanding. Thus, this research builds on existing theory by linking the proposed research to the current state of the art in literature, identifying gaps, and formulating hypotheses to be tested.

2.1 Institutional readiness

The institutional readiness framework has recently been conceptualized by Webster & Gardner (2019). It was established as, in the last years, academic literature ignored the fact that the main purpose of the technology readiness (TR) approach was to help new technologies to prepare for their distribution in a particular environment and not for measuring the success and development of emerging technologies. For this reason, they claimed that the TR framework has to be extended to a science, technology and innovation studies perspective. Webster & Gardner (2019) shifted the focus from a supply-side perspective to a user-side perspective by theorizing the concept of institutional readiness, which is defined as following *"[..] how new technologies are engaged with and made sense of through cultural processes and institutional structures within and outside of specific organizations.*" (p.1234). Hereby, the theory evaluates organizational dimensions which form adoption and implementation actions (Webster & Gardner, 2019). Thus, this relatively new approach appears to be a suitable theory as it focuses upon challenges of an institution.

As the society, nowadays, presents a knowledge-based community, the interlinkages between diverse institutions, such as the university, the industry as well as the government, are of importance in order to have an effective innovation system (IS), whereby each institution improves the performance of the other. By means of this, each institution undertakes some of the competences of the other institution. For example, the university obtains further resources from the public as well as the private sector in order to improve one of its conventional tasks, namely conducting research and the dissemination of knowledge. However, at the same time, the university takes over some functions from the industry and the government, such as the creation of novel ideas. For these reasons, the university revolutionized in the early 20th century from a teaching academy to an entrepreneurial university. What has changed is that the outcome from basic research is considered as well as organizational instruments, such as patent offices and technology transfer offices (TTOs) within an academic institution, were developed in order to disseminate technology to the larger society by commercializing it to potential users. Thereby, the central expertise of a university has enlarged from knowledge distribution to the dissemination of intellectual properties (IPs) (Etzkowitz, 2003). As academic institutions most probably lack the ability to exploit new technologies sine they are relatively new to these activities, universities should examine their institutional readiness in terms of commercialization activities.

In order to determine the readiness of an institution, Webster & Gardner (2019) outlined eight IR categories, being (1) Demand for new technology, (2) Strategic focus, (3) Relative need and benefit of new technology, (4) (E)valuation processes in place, (5) IR enacted through specific enablers within and outside the organization, (6) Receptivity, (7) Adoptive capacity, and (8) Sustainability. In their paper the authors claim that these categories are not progressive to each other, meaning that one category does not inevitably presuppose another one. Table 2 below, gives an overview of the eight IR categories and how each of them is operationally defined based on Webster & Gardner (2019). In the context of this study, the first category, *Demand for new technology*, deals with the identification of new technologies that meets the needs of a university as well as the society, by key actors of a university. The second category, *Strategic focus*, is a university's ability to identify potential new technologies and ascertain the relation to existing ones. *The relative need and benefit of new technology* (category 3) determines the skills of a university's employees to evaluate the adoption of new technologies within current and future contexts. Category 4, *(E)valuation of processes in place*, examines a university's capability to assess the value of novel technologies. Category 5, *IR enacted through specific enablers within and outside the organization*, measures the alignment of a university's new invention with both internal as well as external actors by their flexibility to modify work practices across these groups. *The Receptivity* (category 6) determines, if a university is capable of creating novel structures and thereby being able to cope with (organizational) challenges known prior to the new invention. Category 7, *Adoptive capacity*, measures if the novel invention aligns with a university's priorities as well as its capacity to cope with unforeseen challenges that arise during the adoption of the new invention. The last category, *Sustainability*, describes if a university can use/produce the new invention routinely. Subsequently, it also encompasses whether a university has enough resources and adequate knowledge.

Table 2: Overview of IR categories (Webster & Gardner, 2019, p.1234)

IR Category	Operationally defined
C1: Demand for new technology	Institution has key actors engaging with and identifying new technologies that meet field/organizational needs
C2: Strategic focus	Institution has identified potential new technologies and determined their relation to existing ones
C3: Relative need and benefit of new technology	Institution has key actors assessing capacity to take-on and developing new technologies within current and future contexts
C4: (E)valuation processes in place	Assessments of the (diverse) values of new technologies are undertaken and shared
C5: IR enacted through specific enablers within and outside the organization	Key individuals/groups are formally tasked to enable adoption especially in regards to meeting standards and regulatory requirements

C6: Receptivity	Novel institutional structures are created, in anticipation of expected challenges/affordances presented by new technology. These structures reflect the need to retain staff, the construction of new innovation spaces and new technology platforms etc.
C7: Adoptive capacity	Novel technology aligns with institutional priorities and organizational capacities. Initial problems and unanticipated challenges/affordances are identified and seen to be manageable
C8: Sustainability	Novel technology is routinely produced/used/assessed within institutions. Current institutional arrangements and resources are sufficient for routine and ongoing production, assessment, and deployment

In this study, the focus lies on the following categories *Demand for new technology* (C1), *Strategic focus* (C2), and *(E)valuation processes in place* (C4) as the center of attention of these resulting institutional problems are on the invention itself and thus might influence the commercialization of novel inventions by a university. In contrast, the categories *Relative need and benefit of new technology* (C3), *IR enacted through specific enablers within and outside the organization* (C5), *Receptivity* (C6), *Adoptive capacity* (C7), and *Sustainability* (C8) were not considered in this research since they mainly asses a university's capability to adopt a certain technology on an institutional level as well as refer to the usage and production of a product. In the next subsection, first reasons why universities patent in the first place are investigated in order to understand and encounter potential reasons why some university owned patents remain unused. Literature on the used IR categories was explored and gaps were identified which grounded a rationale for this study.

2.2 Conceptual framework

In this study, the institutional readiness theory is used in order to gain insights into why some university owned patents are sleeping and not being commercialized. The reasons for a university filing patents in the first place are being explored. As universities are still rather new to the possibility of owning patents, as mentioned in the introduction (section 1), they most probably lack capabilities to exploit their newly invented technologies. For this reason, this study examines a university's potential ruptures by using the eight IR criteria in order to understand the characteristics of sleeping patents. Figure 1 on page 11, gives an overview of the used conceptual framework.

To begin with, in the early 20th century, the sociologist Robert Merton already stated that in order to fulfill collective progress, scientific knowledge strongly depends on the sharing of theories and research materials (Lee, 2013). However, nowadays, private ownership is most of the time required since it is necessary to yield ample inducement for investment in R&D of scientific inventions (Berman, 2008). As mentioned in section 1, since the introduction of the Bayh-Dole Act universities patent their inventions more frequently than before (Mowery & Sampat, 2004). According to Owen-Smith & Powell (2001) reasons why academic institutions file patents vary notably across research areas. They found that both physical and life scientists aim to protect their inventions. Nonetheless, they also point to a difference in incentive as they state the following: "*physical scientists patent for freedom of action, life scientists patent for strategic advantage*" (Owen-Smith & Powell, 2001, p.16). The former do so as most markets they enter are crowded whereby entrenched products and IPs constrain a university's ability to obtain income from it. Whereas, in the latter, scientists are not threatened by this, as such patents have a greater potential to open markets. What is more, Owen-Smith & Powell (2001) found that scientists also file patents as it *" […] increases their academic visibility and status by reaffirming the novelty and usefulness of their work."* (p.20f). Another reason why universities patent is the leverage due to patents. Again, there is a difference between the two aforementioned research areas. Life scientists' purpose is to attract financial investments from companies or venture capitalists, whereas physical scientists strive to gain relationships with firms (Owen-Smith & Powell, 2001).

2.2.1 Demand for new technology (C1)

The IR category 1, *Demand for new technology*, describes university's key actors and their capacity to identify new technologies to fulfill the field as well as organizational needs. As previously mentioned, the knowledge-based society challenges a university's main role as knowledge producers. Therefore, in order to maintain this role, universities will need to take on a market-oriented role which can be attained through collaborations to enhance knowledge production which meets the needs of the society as well as the university (Snellman, 2015). Moreover, the consensus of several studies is that collaborating institutions foster knowledge spillovers and thus will lead to innovations (Etzkowitz & Leyesdorff, 2000; Hájek & Stejskal, 2018). The foremost reason for this is that new inventions, that meet a field as well as organizational need, are mostly identified by the alliances with key actors as Anderson (2008) outlines. Additionally, in the 1990s Etzkowitz & Leyesdorff (1995) already claimed that in order to follow either a national or international innovation strategy, the relationship between an academic institution, the industry as well as the government will be a fundamental element in the late 20th century. However, since the global 'hollowing out of the nation state' (i.e. the nation state was losing functions, legitimacy, and authority to multiple actors (Ferlie et al., 2008)), the government restricted federal research funds (Ferlie et al., 2008; Jones, n.d.; Venturewell, 2019). For this reason, universities need to seek other institutions, such as from the private sector, to fill this financial gap and ultimately to fulfill the society's needs. The literature suggests that collaborations between a university and the industry are crucial as both strengthen each other, with each benefiting from the other. Universities not only benefit financially through university-industry collaborations (UICs), but also gaining additional resources to conduct further research, such as scientific equipment (Jones, n.d; Venturewell, 2019; Zieba & Vik-Langlie, 2020). In light of this above, it is highlighted that collaborations of diverse entities are of importance in order to understand the demand for a new technology. Specifically, UICs are essential as universities benefit financially as well as create market-oriented innovations that fulfill the needs of the society and the institutions. Thus, it can be said that universities which collaborate with different entities, specifically with the private sector, are more likely to hold patent inventions which are successfully commercialized. Implying that if a university does not collaborate with different institutions to develop a patent invention, especially with companies, these patents will remain unused, thus sleeping. Based on this, the following two hypotheses were developed:

Hypothesis 1: There is a negative association between a university's collaboration with different institutions and sleeping patents.

Hypothesis 2: There is a negative association between a university-industry collaboration and sleeping patents.

2.2.2 Strategic focus (C2)

The second IR category, *Strategic focus*, refers to the skills of a university's employees to identify a relation between a new invention and previous technologies. Thursby & Thursby (2001) recognize a greater increase of success of a new invention by the university, if a prototype already exists. Furthermore, according to Packalen & Bhattacharya (2015) inventions which build on most previous ideas/technologies have a higher chance resulting in subsequent innovations. However, some scholars disagree on this subject matter. Cooper (2018), for example, highlights success drivers, inter alia, the uniqueness of a product. He claims that an invention which is more differentiated and entails distinctive benefits, will thrive higher success rates compared to inventions relating to previous technologies. Khademi & Ismaila (2013) agree with him by highlighting the fact that technologies from a university must diverge from existing ones in order to be successfully commercialized. Henceforth, the researcher expects that if a new invention is unique and not strictly incremental, it will not remain unused, thus, leading to the hypothesis below:

Hypothesis 3: There is a negative association between the uniqueness of a new invention and sleeping patents.

