The Far from Perfect Markets for Patents

A Quantitative Study on Patent Quality

Master's Thesis in the Master's Programme
Entrepreneurship and Business Design

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SUMMARY: This thesis sets out to evaluate the ability of marketplaces for intellectual property (IP) to attract high-quality patents. Through a conducted literature review of theories on markets in general and markets for technology, in particular, the importance of high-quality goods for a functioning market is established. IP marketplaces are important intermediaries in the facilitation of an efficient market for intangible assets, in this case, patents. One of their primary function in this complex market structure is to minimize the search cost for participating actors. By establishing a theoretical foundation of patent value indicators, a method based on composite indexing is used, to evaluate the quality of patents listed on four different IP marketplaces. The study finds that the marketplaces under study struggle to attract patents of high quality and their current potential to minimize search cost and counteract the emergence of a market for lemons is limited.

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Keywords: Patent, IP, Quality, Marketplace, Patent Value Indicators, Search cost.

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1 Introduction

1.1 Background

In the knowledge-intensive economy of the 21st century, intellectual property is no longer a complimentary resource to tangible resources of the firm. Instead, it is many times the primary asset. In 2018, 84% of the assets on the balance sheets of the world's five largest companies by market cap were intangible assets (AON, 2019). This pattern is not only present among the largest companies in the world. Start-ups and SMEs of the knowledge economy generate value from an intellectual resource base. Many businesses of today are entirely built upon intellectual assets, packaged in a brand, delivered through digital means with knowledge in some form as the backbone of the operations and the competitive advantage. With the increasing importance of intellectual assets, it seems logical that an efficient market and an increase in trade of such assets would follow. The aggregated value of transactions for intellectual assets is growing, but it is still comparably small. The market size is hard to estimate due to the bilateral nature and secrecy around the transactions. The 2018 transacted market was estimated to be $353 million (Richardson et al., 2019) with the majority of transactions being bilaterally brokered deals.

Structured markets for intellectual assets are still relatively uncommon. Instead, the majority of the transactions of intellectual assets are best described as a form of bilateral monopolies. In bilateral monopolies, buyers and sellers engage in negotiation and trade without exposure to any alternative exchange opportunities outside their relationship (Gans and Stern, 2010). These transactions are facilitated exclusively between two actors, and negotiations are held in private and not seldom include large patent portfolios rather than individual assets (Hagiu & Yoffie, 2013). Many authors such as Hagiu and Yoffie (2013), de Rassenfosse (2010), Solomon and Marcowitz-Bitton (2014), Murphy, W. et al., (2012) and Oecd.org. (2020) have noted the illiquidity of intellectual assets and particularly patents.

In an era where most assets are intangible, a functional secondhand market for IP can be expected to be crucial for the firm's ability to, for example, raise sufficient funds through the use of IP as collateral or monetize existing resource base in alternative ways (Bressel and King, 2013). New ways of IP-based financing will enable IP-intensive firms to develop and innovate when traditional alternatives based on tangible resources, are not an option. The illiquidity in IP transactions results in a failure to fully utilize existing resources and risks creating harm both for the individual firm and also to the speed of societal development and innovation. On a general note, a functional market for IP is essential for future economic development; thus, the failure of IP marketplaces is an important matter to study and investigate further.

The literature on markets for technology and IP is vast, and the arguments for why efficient markets for IP are hard to establish are numerous. Firstly, patents are, to a large extent, dependent on complementary technologies, resources and knowledge for their exploitation and value extraction (Gans and Stern, 2010). Parchomovsky and Wagner (2005) take the discussion of portfolio effects and complementarities one step further and argue that the actual value of patents is not in "their individual worth but in their aggregation into a collection of related patents". Furthermore, patents lack comparables which make valuations based on similar transactions complicated (Hagiu and Yoffie, 2013.) As a result, valuations are often subjective and agreements hard to reach, hence limiting the liquidity.

Dushnitsky and Klueter (2011) established three key factors of importance for the establishment of markets for intellectual assets, *search cost*, *asymmetric information,* and the *expropriation problem*. Dushnitsky and Klueter (2011) further argue that marketplaces for assets have a complementary role in the transaction, primarily creating value through a decreased search cost. In striving to decrease the search cost, the quality of the transacted patents is an important consideration. The clutter significant for online marketplaces in general with thousands of goods available for a transaction is in the context of patent marketplaces problematic. A high ratio of low-quality patents risks making it increasingly hard to identify the quality assets hence increasing the search cost, and worst-case disincentivizing parties from participating in the market (Hagiu and Yoffie, 2013).

Given the potential problems caused by a high ratio of low-quality patents discussed by previous literature, a clutter of low-quality patents on marketplaces for patents could serve as part of the explanations to the illiquid patent market. Investigating the quality of patent listings on current marketplaces is hence essential in order to assess the marketplaces ability to reduce the search cost associated with patent transactions. To the author's knowledge, no such study has previously been conducted. With this study, the authors aim to contribute to academia by providing insights into the marketplaces ability to attract high-quality patents suitable for a transaction and remedy the liquidity problem.

1.2 Problem Statement

For intermediaries in a market, the main objective for value creation is to eliminate obstacles and therethrough contribute to an efficient market. On markets for IP in general and patents in particular, search cost is one of the most notable challenges. Search cost increases when low-quality patents create noise in the search process for potential buyers of patents. It is hence the role of the marketplaces to act as a primary filter to increase the ratio of high-quality patents available for a transaction.

1.3 Purpose

The purpose of the study is to investigate four marketplaces' ability to attract high-quality patents. The objective is to use patent value indicators found in the patent documents to evaluate the quality of the patents listed on the marketplaces as compared to the full patent population. Providing insight into the marketplaces ability to reduce the search cost and improve the prerequisites for multilateral trade, the authors aim to take one step closer to a functional market for intellectual property.

1.3.1 Research Questions

- Do IP marketplaces attract high-quality patents and thereby create prerequisites to remedy the liquidity problem?
  - In what technology areas are IP marketplaces attracting patents?
  - Do the marketplaces attract patents of relatively high quality?
  - Does the quality of patents vary between marketplaces?

1.4 Delimitations

In the scope of this study alive and granted patents will be the only IPR of investigation. The decision to include only granted patents in the study connects to the chosen method and the purpose of the study. A grant decision in itself is a validation of the patent’s quality. The grant decision assures the legal validity of the patents and makes them more suitable for transactions as they are easier to enforce legally. Furthermore, the often, low age of patent applications naturally affects the patent value indicators and would risk generating a skewed result.

The study will focus on the four marketplaces, IP-Marketplace, ExlporeIP: Canada's IP marketplace, IAM Market, and Ocean Tomo Bid-Ask. In the process of deciding which marketplaces to include in the study, the authors studied all current initiatives by strategically searching the internet. The decision to focus on four marketplaces was based on the number of listing on the marketplaces and feasibility in extracting the data required for the study to make it achievable within the set timeframe of the study.

The study only includes and evaluates the quality of patents families with at least one family member filed with the EPO or USPTO. This delimitation is based solely on the availability of accurate patent data in the patent database of the author's disposal. The vast majority of the patents on the marketplaces claim protection with the EPO or USPTO; hence this delimitation is not expected to have any significant effect on the result.

The study is conducted on data from patents with priority between 2000-2015. The lifetime of a patent usually is 20 years from the filing date, hence patents with a priority earlier than 2000 can be expected to be of little interest for a buyer. The decision to exclude patents filed from 2016 and onwards is a result of the conducted method. Patent value indicators are age-dependent, newly published patents can hence be expected to record a lower number on the observed value indicator. Thus, they are excluded to avoid any biases resulting from age.