2.2.3 (E)valuation processes in place (C4)

The IR category 4, *(E)valuation processes in place*, relates to a university's capability to assess the value of novel technologies. Therefore, in this study's context it is crucial that universities are able to determine the value of the inventions that are being patented. The evaluation of university owned patents is used to demonstrate a university's scientific output (Liening et al., 2018). According to Hsu et al. (2021) measuring the economic value of academic patented inventions constitutes a complex task. Nevertheless, Gambardella's et al. (2005) report explains that the economic use of patents can also be understood as indirect measures of a patent's value. This is confirmed by other scholars as well as they highlight that one of the main criteria which influences the value of a patent is the protection strategy (Blind et al., 2008; Lee, 2009). However, there are different types of motives of the inventors to patent, namely (1) commercial exploitation, (2) licensing, (3) cross-licensing, (4) prevention from imitation, (5) reputation, and (6) blocking patents (Gambardella's et al., 2005). The first motivation to patent is the commercial use of the invention, which gives the patent holder exclusive rights to exploit the invention, thereby excluding others to use, make, or sell an invention (Stedeford, 2009). It is expected that this economic use negatively influences sleeping patents when the inventors perceive a high importance, since the main motivation to patent is the commercial benefit. The second motivation, licensing, gives the licensee the right to make and sell the new invention. Hereby, additional money can be raised as the third party (licensee) has to pay a fee to exploit a patent's rights (Mordhorst, 1994, p.14). Again, the researcher expects a negative relationship between those two variables as the licensees are using this invention, therefore, it does not remain unused. Similarly, the third motivation, cross-licensing (i.e. a reciprocal agreement between the owners of independent or dependent patents granting mutual permission to use each other's patent) (Grindley, 2018), benefits by bundling complementary/interdependent technologies in order to prosper superior innovations (Cohen et al., 2000c; Grindley, 2018). Thus, also a negative association between sleeping patents and cross-licensing is expected by the researcher for the same reason as licensing. For the fourth and fifth motivation to patent, the prevention from imitation and the reputation of the inventors, the researcher also expects a negative effect of both on sleeping patents. Concerning the last motivation to patent, a blocking patent is used to patent complementary inventions of the rivals in order to prevent the commercialization of the competitors' patents. Cohen et al. (2002a) highlighted that "*by preventing other firms from controlling all the rights necessary to commercialize products, a firm will assure itself of "player" status in an industry in the sense of assuring itself access to the technology of rivals via cross-licensing*."(p.1361). Hence, it is expected that blocking patents is also negatively associated with sleeping patents. The researcher further expects that the higher the importance of the diverse economic uses of patents, the greater the value of a patent is, which ultimately will lead to a successful commercialization. Therefore, assessing the importance of the above mentioned motives to patent an invention are crucial in order to hold a patent with a greater value. This leads to the following hypothesis:

Hypothesis 4: There is a negative association between the importance of the economic use of patents and sleeping patents.

To sum up, identifying reasons why some patents remain unused by using the IR framework seems to give a more holistic view on institutional problems which impede patents owned by a university to be commercialized.

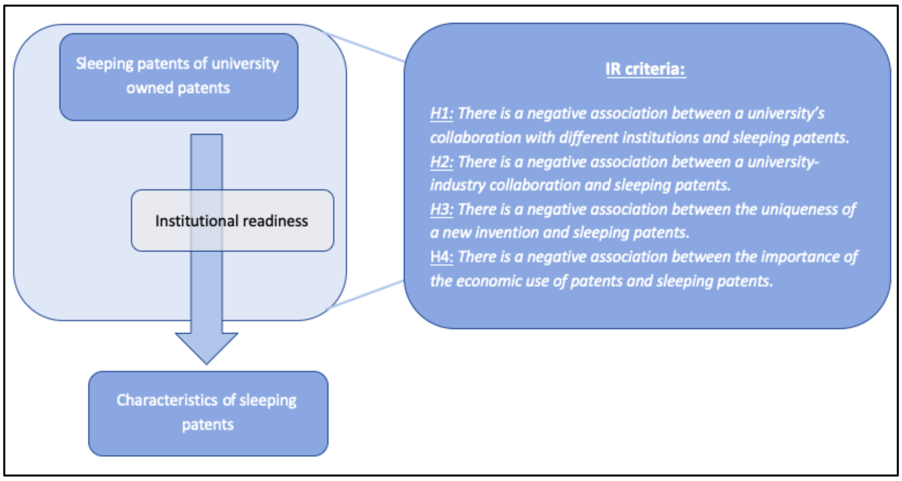

Figure 1: Overview of the conceptual framework (Own figure)

3. Methodology

In this section, the methodological strategies that were applied to conduct this study are discussed. The preceding section (section 2) constitutes the theoretical basis for this. The research design is described first in section 3.1 to give an overview of the used methods. The second subsection (section 3.2) is the description of the collected data, followed by the operationalization of the theoretical concepts (section 3.3). Section 3.4 outlines the method used to analyze the retrieved data. Lastly, in section 3.5, the reliability and validity of the used methods are outlined.

3.1 Research design

As the foundation of this thesis, a primary research approach was adopted as an explanation of the underdeveloped phenomenon of sleeping patents owned by a university is being looked at (Apuke, 2017; Queiros et al., 2017). Hereby, a quantitative method was chosen as the research design since the center of attention is on objectivity. Furthermore, the selected design provides a comprehensive clarification of the investigated phenomenon by gathering determinable measures. According to Yin (1981) there are diverse research strategies for three different purposes, namely exploratory, descriptive, and explanatory. In this research study, first a descriptive research, the description of the filed patents by three Dutch universities, was conducted in which the focal point is facts and characteristics of the phenomenon, disregarding the discovery of the cause and reasons (Bhasin, 2019). This was followed by exploratory research which aims to examine an underdeveloped concept in order to gain a better understanding of it (Formplus, 2007). Hence, this seems to be an adequate approach as limited research has been performed on this distinct subject matter. The used instrument to measure quantitative results in this study is an online survey among inventors from the three universities. What is more, as this thesis builds on preceding theoretical knowledge, a deductive approach appears to be suitable. Deductive research is concerned with testing a particular theory by deducing hypotheses from it, which are then tested (Bell et al., 2019). This method allows continuous reciprocal actions between theoretical and empirical findings. The proposed conceptual framework (section 2.2) was used as a guidance in order to answer the research questions. Further, the operationalization of the conceptual framework will be presented further down in this section.

3.2 Data collection

The following subsections describe the process of the collected data. Hereby, the used data sources as well as how data was collected are outlined.

3.2.1 Desk research

The relevant patents were gathered from the website *Espacenet* which is a worldwide patent search tool provided by the EPO where one can access information about patents freely (Espacenet, 2020). As the focus lied upon inventions owned by a university, the researcher focused on three Dutch universities being (1) Utrecht University and University Medical Center Utrecht, (2) Leiden University and University Medical Center Leiden, (3) Groningen University and University Medical Center Groningen as mentioned above. These three academic institutions were chosen as some scholars argue that they are top owners of academic patents within Europe (Lissoni, 2012; Reuters, 2019). Furthermore, the three Dutch universities are not only among the five oldest universities in the Netherlands, but also one of the largest universities within this country. At Utrecht University more than 35,000 students, at Leiden University 32,806 students and at Groningen University 34,000 students are currently enrolled (University of Groningen, 2021a; Universiteit Leiden, 2021; Utrecht University, 2021). For these reasons, in order to find all relevant patents from these three universities, the filter 'applicants' was applied to select only the appropriate patents. Further, with the intention to find relevant data, the following search terms were selected individually for each university (see table 3 beneath). A database of 1,029 university owned patents was generated. At the same time, first the REGPAT Database by the organization for economic co-operation and development (OECD), which contains EPO and Patent Cooperation Treaty (PCT) patents by region (OECD, 2021), was filtered according to the universities' region. This has been done with the help of the tool *RStudio* which is a statistical open-source tool (RStudio, 2021). Second, the OECD Patent Quality Indicators Database and the filtered OECD REGPAT Database were merged. The former includes a set of indicators, also consisting of the indicator 'forward citations' indicating the importance of a patent, to grasp both technological and economical value of EPO and USPTO patents (OECD, 2021). Afterwards, the number of forward citations of each patent was manually inserted into the dataset by the researcher. This process was carried out for each university individually. However, not all patents from the REGPAT Database were included in the OECD Patent Quality Indicators Database, meaning no indicator could be assigned. The patents with a missing indicator were then matched with google patents manually.

Table 3: Overview of the used search terms (Own table)

Utrecht	Leiden	Groningen
- Ziekenhuis Utrecht - Universitair Medisch Centrum Utrecht - Utrecht University - Univ Utrecht - Utrecht Holdings B.V.	- Ziekenhuis Leiden - Leids Universitair Medisch Centrum - Leiden University - Univ Leiden	- Ziekenhuis Groningen - Universitair Medisch Centrum Groningen - Groningen University - Univ Groningen

3.2.2 Online survey

The used measuring instrument was an online survey, as already mentioned above, to obtain greater insights about potential reasons why only some university owned patents are commercialized and others are left unused. For this, the online survey system, *Qualtrics*, was used (Qualtrics, 2021). An advantage of an online survey is the quick and convenient approach, whereby, in this study, information about the invention process, value as well as the commercialization of the patents was gained. What is more, a clustered sample, which is a probability sampling method, was selected in this study as at least one inventor of each patent was chosen.

Hereby, scientists were included if they have filed a patent whereby one of the relevant universities was an assignee. For each available patent, at least one inventor was reached out to, however, for some patents (n= 124 patents) no contact detail could be found, thus, the sample contained 1,000 inventors of 905 patents. These scientists were either approached through their university/company e-mail address or through their LinkedIn as well as ResearchGate profile. In case an inventor filed multiple patents he/she was asked to refer to his/her most recently filed patent. What is more, the researcher first conducted a pilot of the survey by asking ten inventors to fill in the survey and afterwards give feedback to the researcher. Three inventors were willing to participate in the pilot and thereafter the questions were adjusted accordingly to the participants' feedback.

Appendix 1 provides an overview of the survey. First, general questions about the filed patents were asked, followed by more specific questions on the process of the invention and the value of the patent, which were mostly based on the PatVal study (Gambardella et al., 2005). In order to receive the required data from the survey, closed-ended questions were made use of. With the aim of minimizing ethical issues, the researcher included a short-informed consent statement (see Appendix 1) in the online survey. If the participant did not consent to it, the survey finished automatically. Additionally, the survey was conducted in the period of the 11th of June until the 2nd of July 2021 (three weeks). Hereby, a response rate of 7,5% (75 responses) could be achieved.

3.3 Operationalization

In this section, the researcher presents how the theoretical concepts were measured to be able to perform an analysis on the relation of the dependent variables (DV) and independent variables (IVs). Hereby, table 4 on the next page provides an overview of the variables and its indicators as well as measurement. All variables in this study were operationalized by the questions from the online survey. For the dependent variable, a binary system was used by which the success of a patent was grounded. The two categories determine whether a patent has been exploited (0) or not exploited (1). This was assessed by asking the inventors if their patent has been used for commercial or industrial purposes and if the invention has been used for subsequent innovations. Further, for the context of the regression analysis, the patents where the inventors are still investigating possibilities were categorized as commercialized patents.