2 Theory

Under the course of this study, the authors aim to shed some light on the ever-growing market for technology (MfTs) in general and the market for patented technology in particular. This section will provide insights into the purpose that markets serve and how they should be designed. The authors bring forward general insights from the efficient market theory and the Markets for Technology (MfT) literature and project these insights on the specific market of interest, namely the market for patented inventions. Existing literature defines the transacted good under study in different ways. Some are satisfied with conceptualizing goods with inclusive definitions such as ideas, information, or knowledge, while others focus on intellectual assets and intellectual property. All aforementioned is arguably interesting for this study because patents are ideas, information and knowledge, packaged as intellectual property. Hence, no sharp distinction is necessary between the different conceptualizations, but differences will be highlighted in this section. The last section of the theory section bridges the phenomenon under study to the conducted method providing insights into the literature on patent value indicators.

2.1 Market Characteristics

The characteristics of marketplaces for intellectual assets vary in many ways. Marketplaces differ in everything from the types of assets that can be listed to the actors allowed to participate in the transactions. Dushnitsky and Klueter (2017) found that MfTs have a particularly important role in the first step of a transaction by facilitating matchmaking and decreasing the search cost, while the later stages of a transaction can still happen offline. These observations are coherent with the structure of the marketplaces under study which all primarily facilitate matchmaking by allowing knowledge owners to list their patents for sale and knowledge seekers to browse the listings and approach the knowledge owners. The transaction is for all marketplaces except Ocean Tomo managed by the transacting parties outside of the marketplace. Using the vocabulary of Dushnitsky & Klueter (2017) the marketplaces under study have a complementary role in MfT transactions facilitating the search for patents primarily.

In order to better understand the phenomena under study, a framework to deconstruct MfT proposed by Natalicchio et al. (2014) will be used. The framework deconstructs MfTs into three main pillars; ideas, knowledge owners, and knowledge seekers.

Ideas

In theory, a technology listed on an MfT could be anything from an early-stage idea to a product ready for market. The search cost and risk associated with the investments naturally vary with the asset being transacted (A. Natalicchio et al. 2014). The assets in scope for this study are patents. Transacting patents can be expected to be of a lower risk and search cost than raw ideas but riskier than the transaction of technology ready for the market.

Knowledge owners

A knowledge owner could be anyone with an idea to sell that would benefit from the intermediary services of a marketplace. Knowledge owners thus range from individual inventors to large companies and governmental organizations. The interest and so also the barriers of participation differ between knowledge owners. General barriers of participation observed in academia include passiveness of the marketplace, adverse selection, knowledge expropriation, and the "not-sold-here" syndrome (A. Natalicchio et al. 2014). Knowledge owners are primarily motivated by extrinsic motivators (Boudreau and Lakhani, 2009) participating in marketplaces to monetize their assets or to create a reputation within the field.

Knowledge seekers

The most active knowledge seekers in the market for technology are firms and venture capitalists (Nambisan and Sawhney, 2007). However, as for knowledge owners, the knowledge seeker could in practice be anyone benefiting from the service provided by the market intermediary. Arora and Gambardella (2010) observed three main barriers of participation for knowledge seekers, the not-invented-here syndrome, the absorptive capacity of the organization, and the role of the organization's internal R&D. Another barrier of participation is adverse selection, as discussed by Dushnitsky and Klueter (2011).

The main objectives for knowledge seekers to participate in the market for technology as observed by Terwiesch and Xu (2008) are increased access to knowledge owners and increased competition among the knowledge owners, the opportunity to cost-efficiently browse a wide selection of ideas and paying only for the ones of interest, and a decreased search cost.

2.2 Efficient Market Theory

In its essence, markets facilitate the trade of goods and services, allowing for reallocation of assets. In a functional market, the reallocation of assets leads to increased exploitation efficiency by re-positioning resources where maximum utilization can take place. Market participants can consider multiple trading opportunities with full access to knowledge about potential alternative transactions, deriving higher efficiency than bilateral exchange mechanisms can offer (Gans and Stern, 2010).

The sole existence of a marketplace does not in itself create better opportunities for trade. Market failures is a well-researched topic with the arguably most prominent contribution of Akerlof (1970) and his market for lemons. In the context of marketplaces for patents, previous literature discusses low-quality patents and the presence of malfeasant individuals as critical issues that have limited the traction of current and previous initiatives within the field. The broad inclusion enabled by online marketplaces risks attracting not only high-quality patents but also opportunistic knowledge owners looking to monetize patents of low quality (Hagiu and Yoffie 2013, Dushnitsky and Klueter, 2011, Chesbrough and Smith 2000). The clutter created by a large portion of low-quality patents risks to disincentive both knowledge seekers and knowledge owners from participating in the transaction (Hagiu and Yoffie 2013). A clutter of low-quality makes it increasingly difficult for market participants to distinguish between a patent of high and low quality inevitably increasing the search cost. Ensuring the quality of patents and thereby, the credibility of the marketplace is crucial for the long-term success of a marketplace (Chesbrough and Smith 2000).

Roth (2008) presents a framework of three structural components crucial for the efficiency of a market. The three structural components are market thickness, congestion and, market safety.

Market Thickness

Markets need to be of a certain *thickness*, meaning that a marketplace needs to be attractive to a certain number of participants that are ready to take part in transactions. Intuitively one might think that the thicker the market is, the more options there are for both buyers and sellers leading to greater freedom of choice. From a seller's point of view, an overpopulated and too thick market reduces the chances of selling; hence, a market needs balance. Returning to the arguments of Hagiu and Yoffie (2013) and other market thickness is not only a matter of the number of participants, but the quality of the goods and participants is equally important. Extrinsic motivators are useful to create market thickness, but there is a risk that extrinsic motivators attract opportunistic knowledge owners seeking to earn monetary rent on low-quality assets. This phenomenon is observed by Frey et al. (2011) that found a positive relation between extrinsic motivators and listings of non-substantial or low-quality assets. The paradox hence lies in the goal for stakeholders in a market to create market thickness by attracting a certain number of participants, through means that are sustainable and do not compromise the quality of goods.

Congestion

Roth's (2008) second structural component is *congestion*. In theory, if the thickness gets too high, matching between sellers and buyers will either be easy, and transactions will take place at a very rapid pace, or there will be too many alternatives resulting in a constant loop of evaluation of different options. Dealing with congestion is primarily an issue of constructing the process, leading up to a transaction satisfactorily. The quality of the transacted goods naturally affects congestion. The difficulty in distinguishing between high and low-quality goods is central for the market for lemons theory (Akerlof. 1970) as it affects the buying parties' ability to evaluate the opportunities at hand and hence the pace of transactions.

Market Safety
Roth's (2008) third and last variable for a functioning market is *market safety*. A market can be considered unsafe following many different circumstances and behaviours. Online marketplaces are particularly exposed to become unsafe markets because they are "attractive setting for malfeasant individuals" (Dushnitsky and Klueter, 2011). Failing to create market safety can result in a harmful and counterproductive environment for transactions with market failures such as adverse selection or even fraud. Quality is naturally an essential aspect of market safety, without trust in the quality of the transacted goods very few or no transactions can be anticipated.

2.3 Marketplaces for Knowledge Assets

To use Roth's own words, he is only "scratching the surface" of a well-studied area, and the guidelines that he highlights are arguably relatively generic (Roth, 2008). For contextualization, the focus from here on will be on the specific phenomena under study, namely MfTs and the assets that are traded on these markets. The literature on MfT explores how intangible assets differentiate from traditional goods and services and what implication that has for the establishment of markets (Gans and Stern, 2010). In this study, we focus on patents, but the MfT literature encompasses intangible goods in any form. Many of the findings in the literature are directly applicable to patents, and some findings need to be nuanced since patents, in their nature, are differentiated from raw knowledge or ideas concerning control, ownership, packaging and regulatory frameworks.

Gans and Stern (2010) use market design literature (mainly Roth, 2008) and insights from the literature on MfT to analyze how innovation and intangible goods differ from traditional goods and the implications of the differences in trade and transactions. It is worth mentioning that their analysis focuses on market design for abstract and pure ideas, but the findings do bring valuable insights to our study of markets for patents. Gans and Stern (2010) focus on three characteristics of ideas that need to be considered for the feasibility and construction of an efficient market, namely, *idea complementarity, value rivalry, and user reproducibility*.
In another study, Dushnitsky and Klueter (2011) studied 30 online marketplaces for intellectual assets to investigate how they are constructed to overcome obstacles in the establishment of a market for intellectual assets. In their literature study, the authors identify three key factors of importance for the establishment of markets for intellectual assets, *search cost*, *asymmetric information*, and the *expropriation problem*.

Idea Complementarity & Search Cost
The value of ideas is often wholly or partly dependent on other ideas that need to be used in combination for value extraction. Gans and Stern (2010) refer to this challenge as ideas complementarity and state that the ability to trade one idea might depend heavily on the ability to trade a complementary idea. On a similar note, Hagiu

& Yoffie (2013) highlight that patents are subject to complementarities and portfolio effects and hence pose challenges for a market establishment. Hagiu and Yoffie (2013) furthermore highlight that even though patent offices around the world provide comprehensive and searchable databases, the results that can be obtained are hard to grasp because the language used in patent applications is often vague and difficult to interpret. The idea complementarity and the hard to grasp patent data makes it challenging to identify a suitable patent to transact; hence the search cost associated with a patent transaction is high. Decreasing the search cost hence ought to be one of the main objectives for a marketplace for patents (Dushnitsky and Klueter, 2011). Decreasing the search cost the quality of the patents or ideas listed is essential as the additional clutter of low-quality patents risk to increase the already high search cost (Hagiu and Yoffie, 2013). Knowledge seekers prefer a few high-value innovations over multiple average innovations (Terwiesch and Ulrich, 2009).

A market with diverse participation from multiple fields will naturally increase the market thickness but consequently also make it harder for the knowledge seekers to identify the assets of value for them. A closed market with participants only from selected industries or technical fields, on the other hand, allows for a reduction in search cost but consequently risks decreasing the market thickness (A. Natalicchio et al. 2014). The desired distribution of technologies on the market, therefore, depends on the participants in the market. Boudreau et al. (2011) found that when the knowledge seeker faces a high degree of uncertainty, a broader pool of technologies is desired. Naturally, the opposite is true for an actor looking for a technology or patent within a specific technology area.

User Reproducibility, Value expropriation & Value rivalry

The value of an idea is in many cases declining with an increase in the number of actors that have access to that very idea and hence can use it for value extraction. In the absence of intellectual property rights, user reproducibility becomes an issue as other actors might compete in expropriating the same idea. This creates a problematic situation, if the idea cannot be disclosed exclusively, transactions might not take place, and if the idea is disclosed non-exclusive, the value will be undermined (Gans and Stern, 2010). In theory, intellectual property has the potential to mitigate the problems by giving the knowledge owner an exclusive right to the asset. By ensuring exclusive rights to the assets the market safety is increased, and the prerequisites for multilateral transactions improved (Dushnitsky & Klueter, 2011). In reality, however, enforcing IPRs is costly, and it might be in the interest of the participants to keep the information confidential. Even though the market safety enjoyed by IPRs is not perfect, the literature is seemingly unanimous in that it creates better circumstances for multilateral trade (Dushnitsky and Klueter, 2011, Gans and Stern, 2010).

Adverse selection

Adverse selection and information asymmetry are problems in markets for intellectual assets (Dushnitsky and Klueter, 2011). This means that the inventor or owner of an invention, idea, or knowledge, naturally has more information and a better understanding of the asset and its potential. Hence, the owner is in a better position to make an accurate evaluation of the quality and monetary value of the asset. Information asymmetry, complementarity, and the fact that patents lack accurate comparable makes valuation highly subjective, which leads to difficulties in finding mutual ground for a potential transaction (Hagiu & Yoffie, 2013). The asymmetric information problem rises with the ratio of low-quality patents, and as exemplified by Akerlof (1970), it might even result in a market for lemons.

To summarize the literature, knowledge owners are expected to participate in the marketplace mainly driven by extrinsic motivators. Knowledge seekers, on the other hand, are expected to turn to marketplaces for patents primarily to decrease the search cost associated with patent transactions. The marketplaces hence hold a complementary role in the transaction process, facilitating the search process primarily. Given the effect of patent protection on value expropriation, user reproducibility, and value rivalry, the primary consideration when constructing a marketplace should arguably be search cost, adverse selection and idea complementarity. To address the aforementioned issues, marketplaces need to attract patents of equal or higher quality than the general patent population to function effectively and make a valuable contribution to the market. If marketplaces attract patents of below-average quality, the search cost is increased, and the value contribution minimal.

2.4 The Patent Landscape

In order to evaluate the type of patents attracted by the marketplaces, an understanding of the technology distribution in the underlying patent population is necessary. The technology distribution of the full patent population has been more or less static under the years in scope for this study. ”Electrical Engineering”, constitutes the largest technology area with a percentage share of all publications ranging between 30-32%. “Mechanical engineering” and ”Instruments” are other technology areas with a substantial share of the patent population ranging from 21-22% and 14-15% respectively. For detailed patent distribution by technology area, see Figures 1, 2 and 3 below and Appendix 1.

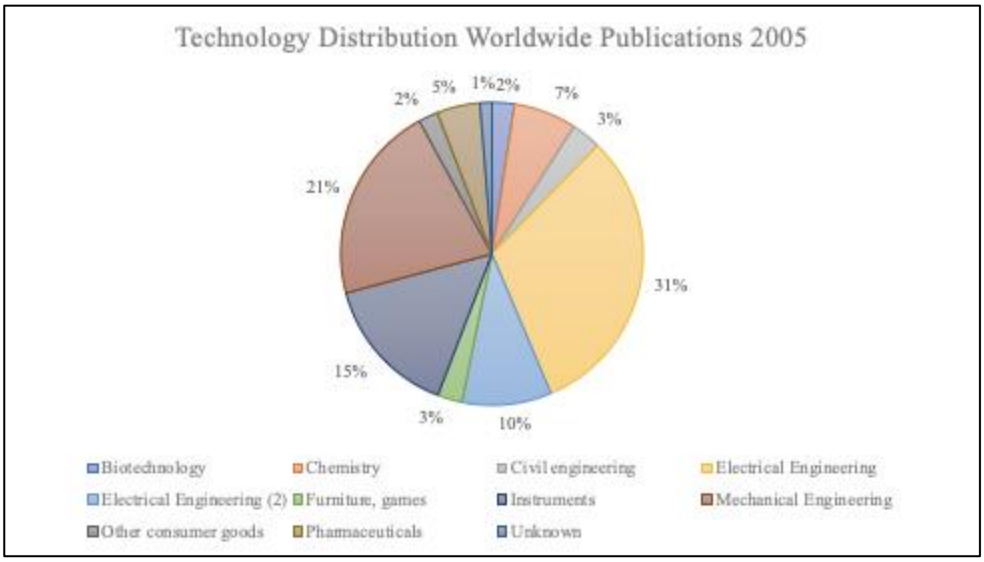

Figure 1. Technology Distribution Worldwide Patent publications 2005 (WIPO, 2017)