Further, the four potential features (IVs), which were identified by the existing institutional readiness theory, were assessed the following. The first IV, *a university's collaboration with different institutions*, was operationalized by determining whether the particular universities established a formal collaboration with key actors or not. This variable was also measured as a binary variable demonstrating whether a formal collaboration (1) or no formal collaboration (0) was formed. The second IV, a *university-industry collaboration,* was determined by the type of collaborations. Hereby, collaborations with the private sector (1) and collaborations with others (0) was assessed. The third variable, *uniqueness of a new invention*, was assessed based on the relation between a new invention and previous technologies by asking the inventors whether their patent invention was built on previous technologies or not. The fourth IV, *the importance of the economic use of patents,* was operationalized by looking at the importance of the different motivations to patent, whereby for each inventor the level of importance was added up.

Lastly, in this research three control variables (CVs), namely *University, Year of the application, and IPC*, were used, which were all factorized in the regression analysis. The first CV, *University,* control for the universities where the particular patent was filed. The second control variable, *Year of application,* was used in order to control for the year in which a particular patent was filed by one of the three universities. This variable was taken as a categorical variable that ranges from 1990 to 2020, as the obtained patents from the survey were filed in-between these years. The last control variable in this study, *IPC,* controls for the field in which a patent belongs to. This variable was based on the International Patent Classifications (IPCs), which will be further described in section 4.1, in order to control for the patents' technical fields.

Table 4: Operationalization table (Own table)

Variables	Terms	Variable	Indicator	Measurement	Type
DV	Unused patents	Sleeping patents	Commercialization of a patent	Sleeping patents (1) Commercialized patents (0)	Categorical (Binary/ Dichotomous)
IV	Characteristics of sleeping patents	Demand for new technology (C1)	A university's collaboration with different institutions	Formal collaboration (1) No formal collaboration (0)	Categorical (Binary/ Dichotomous)
		Demand for new technology (C1)	A university-industry collaboration	University-industry collaboration (1) No university-industry collaboration (0)	Categorical (Binary/ Dichotomous)
		Strategic focus (C2)	The uniqueness of a new invention	Uniqueness of patents (1) Build on previous technologies (0) Inventor does not know (2)	Categorical (Nominal)
		(E)valuation processes in place (C4)	The importance of the economic use of patents	Added number of the importance of the economic use of patents	Categorical (Ordinal)
CV		University	Universities	Utrecht Holdings B.V. (0) Leiden University and LUMC (1) Groningen University and UMCG (2)	Categorical (Nominal)
		Year of the application	Year of the application	Years	Categorical (Nominal)
		IPC	IPC	IPCs (A – NA)	Categorical (Nominal)

3.4 Data analysis

This subsection presents the chosen analysis methods as well as how the retrieved data will answer the research question. The analysis of the obtained data took place by means of a regression analysis as well as correlations in order to assess the deduced hypotheses. Also, this method was chosen in order to analyze which of the above described independent variables are associated with the dependent variable as well as which type of relationship they present. More particularly, as the dependent variable, sleeping patents, can only take two different values, as described in the operationalization namely zero and one, a binary logistic regression model was used. A binary logistic regression analysis calculates the maximum likelihood of observing the data, thereby predicting whether an outcome is observed or not. In this study the outcome refers to 'exploited' or 'not exploited'. Furthermore, as the dependent variable is a categorical variable, the assumption of linearity between the variables is violated. The logistic expression of this model transforms the linear function into a S-shaped logistic function giving the probabilities of an observation. For this, RStudio was used in order to examine the relationships between the DV and IVs.

3.5 Quality research

The last subsection outlines the quality of this research. The quality in a quantitative research can be evaluated with two different indicators namely, reliability and validity (Sürücü & Maslakci, 2020). *Reliability* refers not only to the consistency of the process and the measures of this research, but also to the replicability of the findings. This is being assured as the used method, data sources and analysis techniques, are specified throughout this study, thus replicable for other researchers. In particular, the prior operationalization is closely followed in the analysis in order to assure reliability of this study. Also, as a pilot survey was conducted, as described in section 3.2.2, consistency could be guaranteed.

The second quality indicator, *validity*, can be divided into two categories, namely internal and external. The differences of the two validity categories are the following. The former validity category relates to the appropriateness of the chosen process and tools to collect and analyze data, whereas the latter measures whether the findings of a study are generalizable or not (Slack & Draugalis, 2011). The internal validity is also being granted as most of the questions asked are deduced from the European PatVal survey. Further, in case of closed-ended questions, the response category 'neutral' was excluded increasing the validity of the inventors' response. Also, in order to ensure that the theoretical concepts were measured correctly, the findings were compared regularly to the integrated conceptual framework. However, triangulation cannot be guaranteed since only one researcher conducts this study which has a limited timeframe. The external validity indicator, generalizability, cannot be assured as this research focuses only on three universities in the Netherlands which might not be applicable for other countries or even universities within the Netherlands.

4. Findings

The following section describes the findings of the two datasets, namely the full as well as the survey sample, which is divided into two main subsections. The first section 4.1, discusses the dataset retrieved from the EPO website which grounded the foundation for further and detailed analysis. Whereas in the last section, section 4.2, the data of the collected survey sample is described.

4.1 Patent portfolio of the three Dutch universities

The results, which will be presented at a later stage of this study, are drawn from the following dataset described below. The dataset consists of all existing university owned patents that were granted by the EPO to one of the three universities. Hereby, patents from the University of Utrecht and the University Medical Center Utrecht are held by Utrecht Holdings B.V. which constitutes the knowledge transfer office (KTO) of both (Utrecht Holdings, 2020). In contrast, the other two universities' KTO (LURIS in case of the University of Leiden and University Medical Center Leiden; IP & Business Development in case of GU and University Medical Center Groningen) do not hold the patents, nevertheless, they support patent applicants with the application, commercialization, and finding potential partners (LURIS, 2021; University of Groningen, 2021b).

The first patent filed from the three academic institutions at the EPO was Leiden University in 1969, thus, the dataset ranges from this year and the most completed recent year 2020. However, in the years between 1970 and 1975 as well as in the 1980s no patents from these universities were filed. Regarding the number of patents filed, on average 20 inventions per year were protected. The graph on the next page (figure 2) illustrates the number of patents filed in total as well as per university in the given period of time. Overall, a link between the Bayh-Dole Act in the 1980s, as mentioned in section 1, and an increase of filed patents can be seen. All three universities experienced a fluctuation in patenting inventions after the year of 1980. In the preceding years, between 1970 and 1975 the number of filed patents reached a plateau, however, in general a gradual increase can be observed. In 2004, the majority of Utrecht Holdings B.V.'s patents were filed with 18 patents. In contrast, LU and LUMC peaked in 2014 as well as in 2017 with 27 filed patents in both years, whereas GU and UMCG filed most patents (25 patents) in 2016. All three universities collectively reached a peak of 53 patents filed in 2017, followed by a rapid downward trend.

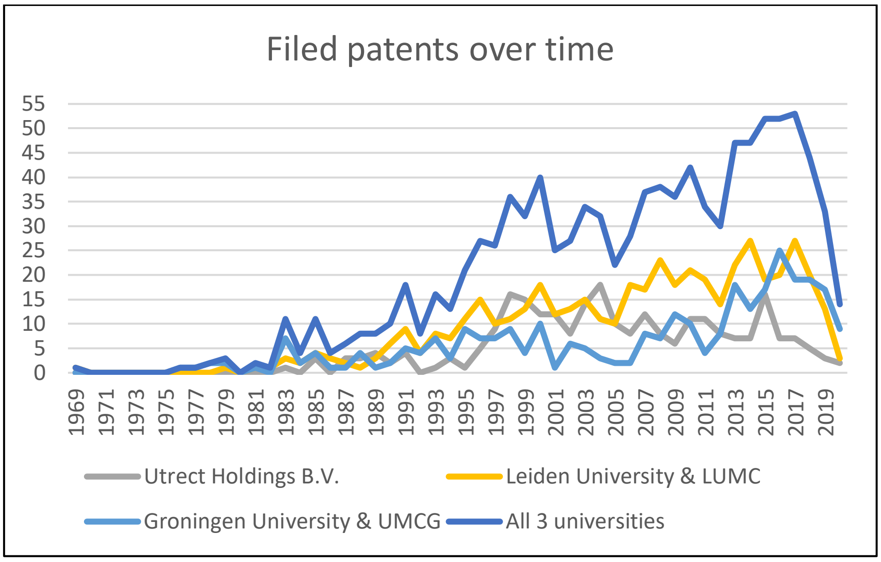

Figure 2: Overview of all patents held by Utrecht Holdings B.V., Leiden University & LUMC, and Groningen University & UMCG (Own figure)

The dataset shows that a total of 1,029 patents were filed by either one of the three academic institutions in the previous mentioned period of time.[1] Table 5 on the next page summarizes the following described values. Hereby, Utrecht Holdings B.V. possesses 262 patents (25.3% out of the full dataset) and has individual ownership of 171 patents (65.3%). These can be further divided into 67 patents filed by UMCU and 104 patents by UU. Additionally, 22 patents (8.4%) were filed by UU as well as UMCU jointly, referring to an internal collaboration. Hence, these patents will not be treated as a collaboration with other institutions as Utrecht Holdings B.V. has sole proprietorship. The remaining, 69 patents (26.3%) are outcomes of collaborations with other institutions, such as universities at a national as well as international level or companies. Concerning the patents owned by Leiden University and LUMC, this academic institution holds the most patents compared to the other two universities namely 476 (45.9% out of the full dataset). Similar to Utrecht Holdings B.V., nine patents (1.9%) were filed by LU and LUMC collectively, thus also treated as individual ownership of LU and LUMC. Another 26.1% (124 patents) are owned by LUMC, 33.6% (160 patents) by LU individually, and the remaining 38.4% (183 patents) have multiple assignees. The retrieved data further demonstrates that the remaining university also holds 12% of its patents (36 patents) which were filed by GU and UMCG cooperatively. Only seven patents (2.3%) were registered by UMCG individually, 48.2% (144 patents) and 37.5% (112 patents) were filed by GU and through collaborations respectively leading to a total of 299 patents (28.8% out of the full dataset).

In terms of patent number, Leiden University and LUMC appear to be the most innovative institutions of the three, which was also confirmed by Reuters' Europe's top 100 most innovative universities in 2019. Hereby, Leiden University was ranked under the top 20 universities, being the most inventive academic institution in the Netherlands. UU as the third and GU as the sixth most innovative within the Netherlands (Reuters, 2019). What is more, on average, innovations from all

[1] Note the difference between the total number and the sum of the filed patents for the three universities is due to the fact that eight patents were filed by two of the three universities at the same time, whereby both universities are the assignees. Thus, each of these patents only counted as one patent in the full dataset as they are the exact same patent.

three academic institutions were invented by four inventors. Nevertheless, the minority, 6.7% (9.5% of the Utrecht dataset, 4.8% of the Leiden dataset, and 7% of the Groningen dataset) of all patents, have only one inventor and 52 patents (5%) have no inventor assigned.

Table 5: Overview of the patents per university (Own table)

	n= 1,029 patents					
	Utrecht Holdings B.V.		**LU & LUMC**		**GU & UMCG**	
Total number of patents	262 (25.3%)		476 (45.9%)		299 (28.8%)	
Collaborations with other institutions	69 (26.3%)		183 (38.4%)		112 (37.5%)	
Individual ownership	**UU**	**UMC Utrecht**	**LU**	**UMC Leiden**	**GU**	**UMC Groningen**
	22 (8.4%)		9 (1.9%)		36 (12%)	
	104 (39.7%)	67 (25.6%)	160 (33.6%)	124 (26.1%)	144 (48.2%)	7 (2.3%)
Average number of inventors	4					
1 inventor only	25 (9.5%)		23 (4.8%)		21 (7%)	
No inventor	12 (4.6%)		19 (4%)		21 (7%)	

Note: the percentages always refer to each university's total number of patents hold

The 1,029 inventions can further be classified into the IPCs which constitutes a classification system. Its purpose is to classify patent documents, thereby making it easier to search for a particular patent according to its technical field (WIPO, n.d.). The following fields are covered by the IPCs: *A – Human necessities* such as personal or domestic articles and health-related inventions, *B – Performing operations*; *Transporting*, for example physical or chemical processes, *C – Chemistry; Metallurgy* such as inorganic chemistry and treatment of water, *D – Textile; Paper* for example braiding and yarns, *E – Fixed Constructions* such as construction of roads and earth or rock drilling, *F – Mechanical engineering; Lighting; Heating; Weapons; Blasting* for example machines or engines in general, *G – Physics* such as nuclear physics, and *H – Electricity* for example basic electronic circuitry. The dataset obtained from the three universities cover all technical fields apart from IPC E, *Fixed Constructions*. Most patent inventions (43.4%) are assigned to the IPC C, *Chemistry; Metallurgy*, followed by the IPC A, *Human necessities*, with the second highest number of patents (359 patents), and IPC G, *Physics* which makes up 14.1% of the full dataset. Particularly, the majority (95% out of the IPC A) relates to health-related inventions classified in the subcategory *A61 – Medical or veterinary science, Hygiene*.

Table 6 on the next page displays the number of patents per field in which all the inventions were established for the full dataset including the division per university. Interestingly, it can be seen that all three universities' most inventions relate to chemical inventions (IPC C). Utrecht Holdings B.V. holds 40.8%, almost half (46.4%) of LU's and LUMC's inventions, and 41.1% of GU's and UMG's patents relate to this particular category. Also, the second greatest number of patents held belongs to the area of human necessities. Hereby, Utrecht Holdings B.V. holds 39.7% out of all its patents from IPC A. LU and LUMC have 147 patents (30.9%), whereas GU and UMCG hold 111 patents (37.1% out of their patent portfolio) relating to this specific field.

Furthermore, 263 out of the 1,029 patents (25.6%) held by the aforementioned universities were not cited by others, thus signaling an insignificance of these particular patents, which might indicate sleeping patents. Therefore, further research on this dataset is needed to conclude on sleeping patents described in the following sections.

Table 6: Overview of the IPCs from the full dataset (Own table)

	Total number of IPCs	Utrecht Holdings B.V.	LU and LUMC	GU and UMCG
A – Human necessities	**359 (34.9%)**	104 (39.7%)	147 (30.9%)	111 (37.1%)
B – Performing operations; Transporting	**43 (4.2%)**	11 (4.2%)	18 (3.8%)	14 (4.7%)
C – Chemistry; Metallurgy	**447 (43.4%)**	107 (40.8%)	221 (46.4%)	123 (41.1%)
D – Textiles; Paper	**2 (0.2%)**	0 (0%)	0 (0%)	2 (0.7%)
E – Fixed Constructions	**0 (0%)**	0 (0%)	0 (0%)	0 (0%)
F – Mechanical engineering	**5 (0.5%)**	0 (0%)	1 (0.2%)	4 (1.3%)
G – Physics	**145 (14.1%)**	33 (12.6%)	78 (16.4%)	35 (11.7%)
H – Electricity	**21 (2%)**	5 (1.9%)	7 (1.5%)	9 (3%)
NA – Unassigned	**7 (0.7%)**	2 (0.8%)	4 (0.8%)	1 (0.4%)

4.2 Description of the survey sample

This section describes the main findings of the survey sample which is divided into three subsections. The first, section 4.2.1, outlines a comparison with the full dataset, followed by section 4.2.2 that illustrates insightful survey questions. The last subsection 4.2.3 presents first relations of the dependent and independent variables which will be further analyzed in section 5.

4.2.1 Comparison with the full dataset

To begin with, it is essential to examine the distribution of the filed patents over the three universities. A comprehensive online survey of inventors from patents owned by either Utrecht Holdings B.V., Leiden University and LUMC, or Groningen University and UMCG was conducted. In total, 75 responses were received, however, six answers were removed as these inventors were not aware whether their patent has been commercialized or not. Thus, resulting in 69 adequate responses representing the years between 1990 and 2020 as the participating inventors filed their patents between this period of time. On average 2.3 patents per year were filed in the last 30 years. The line graph on the next page (figure 3) demonstrates the number of patents filed in the survey sample for both each university and the sum of all universities together. Congruent to the full dataset, the quantity of patents filed oscillates within these years. Nevertheless, the majority of patents (55.1%), relating to all three universities, were filed in the last ten years reaching its peak in 2014 and 2018 with each seven patents filed, which are equally divided among the academic institutions. This can be explained by the fact that the researcher asked the inventors to name their most recent filed patent. While in the prior 20 years, from 1990 – 2010, a slight increase can be observed, whereby on average 1.6 patents were filed. The Utrecht Holdings B.V. reached its highest point in several years namely, 1999, 2008, 2010, 2015, 2018, and 2020 by protecting two inventions at that time. Similar to the full dataset, LU and LUMC reached a peak of three patents in the following two years, 2009 and 2016. In contrast, GU and UMCG hit a high of four patents in 2014 being the greatest number of patents filed in the survey sample. What is more, out of the 69 responses 40.6% of the inventions were assigned by Leiden University and LUMC, 33.3% by Utrecht Holdings B.V., and the remaining 26.1% by Groningen University and UMCG. The majority of the patented inventions (60.9%) did not set up a formal collaboration (i.e. collaborations involving well defined contracts among the parties), for example with other universities or companies.

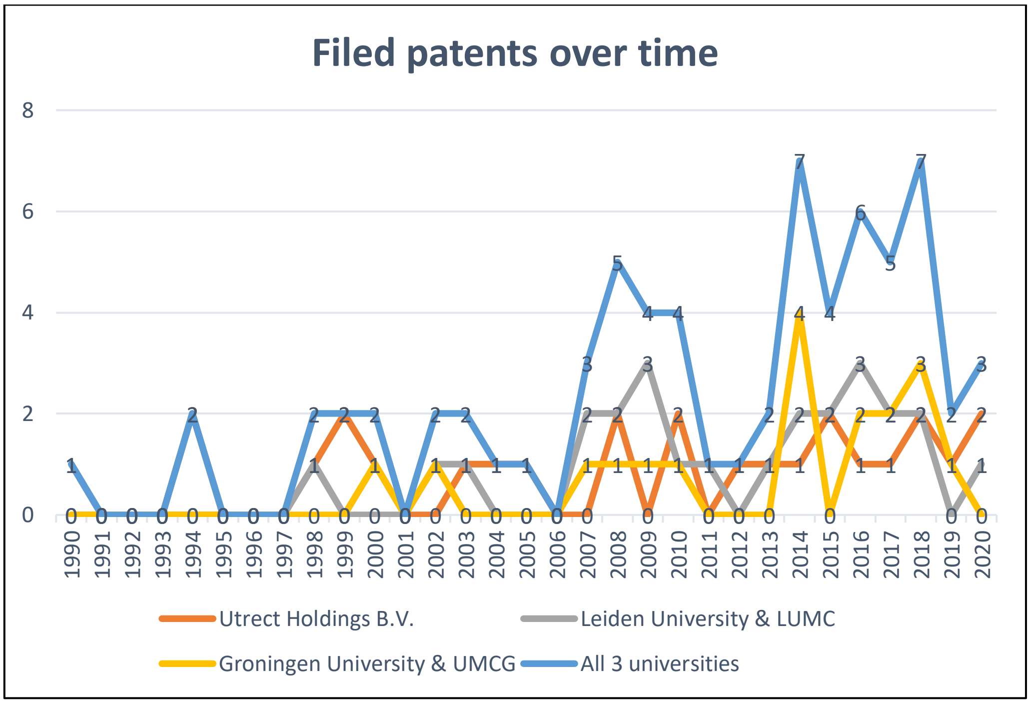

Figure 3: Overview of the number of patents hold per University in the period of 1990 – 2020 (Own figure)

The protected inventions from the survey sample represent various fields with a majority relating to both *Human necessities* (IPC A) and *Chemistry and Metallurgy* (IPC C) with each representing 34.8% which is equal to 24 patents. Within the former category, almost all responses from this category (95.8%) are health-related inventions (A61) and within the latter category a little over 50% relate to the subcategory Biochemistry (C12). Figure 4 in Appendix 2 displays these subcategories per IPC category for the survey sample. From the full dataset (table 6 on page 19) it is noticeable that the highest number of patents relate to the chemistry field and not relating to two different areas. Figure 5 on the next page demonstrates a comparison of the two datasets in order to have a clear overview of the quantity of patents per category. A further detailed comparison from the two datasets about the subcategories can be seen in table 7 in Appendix 3. Nevertheless, comparing the two datasets and dividing the two major categories, *Chemistry and Metallurgy* as well as *Human necessities*, further per university, it can be seen that Utrecht Holdings B.V.'s ratio of the number of patents hold relating to category A, *Human necessities*, has the same value (full dataset: 29% and survey sample: 29.2%). However, concerning the second major category, the survey sample holds almost twice as many patents from this category in relation to the full dataset with 41.7% and 23.9% respectively. The LU's and LUMC's ratio of the number of patents diverge slightly within both categories. Category A, *Human necessities,* holds nearly 5% more patents in the survey sample than in the full dataset (45.8% and 40.9% respectively), whereas in category C, *Chemistry and Metallurgy*, a variance of 7.7% was observed (full dataset: 49.4% and survey sample: 41.7%). With regards to the third university, GU and UMCG, category A has almost 5% more patents, similar to LU and LUMC, however, a greater amount is held within the full dataset (30.9% and survey sample: 25%). In the field of chemistry, GU and GUMC filed 123 patents in total (27.5% out of this particular category) and four patents (16.7% out of this particular category) are held in the survey sample, resulting in a 10.8% disparity. What is more, the last category with a great value of patents relates to an area concerning the attributes and character of energy as well as non-living matter, namely the field of *physics* (IPC G). In the full dataset 145 patents (14.1%) belong to this area, whereas 13 patents (18.8%) out of the survey sample are categorized in the field of physics. The residual IPCs were divided among the fields of physical or chemical processes, electricity, and textiles accordingly. In both datasets these classifications constitute only the minority of all hold patents. One invention out of the 69 responses has not been classified in its original document at a patent office as shown in figure 5 on the next page.