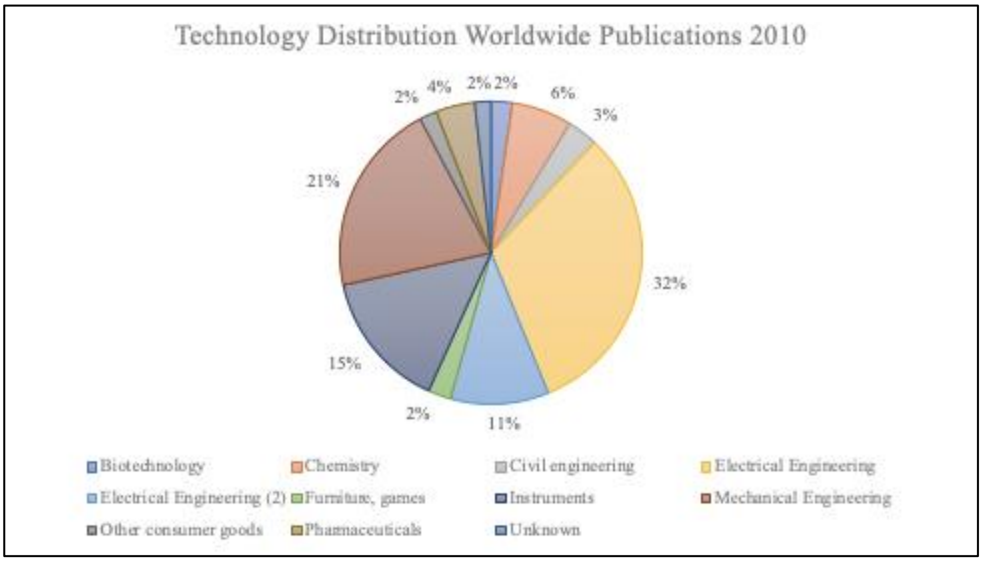

Figure 2. Technology Distribution Worldwide Patent publications 2010 (WIPO, 2017)

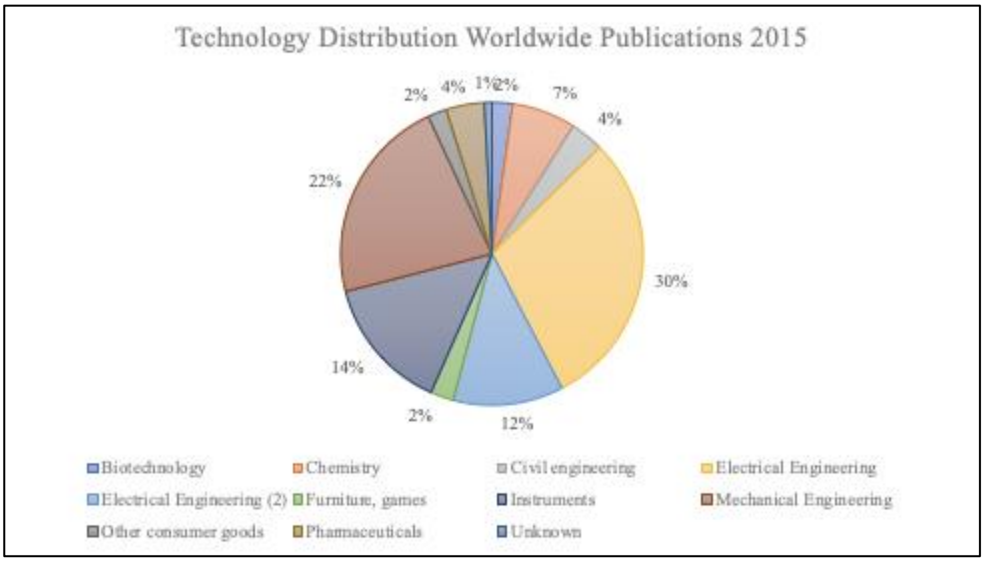

Figure 3. Technology Distribution Worldwide Patent publications 2015 (WIPO, 2017)

2.5 Patent Value Indicators

2.5.1 Patent Value

The main objective for the majority of organizations that take part in patenting activities (ground-up creation through innovation or acquisition) is to generate net economic benefit. A patent valuation process hence becomes a question of judging the ability of a patent to support that process. Murphy et al. (2012) state that "...a patent valuation analysis is an attempt to measure the net economic benefit that comes from a firm's patent-related decisions". With that being said, a patent can create value for the right holder in a variety of ways either by generating direct or indirect economic benefits. Economic benefits can be generated in multiple ways, e.g. licensing revenues, pricing premiums, or market penetration as a result of competitive exclusion, relative cost savings due to a patented manufacturing process. A high-quality patent is hence a patent with the ability to yield the holder high economic returns.

Following the wide variety of ways that a patent can generate economic benefit is an almost infinite variety of possible ways to value patents. The red thread through all methods, however, is that it is a translation process. A sophisticated and ever-changing network of technologies and actors has to be interpreted and then translated into numbers (Murphy et al., 2012). This translation process in itself is relative to the user, and the reality lies in the eye of the beholder. Furthermore, the value of a patent varies substantially depending on the ability of the right holder to exploit the economic benefit that the patent can generate; thus, the value of a patent is highly subjective. This is because the exploitation of a technical solution is dependent on complementary technologies, resources, and knowledge.

There are several well-established methods for estimating the monetary value of a patent the most commonly used being, the cost-based approach, the market-based approach, the income-based method, and the option-based method. The majority of these methods require technology and firm-specific information not available from the patent documents alone and are for that reason unfit for evaluating large datasets of patents. Due to the complexity in patent valuation using the methods mentioned above, another academic field has emerged. In this field, patent characteristics are used as value indicators to assess the quality of patents and their expected ability to yield economic returns. Monetary value and quality are not synonyms but given IPs role as a source of competitive advantage and a mean to generate monetary rents (Rivette & Kline, 2000) the quality of the patent serve as a proxy for the patents ability to yield economic returns.

2.5.2 Methods and Patent Value Indicators

Estimating the quality of a large set of patents, utilizing patent value indicators is the only viable method. Traditionally three conventional types of valuation methods have been deployed within the academic field. The main methods within the literature are briefly outlined below.

- Financial data, researchers within this strain has investigated the correlation between patent characteristics and firm value. Contributions within this strain include among others Lanjouw & Schankerman (2004) and Hall et al. (2005)
- Data from patent documents, methods within this field focus entirely on publicly available data from patent documents and patent offices. Data points such as forwarding citation counts, the number of claims, the number of litigations is used to find patterns in patent value. Contributions within this strain include, among others Zeebroeck (2007).
- Interviews with experts, this strain utilizes surveys and interviews with inventors and subject matter experts to assess the value of the patents under study. Interviews and studies are often complemented with patent data. Contributions within this strain include, among others Harhoff et al. (1999).

A fourth method, previously not possible due to the lack of data, is a valuation method based on transaction data. Fischer & Leidinger (2013) was the first to test the value indicators on data on transacted patents opening up for a new method for patent valuation.

Given the scope of this study, the accessible data and the time at hand the study will use the second of the above mention methods, utilizing publicly available patent data to assess the relative value of the patents under study. The method will not allow valuation in monetary terms but will allow insight into the relative quality of the patents listed.

2.5.3 Patent Value Indicators

The practice of using value indicators from patent documents is well established in academia, and the literature on the subject is dense. For some value indicators, the literature is unanimous in their validity as a proxy for patent value and for others the findings diverge. The patent value indicators included in the evaluation of patents have a direct effect on the estimated quality or value; hence the patent value indicators need to be chosen carefully. In the OECD Patent Statistics manuals (2009), a literature review presents the most established value indicators as seen in below Table 1.

Table 1. Established Patent Value Indicators OECD (2009)

Value Indicator	Rationale
Grant Decision	• A pending patent holds limited legal protection.
Forward Citations	• Indication of downstream research and investments in the field. • Suggest that is has been used by the patent office to narrow the scope of protection for later applications.
Number of Family Members	• Filing in multiple jurisdictions is costly.
Number of inventors	• A proxy of the cost of the underlying research.
Renewals	• Maintaining a patent is costly, a renewal decision can be expected to be grounded in economic rationale.
Number of claims	• Indication of a wide scope of protection.
Number of IPC classes	• Indication of a wide scope of protection.
Oppositions & Litigations	• Indicates that third parties see a value in the technology.