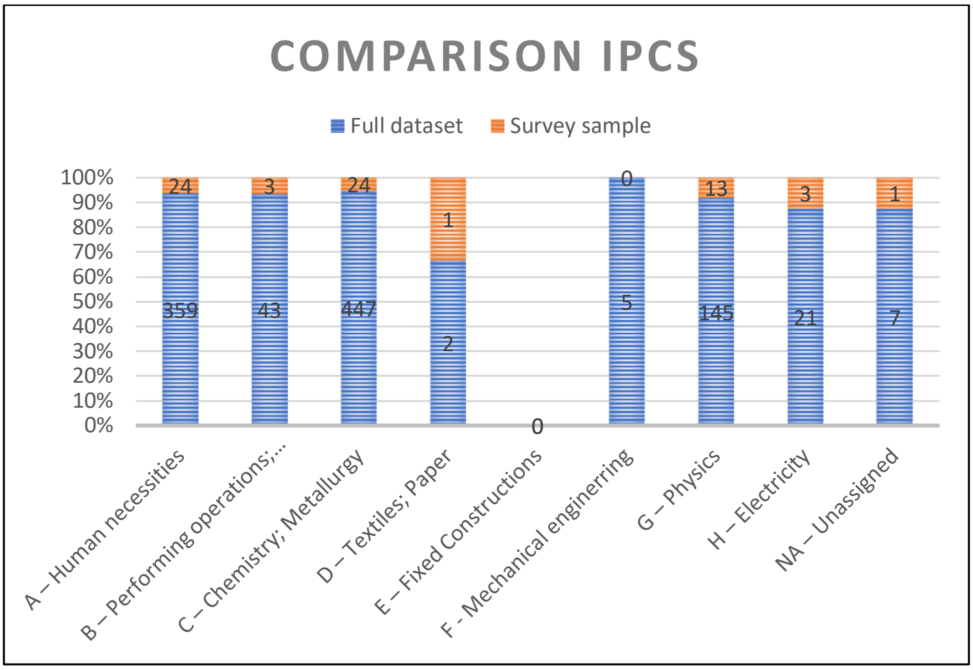

Figure 5: Comparison of the IPCs of the full dataset and the survey sample (Own figure)

4.2.2 Description of the survey questions

This section highlights some aspects found when analyzing the survey questions. Concerning the commercialization of the patents, 44.9% (31 inventions) have been successfully exploited by the universities, whereas 30.4% (21 patents) have been unused according to the respondents. The remaining 24.6% (17 patents) have not been commercialized, but its inventors are still investigating possibilities. As mentioned in the operationalization (section 3.3), the patents where the inventors are still investigating possibilities were not categorized as sleeping patents. Thus, in total the majority of patents in the survey sample, in particular 69.5%, were commercialized. A further aspect of how to recognize sleeping patents could be the number of citations. As mentioned in section 4.1, no citations might imply sleeping patents. From the retrieved datasets it is evident that zero citations are no indicator for a patent to be exploited or not. The data points out that 3 patents (4.3%) with no citations have not been commercialized, however, 11.6% (8 patents), which were not cited by others, were exploited. With regards to the patents where the inventors are still investigating possibilities to commercialize, 15.9% (11 patents) received no citations from other researchers. Almost half of the participating inventors' patents (34 patents) received no or at least one citation. Interestingly, it was further found that the average number of citations for commercialized patents (6.8 forward citations) is slightly lower compared to sleeping patents (7.3 forward citations). Patents where the inventors are still searching for the possibility for commercial use, on average these patents received 2.1 forward citations. In light of this above, there is no clear evidence of a connection between a low number of citations and unexploited patents.

Table 8 on the next page shows relevant aspects relating to the commercialization of university owned patents. When looking at the creative process which led to the inventors' invention, it was found that a bit over 40% (29 patents) of all inventions were an outcome of a targeted achievement of a research or development project (see table 9 in Appendix 4). Hereby, 8 patents (11.6%) were exploited by the inventors, while 17.4% were patents which have not been used. Whereas, 16% (11 patents each) were either an unexpected by-product of a research or development project or came from pure inspiration/creativity, and was then further developed in a (research or development) project. Inventions which were created through an unexpected by-product as well as pure inspiration were mostly successfully commercialized (8.7% each) and only a small percentage (4.3% and 2.9% respectively) are still left unused. Thus, it can be said that inventions which result from a project unexpectedly have a good chance of being successfully commercialized.

Out of the results it is also apparent that most patents filed by the three universities are subsidized by the Dutch government or the academic institution itself. More particularly, 26.1% were financed by Government Research Programmes, such as the Dutch Research Council (NWO), or other government funds with an almost equal share in terms of the commercialization rate. However, most sleeping patents (8.7%) and patents where inventors are investigating possibilities (10.1%) were inventions financed by the government. In contrast, most commercialized patents (13%) were supported financially through internal funds of the university, whereas only a small number of patents are sleeping which were internally funded.

The majority of the inventors (62.3%) further indicated that university laboratories were extremely important as a source of knowledge to create the patented invention, whereby 21 patents (30%) were successfully commercialized and 11 patents (15.9%) are still left unused. With regards to scientific literature, inventors mostly agree upon that this was an important source of knowledge. Nevertheless, 10 patents (14.9%) still remain unused, whereas more patents (22.4%) were commercialized. The only significant distinction that was found relates to patent literature. Most inventors, from patents which still remain unused (9%), did not use patent literature in order to create the novel invention, however, some inventors, from 10 commercialized patents (14.9%), were of the opinion that this particular source of knowledge is somewhat important. Other than that, no real difference between commercialized and sleeping patents were found in terms of the importance of the source of knowledge. Furthermore, most inventors also agreed upon that some knowledge sources such as non-university public laboratories, technical conferences and workshops, customers or product, and suppliers were not important at all as they did not use this source to create their invention. This relates to both commercialized and sleeping patents.

Another aspect found are the challenges related to the academic environment in terms of patent activity. First, the participating inventors highlighted that receiving enough funds (externally or internally) for the new invention constitutes the biggest challenge. For both commercialized and sleeping patents most inventors (29% and 24.6% respectively) indicated that the preservation of monetary resources was a big challenge. Second, the accumulation of academic knowledge rather than focusing on trying to meet market demands was perceived as the second biggest challenge. Hereby, 17 inventors (24.6%) who commercialized their patents, whereas only 7 inventors (10.1%) whose inventions remain unused, displayed that this constituted a challenge. Within this, half of the inventors of sleeping patents indicated that this was no challenge while creating a new invention. Third, keeping the balance of the university's main mission and the research itself was recognized as the slightest challenge. Therein, most inventors from sleeping patents (59.1%) were of the opinion that keeping the balance between the two, presents no challenge, whereas most inventors from successfully commercialized patents (46.7%) perceived it as a challenge. Furthermore, some other challenges were highlighted by the inventors such as finding appropriate industrial partners to further develop and/or commercialize the newly created invention, finding a good technology TTO as well as receiving enough funds to not only develop a new invention, as mentioned above, but also to maintain the patented invention further.

Table 9: Overview of the relations of different variables and the commercialization of patents (Own table)

		Commercialized patents	**Sleeping patents**	**Investigating possibilities to commercialize**
Creative process		targeted achievement of a research or development project	targeted achievement of a research or development project	targeted achievement of a research or development project
Funding		Internal funds of the university	Government Research Programmes	Government Research Programmes
Source of knowledge	Most important source of knowledge	University laboratories	University laboratories	University laboratories
	Least important source of knowledge	- Non-University public laboratories - Technical conferences and workshops - Customers or product - Suppliers	- Non-University public laboratories - Technical conferences and workshops - Customers or product - Suppliers	- Non-University public laboratories - Technical conferences and workshops - Customers or product - Suppliers
Challenges related to academic patenting	Balance between a university's main mission and the research itself	Challenge	No challenge	No challenge
	Accumulation of academic knowledge	Challenge	No challenge	Challenge
	Receiving enough funds	Big challenge	Big challenge	Big challenge

4.2.3 Relations of the dependent and independent variables

In this section, first observed relations between the DV and IVs are presented, which were analyzed in more detail, based on the IR categories, in section 5. Firstly, the correlations between a university's collaboration with at least one entity and the commercialization of patents was looked at. The survey revealed that if a formal collaboration was established with another institution, less patents (14.5%) were unused instead of being exploited (24.6%) (see table 10 on the next page). Meaning that inventions from inventors who collaborated with another entity are more likely to be commercialized. However, the findings also showed that in the case of no collaboration, with other universities or companies, also more patents (43.5%) are being commercialized. This indicates that universities which do not establish strategic alliances were also able to exploit their patents. When looking at the commercialized patents it can be seen that the more successful innovations are the ones which did not establish a collaboration. Furthermore, patents which have not been used commercially did not show a big difference regarding a collaboration with other institutions. Meaning that patents, which remain unused, have equally established or not established a collaboration with other institutions. Secondly, the same was found for UICs, since 58% of all patents have been commercialized, whereby the three universities did not collaborate with an institution of the private sector. However, it further indicated that, in terms of sleeping patents, more patents remained unused (26.1%) when also no university-industry collaboration was established, whereas, only 5.8% (4 patents) of the inventors established a UIC. Thirdly, new inventions that were based on previous technologies, were all successfully commercialized and no patents remained unused. However, when looking at radical inventions it can be seen that more patents (23.3%) were left unused compared to commercialized patents (13%). In some cases, inventors did not know whether his/her invention was built upon previous technologies or if they were unique in character. Nevertheless, a large proportion of these inventions were exploited (31.9%), whereas only a small number of patents (8.7%) remained sleeping. Lastly, the correlations of the importance of the economic use and the commercialization of patents is described. According to the findings, patents with an importance that was above the average were mainly successfully exploited (37.7%). Only 8.7% where the inventor perceived a high importance of the economic use of patents were left unused. In contrast, patents where the inventors perceived an importance below the average did not show a big differentiation (a deviation of 7.2%) between commercialized and sleeping patents.

Table 10: Overview of the four independent variables' descriptive statistics (Own table)

Independent variables		Commercialized or investigating possibilities	Sleeping patents
Collaboration with different institutions	Formal collaboration	17 (24.6%)	10 (14.5%)
	No formal collaboration	30 (43.5%)	12 (17.4%)
University-industry collaboration	Collaboration with industry	7 (10.1%)	4 (5.8%)
	No collaboration with industry	40 (58%)	18 (26.1%)
Uniqueness of a new technology	Build on previous technology	16 (23.2%)	0 (0%)

	Uniqueness of a new technology	9 (13%)	16 (23.3%)
	Inventor does not know	22 (31.9%)	6 (8.7%)
Importance of the economic use of patents	Above the average of the importance	26 (37.7%)	6 (8.7%)
	Below the average of the importance	21 (30.4%)	16 (23.2%)

5. Analysis

In this section, first the descriptive analysis (section 5.1) is described, whereby the descriptive statistics of the used variables as well as a correlation table are presented. This is followed by the empirical analysis (section 5.2), therein the hypotheses are confirmed or rejected.

5.1 Descriptive analysis

Table 11 below shows the descriptive statistics of the used variables as well as how each of them correlate with each other. It indicates that none of the variables significantly correlate with the underlying phenomenon. The first independent variable, *collaboration with different institutions*, correlates positively (r = 0.096) with sleeping patents, meaning that the number of sleeping patents increases if a collaboration with different institutions was established. However, *a university-industry collaboration* negatively correlates (r = - 0.004) with sleeping patents, implying that sleeping patents decrease if universities collaborate with the private sector to fulfill the field as well as organizational needs. The third variable, *the uniqueness of a new invention*, positively correlates (r = 0.381) with sleeping patents, indicating that the number of sleeping patents increases if the newly created invention is unique in character. Lastly, the variable, *importance of the economic use of patents*, positively correlates (r = 0.206) with sleeping patents. This results in an increase of sleeping patents when the value of a patent is higher.

Table 11: Descriptive statistics and correlation table (Own table)

Variables	Mean	SD	Min.	Max.	(1)	(2)	(3)	(4)	(5)
(1) Sleeping patent	0.3188	0.469	0	1	1				
(2) Collaboration with different institutions	0.3913	0.492	0	1	0.096	1			
(3) University-industry collaboration	0.1594	0.369	0	1	-0.004	0.543	1		
(4) Uniqueness of a new invention	1.174	0.785	0	2	0.381	0.012	-0.148	1	
(5) Importance of the economic use of patents	16.09	4.432	4	27	0.206	-0.137	-0.125	-0.021	1

N = 69

5.2 Empirical analysis

A further analysis, a binary logistic regression, was conducted in order to examine associations between potential characteristics of the underlined phenomenon and sleeping patents. Table 12 below represents the results of this analysis to test the four deduced hypotheses. Hereby, the coefficients and standard errors in-between brackets of each model are displayed. The table shows that two out of the four independent variables, namely *uniqueness of the new invention* and *the importance of the economic use of patents*, are statistically significant on a 5% level. For the remaining two independent variables no significance could be observed, thus they do not statistically affect sleeping patents. Models 1 to 4 are discussed separately in the subsequent subsections. Concerning Model 5, all IVs were included in one model to see if the four variables together have an effect on sleeping patents. However, no significance, for any of the four variables, was found which might be explained by the low number of observations or how the IVs correlate with each other.

Table 12: Overview of regression results (Own table)

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
(1) Collaborations with different institutions	0.185 (1.306)				3.299 (4.011)
(2) University-industry collaboration		- 0.758 (1.346)			- 1.708 (2.776)
(3) Uniqueness of the new invention			3.717** (1.689)		2.944 (1.807)
(4) Importance of the economic use of patents				- 0.754** (0.363)	- 0.432 (0.324)
(5) University	Yes	Yes	Yes	Yes	Yes
(6) IPCs	Yes	Yes	Yes	Yes	Yes
(7) Year of application	Yes	Yes	Yes	Yes	Yes

Note: The table displays logit models with its coefficients and standard errors in-between brackets
* p < 0.1, ** p < 0.05, *** p < 0.01
N= 69

5.2.1 Hypothesis 1

The coefficient that is given (in table 12 above) refers to an increase of a sleeping patent when the inventor/s formed a *collaboration with different institutions* compared to when no collaboration was formed. Accordingly, there is a 0.185 increase in sleeping patents when a collaboration with other entities was formed compared to when no collaboration was established. Meaning that the more successful innovations are the ones which did not establish a collaboration which is contrary to most literature streams (Anderson, 2008; Etzkowitz & Leyesdorff, 2000; Hájek & Stejskal, 2018). However, these results are not statistically significant, thus these results cannot be considered reliable. For this reason, the first hypothesis: "*There is a negative association between a university's collaboration and sleeping patents*" cannot be confirmed nor rejected. The only positive and significant, at a 10% level, results in this model indicated the control variable *University 2*, referring to GU and UMCG. What is more, in the results the response indicates whether a patent is sleeping and the categorical predictor indicates whether a formal collaboration was established or not. Since the odds ratio is more than 1, the odds that a patent is sleeping is 20% higher for inventors who set up a collaboration with different entities compared to when no collaboration was established. As such, collaborations with different institutions do not appear to align more in this study than if no collaboration was established. Hence, in order to fulfill the field as well as organizational needs, referring to the IR C1, *Demand for new technology*, this research suggests that collaborations with other entities are not necessarily needed. Therefore, further research should be undertaken in order to find out if the nonexistence of this relation between these two variables are caused by the used approach or sample or if the relation exists at all. Not discovering an association between these two variables could be explained by the low number of responses in the survey.

5.2.2 Hypothesis 2

The analysis showed a negative correlation between a *university-industry collaboration* and unused patents owned by a university. More particular, the coefficient of this variable indicated a decrease by 0.758 of sleeping patents, if universities collaborate with the private sector. The odds ratio of this variable showed that the probability that a patent owned by a university is sleeping is 53% lower if a university-industry collaboration exists in contrast to when no collaboration between these two actors was formed. However, the second hypothesis: *"There is a negative association between a university-industry collaboration and sleeping patents"* can neither be confirmed nor rejected based on this study, as no significance was found. This implies that a collaboration between academic institutions and the private sector does not particularly stimulate a successful exploitation of an invention which in turn meets the needs of the field and the university. Again, the control variable, *University 2* (GU and UMCG), is the only significant variable in this model, however, this time at a 5% level. Thus, it can be said that a collaboration, regardless with a specific sector or with any institution as shown in the previous subsection, has no effect on unused patents held by universities. Therefore, these findings suggest that a UIC is not necessary to identify the *demand for new technologies* (C1), which meet the needs of the field and the university, as it has no significant influence on whether a patent was successfully commercialized or still remained unused. As such, this finding can relate again to the low number of observations in this analysis.

5.2.3 Hypothesis 3

It was theoretically expected that inventions that do not imitate previous technologies are more likely to be exploited. Nevertheless, resulting from the survey sample, it demonstrated the opposite. In contrast to the previous hypotheses, table 12 above shows that the independent variable, *uniqueness of a new technology*, is statistically significant on a 5% level. The variable suggests that a one unit increase in this variable increases the number of sleeping patents by 3.717. This implies that patents which protect inventions, that are new to the university, are more likely to be sleeping than incremental patents. As these results are statistically significant the third hypothesis: "*There is a negative association between the uniqueness of a new invention and sleeping patents."* can be rejected. As such, in order to successfully commercialize an academic patent, the findings suggest that the newly created invention should build upon previous technologies. This correlation, between inventions that build upon prototypes or previously created technologies, aligns with the findings of the two studies of Thursby & Thursby (2001) and Packalen & Bhattacharya's (2015). These researchers also found that novel technologies are easier to turn into innovations if these are incremental in character. Thus, it suggests that universities should be able to have a *strategic focus* (C2) in order to assess the similarity of previous and new inventions to reduce the number of sleeping patents in their patent portfolio.

5.2.4 Hypothesis 4

For the last hypothesis, the results further showed that the importance of the economic use of patents influences sleeping patents. It was found that this variable also is statistically significant on a 5% level, and it suggests that sleeping patents decreases by 0.754 if the sum of the importance of different motives of a patent is perceived higher by the inventor than compared to a lower degree of importance. Since these results are also statistically significant, the fourth hypothesis: *"There is a negative association between the importance of the economic use of patents and sleeping patents"* can be confirmed. It becomes evident that inventions were inventors recognize a higher importance of the economic use of patents were more likely to be commercialized in comparison to a lower importance. What is more, the odds ratio implies that the probability that a patent is sleeping is 53% lower if the importance of the economic use is higher compared to a lower importance. Thus, implying that the more valuable a patent is the less likely it will remain unused as expected by the researcher. For these reasons, it is essential that *(E)valuation processes* should be *in place* (C4) in order to examine the value of universities' patents, in terms of different economic uses, in order to hold fewer sleeping patents.

6. Conclusion

The globally well-known phenomenon 'Valley of Death', deals with the invention - innovation gap, whereby newly created inventions are failing to be turned into marketable innovations. Many different institutions play an important role in the process of an invention in order to transform it into a successful invention. For example, universities are a substantial institution since the academic institutions help the expansion of novel inventions. This growth can be achieved through the skills the universities provide to their students which can lead to knowledge spillover as well as the creation of new ideas. Such ideas, however, should be protected to assure that no one can make use of the same idea. The patenting process, in universities especially, received more attention after the introduction of the Bayh-Dole Act in the US in the 1980s. This new law increased the patenting activities by academic institutions not only in the US, but also in Europe. However, this trend was not observed as fast as within the US. Nevertheless, even though patenting activities by universities in Europe are only slowly increasing, since the initiation of the Bayh-Dole Act, some countries show a higher rate of patent activities amongst others the Netherlands. For this reason, a case study of three Dutch universities, which are among one of the oldest as well as one of the biggest universities within this country, was conducted. The three chosen universities were the following (1) Utrecht University and UMCU, (2) Leiden University and LUMC, and (3) Groningen University and UMCG. However, patents also constitute a challenge as not all patent inventions are successfully commercialized or licensed to others, hence, remain unused which are referred to as sleeping patents. This phenomenon has been previously given attention to on a firm level, however, on a university level it is still underdeveloped. Thus, there is an urgency for further research on sleeping patents owned by universities to narrow down the invention – innovation gap. This research problem led to the following research questions:

Why are some university owned patents left unused while others are being commercialized?

Sub-questions:

- *To which degree do universities hold sleeping patents?*
- *What factors explain that university patents remain unused?*

The findings of this study shed light that a striking 30%, out of the 69 investigated patents, of the three universities' total patent portfolio are sleeping. At the moment, another 24.6% are not successfully commercialized yet, however, as the majority of these inventions were created in the last 5 years, the inventors are still investigating possibilities to exploit them. The reasons why universities hold that many unused patents can have various sources which were determined in this study. The results outlined that two out of the four analyzed potential characteristics were identified as direct influential features on sleeping patents in this study's dataset. The first statistically significant characteristic of unused patents is the *Strategic focus* (C2) of a university, which measures the skills of employees of an academic institution to create incremental inventions instead of inventions that do not build on previous technologies. It was shown that some university owned patents are left unused since these held patents by the university were too radical in character. This can be explained by the fact that radical inventions are mostly associated with a high-risk potential. The society is mostly not ready to adapt such inventions, resulting in a missing commercialization of these patents which most certainly has its roots in the lack of readiness for radical or drastic changes regarding the habits of consumers. For these reasons, as universities have an obligation to continuously research and to ensure societal progress, academic institutions have to create novel inventions which point out a high affinity to previously created technologies in order to reduce the number of held sleeping patents in a university's patent portfolio. The second statistically significant characteristic is the examination of a patent's value. In that case it was found that university owned patents are more likely to remain unused if a patent is of low value. Therefore, the study suggests that academic institutions should extensively undertake *(e)valuation processe*s (C4) in the planning phase, to increase the commercialization activities.