2.5.3.1 Grant Decision

For a patent to be granted, it needs to fulfill the patentability criteria in the jurisdiction of filing. For a holder of a patent to long-term earn economic rents on the patent, a grant decision is required. Pending applications yield some legal protection to the patent holder. However, the strength of this protection and the ability to enforce the legal protection is ultimately decided by the grant decision (Zeebroeck, 2007).

2.5.3.2 Forward Citations

A Forward citation is a reference received from a later patent application when the patent is deemed relevant prior art to the application. Forward citations are potentially the most common value indicator used. Forward citations indicate that there is continuous R&D (research and development) within the technical field and that the patented invention has contributed to the state of the art. Downstream commercial activity and later inventions potentially being built upon the patented technology naturally increase the potential for the holder to gain economic rents. Campbell & Nieves, already in 1979, discussed the relationship between the number of citations and the technical relevance of the patent. Numerous studies have later on confirmed this relationship. Harhoff et al. (2003) confirmed a positive relationship between the number of forward citations and economic value. Bessen (2008) showed that each additional forward citation increased the expected monetary yield with 5%. Fischer & Leidinger (2013) in their study on transacted patents, confirmed this positive relationship and found that an additional forward citation on average increased the economic value with 9,58%.

The literature is unanimous in the positive relationship between forward of citations and patent value. However, the explanatory power for forward citations is in most studies relatively low. In Fischer & Leidinger (2014) study an additional forward citation only explained an 0,5% increase of the variance. Gambardella (2008) found that a forward explained 1,4% of the variance.

2.5.3.3 Number of Family Members

A patent family refers to the number of patents filed in different jurisdictions claiming protection for the same (simple family) or similar (extended family) technical inventions. All members of a patent family share the priority date from the first filing. Seeking patent protection in multiple jurisdictions is costly. Multiple family members are hence an indication that the holder of the patent believes that the costs associated with the filings will be repaid by the patents future economic rents. Additionally, patent protection in multiple jurisdictions expands the market on which the holder of the patent has the exclusive right to the invention giving access to a broader market and potentially higher economic gains.

Multiple studies confirm the relationship between family size and patent value, Lanjouw & Schankerman (2004), Harhoff et al. (2002), Baron & Delcamp (2012) and Fischer & Leidinger (2013) to mention a few. Fischer & Leidinger (2013) observed a positive relationship between the family size and the monetary value were an additional family member increase the monetary value with 5,2%, these findings are, however, not statistically significant. The same study furthermore found that in their sample sold patents had significantly more family members than unsold patents from the same dataset.

2.5.3.4 Oppositions & Litigation

A patent opposition is when a third-party, questions the validity of a patent. An opposition of a patent filed with EPO or USPTO must be filed within nine months from the grant decision. An opposition of a patent has three potential outcomes; the opposition can be rejected; the patent can remain granted but with amendments and the patent can be revoked. Patent Litigations occur when the holder of the patent sues a third party for infringement of his patented rights. The counteract of the sued party is often to question the validity of the allegedly infringed patent.

Oppositions and litigations are costly, for any party to initiate such a process one could assume that they have an economic gain in the sought-for outcome indicating that the patent has a value if deemed valid. Furthermore, there are arguments that the legal validity of a patent is not ensured until tested in court. A patent surviving litigations or oppositions could thus potentially have a more robust legal standing. Harhoff et al. (2002) found that German patents that survived oppositions had a significantly higher value. Bessen (2005) draw similar conclusions establishing a relationship between American patents and litigations.

2.5.3.5 Office Rejections

Using office rejections is a refined version of forward citations. Office rejections are a rejection of claims in later patent application citing a patent as the reason for rejection. In the case of 102 rejection a patent application in deemed non-novel using an existing patent as reference. A 103 rejection instead means that invention fails to fulfill the non-obvious criteria referring to multiple existing patents (USPTO. 2020). Cotropia & Schwartz (2018) investigated the effect of 102 and 103 rejections on the monetary value. The study finds that citations from office rejections contribute significantly more to the value of a patent than previously investigated citations (Cotropia & Schwartz. 2018). No similar study has to the author's awareness, been conducted on European patents. However, the same effect is likely to be found in the EPO equivalent of 102 and 103 rejections, the examiner citation categories X, Y. (EPO Office, 2020).

2.5.3.6 Technical classes

Technical classes or codes are used to define the technical scope of the invention and sought patent protection. The Cooperative Patent Classification (CPC) system developed jointly by the European Patent Office and USPTO and the International Patent Classification (IPC) established by the Strasbourg agreement are the two dominant classification systems. The argument for using technical classes as an indicator for value is that multiple classes indicate a broader scope of the patent. Lerner (1994) showed that the scope of a patent had a significant effect on the valuation of biotechnology firms. Later studies have examined the relationship without finding any significant relationship (Gambardella. 2008, Fischer & Leidinger, 2013).

2.5.3.7 Number of Claims

The patent claims define the technical invention for which legal protection is sought. By defining the technical invention, the legal scope of protection is limited to what is being claimed in the patent claims. There are arguments that the number of claims serves as a proxy for the breadth of the patent and that the number of claims, therefore, is an indicator for patent value. Gambardella et al. (2008) found a significant correlation between the number of claims and private economic value. Fischer & Leidinger (2013) saw a strong relationship between the number of claims and patent value. The same study, however, showed that the explanatory power of claims is low, an additional claimed only explained an additional 0,6% of the variance.

The number of claims in a patent application is ultimately decided by the actor drafting the patent. Archontopoulos et al. (2007) showed that the drafting styles of patents varied significantly between different jurisdictions. American patents were on average found to have five more claims than a patent filed directly with the EPO. Furthermore, patents filed with PCT were found to have more claims than patents filed with EPO (Archontopoulos et al. 2007). The difference in drafting styles between jurisdictions risks to compromise the utility of claims as a value indicator when evaluating patents from multiple jurisdictions.

2.5.3.8 Number of Inventors

The numbers of inventors are in the literature used as a proxy for the resources required and the cost associated with the patented invention (OECD, 2009). The number of inventors has to the author's knowledge not been proven to be a reliable value indicator. However, Archontopoulos et al. (2007) state that the number of inventors may be viewed as an indicator of the complexity of the invention and that the number of inventors is linearly positively correlated with the number of claims in a patent application.

2.5.3.9 Discrepancies Between Industries

The importance of patents varies between industries and so also the strategy deployed when filing for and defending patents. The discrepancies between industries are reflected in the application activity and affect the value indicators. Zeebroeck (2007) found significant discrepancies between citations, grant rates, oppositions rates and family size in a study on 14 industrial sectors. Archontopoulos et al. (2007) found that the number of claims varied significantly between industrial sectors. In their study, patents in the biotechnology and computer sector had almost twice as many claims on average compared to patents within the vehicle and general technology sector. Bessen (2008) indicated differences in patent value and renewal rates between industries.

The discrepancies in patent data and patent value across industries mean that meaningful comparisons of patents can only be made within the industrial or technical field. The in literature common approach to addressing this problem is to divide the population into subsets based on the technical classes where patent protection is sought. In practice, this means utilizing IPC, CPC or an equivalent classifications system to divide the population into technical clusters. This method is among others, practiced by Archontopoulos et al. (2007), Zeebroeck (2007) and Bessen (2008).

2.5.4 Quality Ranking

The patent value indicators mentioned above serve as proxies for different aspects related to the value of a patent. By using patent value indicators to identify high-quality patents, one is likely to obtain different results depending on the patent value indicators used. Zeebroeck (2007), in a study on forward citations, grant decisions, families, renewals, and opposition, found that many of the value indicators were correlated. The measured correlation between the indicators was, however, relatively low. Despite the correlation between the value indicators, Zeebroeck (2007) found that the patent value indicators mostly identify different patents as high-quality patents. Looking at the value indicators in isolation will thus yield different results depending on the value indicator under study.