What is more, a further factor, even though not statistically significant, demonstrated that collaborations with different institutions, such as universities or the government, increases the likelihood of patents remaining unexploited. It can be presumed that a certain lack of efficiency infiltrates economic efforts concerning market orientation. In contrast, the study additionally showed a downwards trend with respect to academic institutions collaborating with the private sector. This, furthermore, intensifies the assumption of resources being utilized efficiently showing that an overall project management, provided by the industry, enhances the chances of success in terms of the commercialization as profitability is a major driver. Furthermore, the insignificance of these two types of collaborations can be explained by the low number of observations.

This research also shed light on two other essential findings in order to better understand the underlying phenomenon of sleeping patents. A difference was found in the origin of the funding of novel inventions. The findings highlighted that patents owned by universities, which have successfully been commercialized, were predominantly financed internally, whereas patents, which were financed by government programs, showed a tendency towards being left unused. One can assume that monetary resources within a university are scarce, therefore, future patent activities are being selected wisely which eventually lead to a positive outcome in terms of commercialization of newly created inventions. The second finding indicated that when the inventor perceived concentrating on the main mission of the university, which is the accumulation of knowledge and providing that knowledge to future generations, not challenging patents following these efforts tended to be left unused. Emphasizing that inventions solely being academic (radical) run the risk of patents ending up sleeping. Whereas when focusing on the main mission was seen as a challenge, the portion of exploited patents was significantly higher. One can speculate that market demands and economical curiosity are not congruent.

Concluding, as mentioned above, the findings suggest two crucial characteristics of the underlined phenomenon. Firstly, unused patents owned by universities seem to have a low value in terms of the importance of motivations to patent. It appears that universities patented any of their inventions regardless if they want to make use of them or not, since there is no legal obligation to exploit these patents in a given time. This is of importance for policy makers since an increase of such patents could lead to patent thicket that ultimately hampers further innovations. This in turn, can lead to potential economical shortcomings in the future that eventually influences the society as a whole. Secondly, sleeping patents appear to be unique in their character. Therefore, the inability of a university to assess these two features, in the planning process, will increase the probability to hold more unused inventions. Consequently, a great number of patents remain unused which do not reach the market and conclusively block others from developing similar ideas. For these reasons, it is advised that universities should have competent and skilled task forces within its departments which support inventors with targeting and facing the two aforementioned hindering aspects. Thereby providing a service reaching the maximum of each invention's (market) potential. It is also advised that the government should subsidize such task forces to facilitate the commercialization of patents inevitably resulting in inventions translating to immediate advantages to the general public. Considering all this, policy maker have to step in order to turn inventions into successful innovations, thereby narrowing down the invention – innovation gap.

7. Discussion

This study's goal was to identify why some university owned patents remain unexploited while others are successfully commercialized based on three Dutch universities. To answer this research question, some categories from the institutional readiness framework, conceptualized by Webster & Gardner (2009), were applied. In this section, first the theoretical, empirical, and methodological relevance (section 7.1) are discussed. Hereafter, section 7.2 presents the limitations of this study and section 7.3 suggestions for future research are described.

7.1 Contributions of the research

Concerning the theoretical contributions, this study has two significant additions. Firstly, the institutional readiness framework was originally established to review an institution's readiness to adopt and implement a specific technology. In this study, however, it was used to identify institutional, in particular universities', ruptures of the investigated phenomenon. Based on the selected theory, a new research approach was created, which provides new perspectives as well as aspects for the research state. Secondly, the theory provides insights on the commercialization of patents owned by universities. So far, the state of research only contributes aspects on the firm level, but not on the university level. Thus, this research provides first steps regarding the utility of patents filed by universities.

This study further contributed empirically by building a greater knowledge concerning the underlined phenomenon, sleeping patents, in an empirical setting. Insights of the non-use or use of patents is crucial for policy, since patents which remain unused have two drawbacks, namely (1) are more likely to be inadmissible by the society and (2) prevent other researchers from using this invention. Hence, being aware of the causes of sleeping patents might help to overcome this phenomenon by designing better policies which improves the commercialization of the inventions. With the help of this study, a relation between the three chosen IR categories (C1, C2, C4) and the underdeveloped phenomenon was created. In addition, as this study presents first steps to gain insights into this distinct topic, further studies can subsequently expand the research by adding or even combining other IR categories. In any case, it should be noted that the phenomenon of sleeping patents is complex, as it is underdeveloped at a scientific level and other categories of the institutional readiness framework could have an influence on the commercialization of patents owned by universities. Thus, it could be advantageous to focus on the influence of other or even combined IR categories that are relevant to this research topic and which eventually are statistically testable.

Finally, this quantitative study adds value by using a method for measuring sleeping patents in an empirical setting that is more objective and meaningful than previous theoretical approaches. Through this thesis, initial approaches as well as aspects on unused patents have been created, as this study aimed to understand why some university owned patents are left unused while others are successfully exploited. The analysis of the findings can be a benefit for future researchers who want to investigate this specific topic further, but are limited in time. In light of this above, not only could this research topic encourage more researchers, but also universities could benefit from these results.

7.2 Limitations

Firstly, it is important to keep in mind that the research was limited to three universities within the Netherlands, thus the external validity, generalization, cannot be assured. The selected universities do not refer to a representative selection in the Netherlands, and especially not in the whole world, hence a regional limitation is yielded. More specifically, this regional restriction can also be discussed, since this study refers to the three biggest and oldest universities instead of including other universities. These academic institutions were selected by the researcher by means of relevant aspects. For these reasons, the claim of representativeness is omitted.

Another limitation of this study is that only 7.5% of the contacted inventors participated in this study, whereby six inventors were not aware if their patent had been exploited or not. For this reason, these were excluded from the sake of this research, thus leading to only 69 adequate responses. It should be noted that due to the reduced number of responses that could be evaluated, the two variables which did not yield statistically meaningful results could be explained by this. Nevertheless, a regression analysis was carried out in this study to show potential influences of the four ruptures on the underlined phenomenon.

Thirdly, the distribution of the online survey is another limitation in this research. This is due to the fact that the researcher only used the google search tool to find the email addresses of the inventors. Hereby, it was sometimes difficult to find the accurate inventor as the researcher only knew the name of the inventors and in which university (or companies which collaborated with the universities) they were active. In fact, a couple of inventors contacted the researcher saying that they are not the right person to contact. This influenced the low number of responses as a lower number of inventors was contacted since the inaccurate person was contacted.

Lastly, it would be beneficial to refine the operationalization of the used independent variables in order to better evaluate and analyze the fundamental concepts. To analyze the independent variable (importance of the economic use of a patent), a Likert-scale was used which had to be rated by the inventors. Hereby, the inventors had to evaluate several items in which the importance of each economic use of the patent was assessed. The researcher then added up the rates of each inventor. However, in some cases not all items were evaluated by the inventors, thus this automatically led to a lower degree of importance, which in turn distorted the result between this variable and the underlying topic.

7.3 Future research

As noted, the relation as well as the measurement of the phenomenon of sleeping patents is complex, hence this provides room for further research steps and examinations of other influential variables. For this reason, the following directions are recommended for further research.

First of all, as this research only focused on three Dutch universities, some aspects might have been missed in order to better understand this phenomenon. The researcher suggests that further research should focus on a higher number of academic institutions within a country to gain insights on a national level. An even better understanding can be gained when looking at and comparing universities' patents from different countries. When considering a broader scope, the generalizability of the findings could be enhanced as well as a better understanding of sleeping patents owned by a university could be gained. This, in turn, could help design better policies, as already mentioned before, in order to intensify the commercialization of newly created inventions. Second, it would be worth knowing whether some categories of the institutional readiness framework would give more insights into this topic when clustering the IR categories as these are somehow linked and interwoven such as IR C1, *Demand for new technology*, and C3, *Relative need and benefit of new technology*. Further, since the researcher only used three out of the eight IR categories, future research should focus on the other categories which eventually attain statistically significant relations between them and unused patents. Third, in addition to the quantitative approach, a qualitative method approach could be advantageous to obtain insightful and in-depth results to better understand why some university patents remain unused while others are being commercialized. Conducting interviews would allow the researcher to clarify some misinterpretations as well as to ask follow-up questions. Hereby, it is important to interview approximately ten inventors in order to increase the representativeness of this study.

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Appendices

Appendix 1: Online survey

Hello, my name is Nina Czeczelits and I am a student at Utrecht University. For my master thesis I aim to find out to which degree universities hold sleeping patents and for what reasons this happens. Hence, you are invited, as an inventor of a patent assigned by the following 3 Universities (Utrecht, Leiden, Groningen), to participate in my survey. In this survey I will ask questions about the invention process, value as well as the commercialization of the patent. It will take approximately 5-10 minutes to complete the questionnaire.

Your participation in this study is completely voluntary. Further, your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have any questions at any time about the survey or the research, you may contact me by e-mail at n.czeczelits@students.uu.nl.

Thank you very much for your time and support. Please start with the survey by clicking on the button below.

1. By agreeing to participate in this study, you will be giving your consent for the researcher to include your responses in her data analysis. Your participation in this research study is strictly voluntary, and you may choose not to participate without any negative consequences. You will be able to withdraw from the survey at any time and all survey responses will be deleted, including the informed consent agreement.
    a. I consent
    b. I do not consent *(If "I do not consent", the whole survey was skipped)*
2. I have patented an invention which is currently owned by the following university (can check more than one box)
    a. Utrecht (UU, UMC or Utrecht Holding B.V.)
    b. Leiden (LU or LUMC)
    c. Groningen (UG or UMCG)
    d. Other, *please specify*
3. What is the highest degree you have completed?
    a. Bachelor's degree
    b. Master's degree
    c. Doctorate degree
    d. Other, *please specify*
4. Please specify, in which year you obtained your highest degree?
5. What is the exact title (in English) of the patent? (Please only indicate **ONE** patent) [Note: If you <u>own multiple patents</u> please choose the most recent one]

6. Was there a formal collaboration between you and another institution/ individual for the research leading to this patent? *(By formal the researcher means collaborations involving well defined contracts among the parties)*
    a. Yes (*If "yes", question 8 was asked*)
    b. No (*If "no", question 8 was skipped*)
7. Please identify the main partner involved
    a. Firms
    b. Universities
    c. Government research organizations
    d. Private research organizations
    e. Other, *please specify*
8. What was the importance of the following sources of knowledge for the research that led to the patented invention? *(0 I did not use this source of knowledge, 1 not at all important, 5 extremely important)*
    a. University laboratories
    b. Non-University public laboratories
    c. Technical conferences and workshops
    d. Scientific literature
    e. Patent literature
    f. Customers or product users
    g. Suppliers
    h. Competitors
    i. Other relevant sources (*please specify*)
9. Which of the following scenarios best describes the creative process that led to your invention?
    a. The invention was the targeted achievement of a research or development project
    b. The invention was an **expected** by-product of a research or development project, not directly related to the main target of the project
    c. The invention was an **unexpected** by-product of a research or development project, not directly related to the main target of the project
    d. The idea for the invention was directly related to your normal job (which is not inventing), and was then further developed in a (research or development) project
    e. The idea for the invention came from pure inspiration/creativity or from your normal job (which is not inventing), and was not further developed in a (research or development) project (was patented without further research or development costs)
    f. Other, *please specify*
10. Which of the following would best describe the financing of the research leading to this patent? (*can check more than one box below*)
    a. Internal funds of the university
    b. Funds from any other unaffiliated organization joining the project

c. Funds from financial intermediaries of any kind (banks, other financial institutions, etc.)
d. Government Research Programmes or other government funds
e. Other, *please, specify*

11. What do you think are the main challenges related to the academic environment in terms of patent activity? *(1 no challenge, 3 big challenge)*
    a. To keep the balance of the university's main mission and the research itself
    b. Accumulation of academic knowledge rather than focusing on trying to meet market demands
    c. To receive enough funds (externally or internally) for the new invention
    d. Other, *please specify*
12. How important were the following reasons for patenting this invention? *(1 not at all important, 5 extremely important)*
    a. Commercial exploitation *(obtain exclusive rights to exploit the invention economically)*
    b. Licensing *(obtain exclusive rights to license the invention in order to generate licensing revenues)*
    c. Cross-licensing *(improve your bargaining position in the trading of your own patent rights in exchange for other firms' patent rights)*
    d. Prevention from imitation *(protect present or future inventions by patenting the "findings around")*
    e. Blocking patents *(avoid that others patent similar inventions)*
    f. Reputation *(patents as an element of evaluation of the inventors/research unit)*
    g. Other, *please specify*
13. Has the applicant/owner ever used this patent for <u>commercial or industrial purposes</u>?
    a. Yes
    b. No (*If "no", question 14 & 15 was asked*)
    c. Not yet, but still investigating the possibilities (*If "not yet", question 14 & 15 was asked*)
    d. I do not know (*If "I do not know", question 14 & 15 was asked*)
14. Has this patent been <u>licensed</u> by (one of) the patent-holder(s) to an independent party?
    a. Yes
    b. No
    c. No, but willing to license
15. Has this patent been <u>exploited commercially</u> by yourself or any of your co-inventors by starting a new company?
    a. Yes
    b. No
    c. I do not know
16. Has the patent been used for <u>subsequent innovations</u>?
    a. Yes, *please specify*

b. No
c. Not yet, but still investigating the possibilities

17. Did the invention build, in a substantial way, on other products you were aware of?
    a. Yes
    b. No
    c. I do not know
18. On the basis of your knowledge, if patent protection could not be obtained, would the invention in question have been developed anyway?
    a. Yes
    b. No
    c. I do not know
19. Why was it decided to patent the invention as it was, as opposed to developing it further by devoting additional resources? (*can check more than one box below*)
    a. The invention is good enough as it is
    b. The aims initially targeted for this invention were satisfied
    c. Further improvements could have been achieved, but estimated costs were beyond the resources (budget) available
    d. Further improvements seemed beyond existing technological opportunities
    e. Further improvements (could have) resulted in another invention that could be patented separately
    f. The invention had to be patented quickly, because you were aware of other inventors, research groups or firms that were working on inventions in the same field
    g. Other*, please specify*
20. Has this patent been exploited commercially by yourself or any of your co-inventors by starting a new company? *(This question was only shown when "No", "Not yet, but still investigating the possibilities" or "I do not know" in question 13 was selected)*
    a. Yes
    b. No, *please specify*
    c. I do not know
21. Please indicate in which patent office the invention has been patented. (*can check more than one box below*)
    a. EPO
    b. NPO
    c. USPTO
    d. JPO
    e. Other, *please specify*

Appendix 2: IPC subcategories (survey sample)

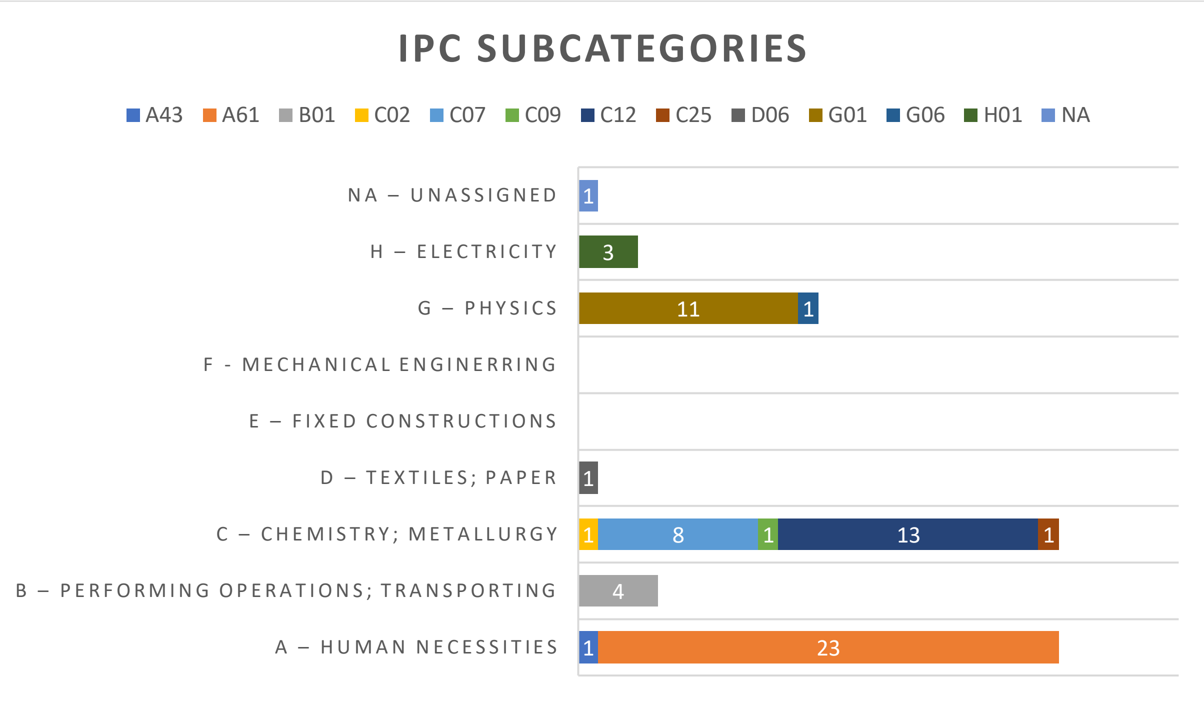

Figure 4: Overview of IPC subcategories of the survey sample (Own figure)

A – Human necessities	A43	Footwear
	A61	Medical or veterinary science; Hygiene
B – Performing operations; Transporting	B01	Physical or chemical processes or apparatus in general
C – Chemistry; Metallurgy	C02	Treatment of water, waste water, sewage, or sludge
	C07	Organic chemistry
	C09	Dyes; Paints; Polishes; Natural resins; Adhesives; Compositions not otherwise provided for; Applications of materials not otherwise provided for
	C12	Biochemistry; Beer; Spirits; Wine; Vinegar; Microbiology; Enzymology; Mutation or genetic engineering
	C25	Electrolytic or electrophoretic processes; Apparatus therefor
D – Textiles; Paper	D06	Treatment of textiles or the like; Laundering; Flexible materials not otherwise provided for
G - Physics	G01	Measuring; Testing
	G06	Computing; Calculating or counting
H - Electricity	H01	Basic electric elements

Appendix 3: Comparison of the IPC subcategories

Full dataset   Survey sample

Table 7: Comparison of the IPC subcategories of the full dataset and survey sample (Own table)

		Total number of subcategories	Utrecht Holdings B.V.	LU and LUMC	GU and UMCG	Share of the subcategories (n = 1,029)	Total number of subcategories	Utrecht Holdings B.V.	LU and LUMC	GU and UMCG	Share of the subcategories (n = 69)
A – Human necessities	A01	10		8	2	1,0%	0				0%
	A21	1			1	0,1%	0				0%
	A23	6			6	0,6%	0				0%
	A43	1			1	0,1%	1			1	1,4%
	A61	341	104	139	101	33,1%	23	7	11	5	33,3%
B - Performing operations; Transporting	B01	32	10	14	8	3,1%	3	2	1		4,3%
	B02	1			1	0,1%	0				0%
	B05	1		1		0,1%	0				0%
	B09	1		1		0,1%	0				0%
	B22	1			1	0,1%	0				0%
	B25	1		1		0,1%	0				0%
	B29	3	1		2	0,3%	0				0%
	B65	1			1	0,1%	0				0%
	B82	2		1	1	0,2%	0				0%
C - Chemistry; Metallurgy	C01	7	5	2		0,7%	0				0%
	C02	3	2		1	0,3%	1	1			1,4%
	C03	1		1		0,1%	0				0%

	C04	1	1			0,1%	0				0%
	C07	180	51	93	38	17,5%	8	6	1	1	11,6%
	C08	28	6	3	19	2,7%	0				0%
	C09	9	2	2	5	0,9%	1		1		1,4%
	C10	2		1	1	0,2%	0				0%
	C12	203	34	112	57	19,7%	13	3	7	3	18,8%
	C23	8	5	2	2	0,8%	0				0%
	C25	5		5		0,5%	1		1		1,4%
D - Textiles; Paper	D06	2			2	0,2%	1			1	1,4%
E – Fixed Constructions		0				0,0%	0				0%
F – Mechanical Engineering; Lighting; Heating; Weapons; Blasting	F03	4			4	0,4%	0				0%
	F15	1		1		0,1%	0				0%
G - Physics	G01	118	29	65	25	11,5%	12	3	5	4	17,4%
	G02	4	1	3		0,4%	0				0%
	G03	4	2		2	0,4%	0				0%
	G05	2		1	1	0,2%	0				0%
	G06	11	2	7	3	1,1%	1		1		1,4%
	G10	1		1		0,1%	0				0%
	G11	4		1	3	0,4%	0				0%
	G16	1			1	0,1%	0				0%
H - Electricity	H01	17	5	4	8	1,7%	3	1		2	4,3%
	H03	3		3		0,3%	0				0%
	H04	1			1	0,1%	0				0%

NA	NA	7	2	4	1	0,7%	1			1	1,4%

Appendix 4: Creative process of the patented invention

Table 9: Overview of the creative process of the patented invention (Own table)

		Commercialized	Sleeping patents	Investigating possibilities
Creative process	targeted achievement of a research or development project	8 (11.6%)	12 (17.4%)	9 (13%)
	expected by-product of a research or development project	4 (5.8%)	3 (4.3%)	1 (1.4%)
	unexpected by-product of a research or development project	6 (8.7%)	3 (4.3%)	2 (2.9%)
	was directly related to your normal job, and was then further developed in a (research or development) project	4 (5.8%)	2 (2.9%)	1 (1.4%)
	came from pure inspiration/creativity or from your normal job, and was then further developed in a (research or development) project	6 (8.7%)	2 (2.9%)	3 (4.3%)
	Other	2 (2.9%)	0 (0%)	1 (1.4%)