Zeebroeck (2007) propose a ranking method incorporating multiple value indicators as a solution to the problem mentioned above. Zeebroeck's (2007) method utilizes the distribution of each value indicator and assigns each patent a score based on its percentile in the total distribution. For each value indicator, a score based on its percentile in a relevant reference population will be assigned to the patent (e.g. 20th percentile would result in 20 points). The aggregated score of all value indicators constitutes the patent score and a proxy for the patent’s relative quality.

3 Methodology

3.1 Research Strategy

The study incorporates a deductive approach, taking a starting point in theory, establishing illiquidity of IP as a considerable obstacle for value creation of IP through transactions. By acknowledging the existence of functional marketplaces as an enabler of liquidity, it becomes relevant to examine the existing marketplaces. The foundation of the research design is a cross-sectional case study. The strategy is to compare the quality of the patents listed on (four) different IP marketplaces with relevant patents in the population.

3.2 Research Method

By evaluating the quality of the patents listed on the marketplaces under study, a quantitative method is used. For each marketplace under study, the listed patents are evaluated towards a reference sample of patents within similar technology area and age. The data is collected from multiple samples (marketplaces) at one point in time, and the analysis is conducted on four patent value indicators. These properties constitute a cross-sectional research design.

Reliability, replicability and validity are the critical quality criteria for a quantitative cross-sectional research method. Building on the findings from a literature review on the area of patent value indicators, the intention is to use existing literature as the empirical foundation constructing a quality ranking model. The reliability criterion is best met by a thorough theoretical analysis and incorporation of patent value indicators that have been scientifically proven to constitute relevant measures. The research seeks to provide thorough descriptions of all procedures within all parts of the research to meet the quality criteria of replicability. Furthermore, the data that is being analyzed is publicly available and transparent. The internal validity of the data analysis and conclusions is strengthened by performing multiple data analysis methods. The external validity is generally strong with quantitative cross-sectional design if the data is selected randomly, which is sought-after throughout the research (Bell et al., 2019).

3.3 Data

3.3.1 Empirical Setting

The study sets out to explore the quality of patents listed on the four online marketplaces; IP-Marketplace, ExploreIP, IAM Market and Ocean Tomo Bid-Ask (OTBA).

IP-marketplace is a free online platform open for anyone looking to buy or sell IP. IP-marketplace is run and governed by the Danish Patent and Trademark Office. The site was initially launched in 2007 and modernized in 2017. The website lists granted patents, patent applications, utility models, design rights and trademarks for sale or for licensing. IP-marketplace facilitates the initial contact between the transacting parties but do not engage in or offer services for negotiations or transactions (IP-Marketplace. 2020).

ExploreIP Canada's IP marketplace is an initiative stemming from Canada's Intellectual property strategy initiated in 2018. The strategy was developed by Innovation, Science and Economic Development Canada (ISED). ExploreIP is a free searchable database to showcase patents of public sector actors. The marketplaces welcome patent listing from public actors in all fields and showcase patents from a wide variety of technical domains. The vendors are only public actors, but the marketplaces address buyers of all types and from all fields. ExploreIP facilitates the listings of patents and the initial communication between the parties but takes no formal role in any agreements or transactions. To be noted is that the marketplaces is a newly launched initiative, and the site is currently in open beta (ISED. 2020).

IAM Market is operated by Law Business Research, an England/Wales registered company. The operations started with IAM Magazine in 2003 and later launched IAM Media ranking patent professionals. Nowadays, IAM Market defines its service as an "online marketplace for buy and sell-side practitioners". The marketplace has procedures in place to vet both buyers and sellers before they list their patents or participate in the marketplace. The vetting system means that the access is somewhat restricted and ultimately governed by IAM, at the time of this study, a total of 26 active vendors are listed on the marketplaces. IAM market as above mentioned marketplaces do not get involved in the transactions; instead, the focus is on facilitating the technology browsing.

Ocean Tomo is an actor with a long history in the market for technology. Back in 2006, Ocean Tomo received much attention when they established the first live patent auctions. In 2008 the first version of the online marketplace was launched. The marketplaces attract knowledge owners and patents from all technology fields as "patents covering any non-objectionable content may be sold on Bid-Ask". In practice Ocean Tomo package the lots offered on the marketplace and have the final say whether a patent should be listed or not. Ocean Tomo charges a minimum fee of $2,500 for a patent lot to be offered for a transaction and an additional commission if the patent is transacted. Unlike the other marketplaces under study, OBTA facilitates the full transaction. Transactions are facilitated through auctions where the buyers are allowed to bid on the assets during a predetermined period. The price data from all previous transactions is available on the webpage to increase the transparency on the patent market (Ocean Tomo. 2020).

3.3.2 Sample Dataset

The marketplaces provide information with varying detail about every patent offered for sale including the patent number of the patents available for transactions. All patent numbers from IP-marketplace, IAM Market and Ocean Tomo Bid-Ask were extracted. The patent numbers from Explore were extracted using a web-scraping tool called Import IO (import.io, 2020). On IP-Marketplace, the reported number of listing did not correspond with the number of identifiable patents on the site. Instead of 630 patents, a total of 245 was identified. In many of the marketplaces, the same patent is listed multiple times but for different types of transactions, i.e. both for sale and licensing but under different listings. The study aims to evaluate the quality of the patents attracted irrespective of transaction type. In order to avoid bias towards certain patents, all four samples are cleared of duplicates. With all duplicates removed the total number of listings identified in the four samples is reported in Table 2 below.

Table 2. Total number of Patent numbers extracted

	Patent count
IPMarketplace	*201*
Explore	*2197*
IAM	*811*
Ocean	*514*
Total	*3723*

In order to access the patent value indicators for each respective patent, access to the full patent document is necessary. The patent data for the sample as well as the reference sample was accessed from Questel Orbit Intelligence, a well-renowned patent database.

The patent numbers extracted from the four marketplaces were imported to the database to complement the data set with the data on value indicators needed to conduct the study. For the full export format, see Appendix 3. The study sets out to explore the quality of granted and alive patents listed on the marketplaces; hence the search filters granted patents and alive patent families where applied in the exports.

The lifetime of a patent is under normal circumstances 20 years from the filing date. The samples from the marketplaces include patents with priority earlier than 2000. This means that individual patents within a patent family are filed later than the earliest priority. The thesis assumes that in order to be relevant for a transaction, a patent must be alive. Patents with priority before the year 2000 are expected to lapse in the near future and are hence excluded from the analysis. Patents filed after 2015 have significantly lower scores on the value indicators given their shorter lifetime, making it hard to assess their quality with the proposed method. For that reason, the timespan under study is set to 2000-2015.

The analysis is conducted on a family level instead of on the individual patent level. By measuring forward citations, multiple patent publications become an issue as both later applicants and examiners might reference a publication other than the one first claiming priority. It is common practice at the EPO to cite patents filed with the USPTO rather than patents filed with EPO hence measuring patent value indicators on individual patents might yield inaccurate results (Zeebroeck, 2007). The patent family classification used is “FamPat Grouping". The grouping utilizes the strict family grouping of EPO with additional rules also designed to include the link between US provisional patents and applications and the link between EP and PCT. For more information about the FamPat Grouping, see Grouping Patent Families (Orbit, 2020). IP-marketplace, IAM Market and Ocean Tomo Bid-Ask all allowed patents to be sold in lots of patents. One lot will naturally often include multiple patents from the same family in order to give the knowledge-seeker the full right to the invention. Moving from individual patents to patent families aggregates individual patent numbers, hence a significant drop in the total number of patents is present.

Additionally, the decision was made to include only patents claiming protection with the EPO or USPTO. The decision to limit the focus on patents filed with EPO or USPTO is made based on data accessibility issues (the database used, provides no information of office rejections outside EPO or USPTO). Across all marketplaces, no more than 54 patent families do not claim protection in the specific region hence this delimitation can be expected to have a limited effect on the reported result. The total number of alive and granted patents families within the relevant timespan and regions exported from the database is reported in Table 3 below.

Table 3 - Number of patents relevant under the scope of the thesis

	Patent count
IPMarketplace	*1 319*
Explore	*432*
IAM	*87*
Ocean	*144*
Total	*1 982*

3.3.3 Patent Value Indicators

In order to evaluate the quality of the patents, the study builds on the following four patent value indicators: Forward citations, Office rejections, the number of family members and the number of litigations. The decision to include the four patent value indicators is based on literature and previous research within the field of patent value indicators. After a conducted literature review, the authors found that the literature is unanimous in these four indicators, positive relationship with patent-quality. For a thorough understanding of the specific patent indicators relationship to patent-quality, see *Chapter 2 - Theory*.

3.3.3.1 Forward citations - CIT

In the analysis, only patent citations from third parties are included, so-called non-self-citing citations. By including only non-self-citing citations, the dataset is cleared from the potential bias of strategic filings. A strategic filing in the case of forward citations is when one actor cites its own patents in later applications. Non-self-citing forward citations hence allow for a better comparison, free from biases resulting from strategic filings. By extracting the raw count of forward citations, the data point "Citing patents (forward citations) Non-self-citing patents - counts" was included in the database export. This value indicator is denoted "CIT" and represents the total number of forward citations received by a patent family during its total lifetime since the date of earliest priority.

3.3.3.2 Office Rejections - OR

The office rejections of relevance are §102 and §103 from USPTO and the equivalent categories from EPO X, Y. The raw count of office rejection in the relevant categories was extracted by applying the filter "Citing patents by examiner - Relevancy categories" in the export. This value indicator is denoted "OR". It represents the total number of office rejections in the relevant categories received by a patent family during its total lifetime since the date of the earliest priority.

3.3.3.3 Number of family members - NFM

The value indicator "Number of family members" was extracted by including the datapoint "Countries/authorities - Count" in the export. The patent family classification used is the Orbit Questel “FamPat Grouping”. This value indicator is denoted “NFM". It represents the total number of countries/authorities that a patent family has been applied for within during its total lifetime since the date of earliest priority.

3.3.3.4 Litigations - LIT

The litigation count per patent was extracted by including the datapoint “Litigation” in the export. The litigation data extracted, includes both the individual cases and how many times the specific patents of the patent families had been litigated. In other words, one litigation case can include multiple patents from the same patent family.

To avoid double-counting, we control for unique litigation cases. This value indicator is denoted "LIT" and represents the total number of litigations received by the patent family during its total lifetime since the date of earliest priority.

3.4 Clustering

The importance of patents varies between industries and so also the strategy deployed when filing for and defending patents. The discrepancies between industries are reflected in the application activity and as a result, affect the value indicators used in this report. The discrepancies in patent data and patent value across industries mean that a meaningful comparison of patents can only be made within the industrial or technical field. The in literature common approach to addressing this problem is to divide the population into subsets based on the technical classes were patent protection is sought. This method is among others, practiced by Archontopoulos et al. (2007), Zeebroeck (2007) and Bessen (2008).

In order to facilitate the grouping of patents, the technology classification of WIPO (2008) is used. The technology classification divides the patent landscape into 35 technology domains and six broader technology areas based on the IPC codes. The technology domain of each patent is autogenerated in Orbit and extracted in the export files.

With the samples broken down into the 35 technological domains, the patent data was clustered into the six technology areas of WIPO. The technology domains "biotechnology", "pharmaceuticals", "Furniture, games", "Civil Engineering" and "Other consumer goods" are kept separate from their respective technology area resulting in leaves a total of 10 technology areas. A study on all patents filed with the EPO between 1990-2009 found that patents filed within biotechnology and pharmaceuticals do in general have a broader scope than average, in other words, they claim protection in a higher number of IPC classes. Furthermore, the same study showed that the two classes do on average, have fewer forward citations from office rejections (OECD, 2015). The two classes are hence treated separately to allow a fair evaluation. The technology areas "Furniture, games", "Civil Engineering" and "Other consumer goods" fall under the technology area "Other fields" in the WIPO (2008) IPC-based technology classification. It is hard to argue that the three classes belong to the same technology area. The rationale behind the bundling of the three is thus likely to be a result of the three classes being different from the other technology areas rather similar traits. The author's opinion is that keeping them in separate technology areas allow for a better comparison.

With the broad timespan under study, the value indicators dependent on the age of the patent is an issue that needs to be considered, i.e. older patents are likely to have more citations on average because of their age. For an accurate evaluation of patent quality across time, each technology area is further divided into subgroups based on the patent family's earliest priority date. Each patent family is denoted "SPi,m,a,t" meaning; sample patent family number i from marketplace m, in technology area a, from year t, e.g. “SP01,explore,chemistry,2001”.

3.5 Reference Sample

In order to evaluate the quality of patents listed on marketplaces, a relative comparison with a greater population of patents within the same technology area and same age is desired. Evaluating all active patents worldwide is not feasible; hence reference samples need to be constructed for every year and technology area. In theory, this would result in a maximum of 160 reference samples (one per year in the 16-year timespan in all of the ten technology areas).

Fully randomized references samples would be ideal but would in practice mean that every currently active patent within the relevant timespan would have to be extracted and randomized. Extracting all active patents would require more time and computational power than viable for this thesis. As a compromise, the first 1,000 search results generated in the database are used to represent the reference sample for each year in every technology area. The search results in Orbit are automatically ranked (given by the algorithm in Orbit) based on their relevance for the search query. Given the relatively broad nature of the technology areas and the large sample size, the search results generated are likely to be representative for the field and free from most biases. In the technology area "biotechnology", through the years 2000-2003 less than 1,000 patents were generated by the database simply because the number of granted patent families still alive was less than 1000. In these cases, the total number of patents available were extracted as the reference sample.

In the samples from the marketplaces, the variable "Earliest priority date" is used to categorize the age of the sample patents. This is because looking at the value indicators on a patent family level, the earliest date of priority is the most consistent delimitation of age. This creates a slight issue in the extraction process of the reference samples because the Orbit database only allows using "Priority Date" in the search string, and not "Earliest Priority date". Therefore, we have to extract > 1,000 search results and in a second step and filter on “Earliest Priority date” in the exported excel files to get the final 1,000 used to form the references samples. This does not limit or deteriorate the data extraction strategy, but it merely adds another step in the process.

The search string used to extract the reference samples included the specific technology area and the filters "patent status: alive and granted" and "Priority Date Between: *respective year*". This search strategy is executed for all years under study for which the samples included at least one patent (Appendix 3). This procedure resulted in a total number of numbers of 140 reference samples (RSa). The exported reference sample files contain the same parameters as the exported sample files (see Appendix 3). Each reference sample is denoted "RSa,t" - Reference Sample for technology area a for year t, e.g. ”RS,chemistry,2001” and consists of 1,000 RPu,a,t (reference patents) meaning reference patent number "u" in technology area "a" in year t, e.g. "RP01,chemistry,2001"

3.6 Data Analysis

The data analysis in this thesis is split into two parts. The first part is adopted from a similar study outlining a method for quality comparison of large patent samples. The second part embodies a statistical test to test the statistical significance of the findings in the first part.

3.6.1 Percentile Ranking

The patent value indicators serve as proxies for different aspects related to the value of a patent. Thus, looking at the value indicators in isolation, the indicators are likely to yield different outcomes and as a result, identify different patents as valuable. Zeebroeck (2007) propose a ranking method incorporating multiple value indicators as a solution to the problem mentioned above. This thesis uses the method proposed by Zeebroeck (2007), utilizing the distribution of each value indicator (e.g. minimum 0 - maximum 233 “forward citations”) and assigns each patent a score between 1-100 based on its location and respective percentile in the total distribution. The function PROCENTRANG.EXK in excel is utilized to perform the calculations for each patent family. E.g. the SPi,m,a,t “SP01,explore,chemistry,2001” has 3 Forward Citations (CIT) and will be compared to the 1,000 patents in its respective reference sample, e.g. “RS,chemistry,2001” and be assigned a score based on the percentile represented by its locations in the distribution.

All sample patents will be individually ranked towards the relevant reference sample based on technology area and year of first priority. Each patent value indicator will be ranked towards the distribution of the same patent value indicator, e.g. CIT for "SP01,explore,chemistry,2001" will be ranked within the distribution of CIT for "RP01,chemistry,2001", "RP02,chemistry,2001", "RP03,chemistry,2001" and so forth. See Tables 4 and 5 below.

Table 4 - Exemplified raw numbers of value indicators for patents within chemistry from the year 2001

SP*i,m,a,t*	CIT	OR	NFM	LIT
SP01,*explore,chemistry,2001*	3	2	13	0
SP02,*ocean,chemistry,2001*	3	1	16	0
SP03,*IAM,chemistry,2001*	1	0	10	0
...	...	...	...	...
...	...	...	...	...

This percentile rank method is performed for each patent family and each patent value indicator. This means that "SPi,m,a,t" will initially be assigned four percentiles, denoted CITip, ORip, NFMip and LITip, meaning sample patent family number *i* and *p* for percentile. See Table 5 below for exemplified numbers.

A total of 140 data runs were conducted to rank the value indicators of the sample patents compared to the reference samples. The average score of the four value indicators constitutes the total patent score and a proxy for the patent's relative quality. This goes for all sample patents i.e. the total patent score for "SPi,m,a,t" = "TPS SPi,m,a,t" = AVERAGE(∑CITip, ORip, NFMip, LITip). In order measure, a final total score for each subject under study, i.e. the final score for one marketplace will constitute of the mean of the total patent score of all patents, i.e. mean TPS = AVERAGE(∑TPS SPi,m, a,t), e.g. "MeanTPS.explore" = AVERAGE(∑TPSi,Explore).

Table 5 - Exemplified results for Explore

SP*i,m,a,t*	CIT	OR	NFM	LIT	**CITip**	**ORip**	**NFMip**	**LITip**	**TPS SPi,m,a,t**
SP01, *explore, chemistry, 2001*	3	2	13	0	0,770	0,690	0,340	0,462	0,566
SP02, *explore, biotechnology, 2001*	3	1	16	0	0,610	0,550	0,660	0,462	0,571
SP03, *explore, electricalengineering, 2001*	1	0	10	0	0,290	0,000	0,240	0,462	0,248
…	…	…	…	…	…	…	…	…	…
…	…	…	…	…	…	…	…	…	…
MeanTPS.*explore*									**0,438**

Given the nature of the data following the percentile ranking method both the median and the average of the RSa,TPS equals 0,5, i.e. the 50th percentile. The median patent score (0,5) for the reference sample based on all reference sample patents constitutes the benchmark figure for the evaluation of the marketplaces. By having the median for the reference sample established at 0,5 (the 50th percentile), the TPS of all patents can be compared to the median of the reference sample to evaluate if it is of better, worse or equal quality.

3.6.2 Kruskal-Wallis H test of medians

The percentile ranking method provides valuable, comparative data and allows for useful visualizations of apparent differences in the quality of patents. However, in order to statistically prove significant differences between the marketplaces it is crucial to take the analysis one step further. In this stage of the data analysis, we use the patent score for each patent as dependent variable performing the Kruskal-Wallis H test.

As described in the previous section, the variable used for comparison is a total patent score (TPS) based on the percentiles for each patent value indicator. Percentiles range from 0-100, and hence, the dependent variable is ordinal, and a nonparametric equivalent to the paired-samples t-test is needed. We will use "TPS SPi,m,a,t" as a dependent variable. The sample patents are assigned a categorical variable (0-3) based on which patent marketplace they are listed on, which is used as the independent variable. Following the circumstances above the assumptions for the Kruskal-Wallis H test are fulfilled (Laerd Statistics, 2020).

Performing the Kruskal Wallis H test the statistical inference that can be made depends on the shape of the distributions of the analyzed data sets. If the distribution of the underlying data differs between the samples, the Kruskal Wallis test can be used only to test the difference of the distributions statistically. With similarly shaped distributions, the statistical test is instead used to test for differences in medians between the groups. There is to the author's knowledge no accepted practice in determining whether the distributions of the groups are similar or not as discussed by Vargha and Delaney (1998). Determining if the distributions of the analyzed data sets are similarly distributed is hence a judgment call based on visual inspection.

The null and alternative hypothesis hence will be:
H0: the medians of patent scores of the groups are equal
HA: the medians of the groups are not equal

The Kruskal Wallis test tests whether the medians of the groups are equal or not. In order to analyze the differences among the five groups, a post hoc test was conducted. The conducted post hoc test is based on the procedure presented by Dunn (1964). The ranking of the Kruskal Wallis method is used to conduct pairwise comparisons of the marketplaces to determine which marketplaces that differ.

By performing these statistical tests, we can say whether there is a significant difference in the quality of patents listed on the marketplaces. In the light of the aim of this thesis, the result provides insights on whether there is a difference in the marketplaces ability to attract high-quality patents and thereby ease the problematically high search costs associated with patent transactions.

4 Results

This section will present the results from both methods described in the previous section. First the section will present descriptive statistics to illustrate the sample datasets and continue presenting the results from the percentile ranking method. Lastly, the result of the Kruskal-Wallis test will be presented.

4.1 Descriptive data illustrations

4.1.1 Patents by Technology Area

The total number of sample patents on the respective marketplace within the relevant timespan is; Explore: 1319, IAM: 432, IPMarketplace: 87 and Ocean: 144, totaling 1982 sample patents. See Figure 4 for a summarized distribution and Appendix 1 for a detailed table over the exact number of patents in each sample data set and technology area.

The technology areas ”Electrical Engineering”, and ”Instruments” have the largest representation on the marketplaces. For the technology areas “Other consumer goods”, “Furniture, Games” and “Civil Engineering”, the number of listed patents are very few. Among the technology areas not mentioned above, the number of listing are similar, ranging from 6,36% to 9,9% of the total sample.

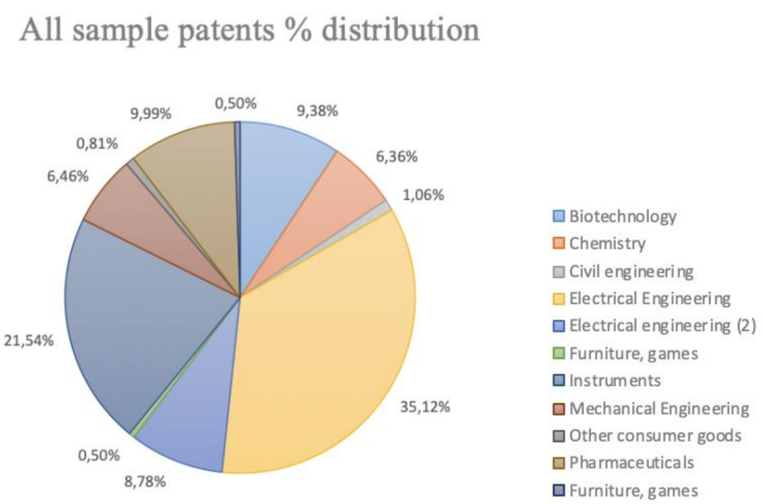

Figure 4. Percentage distribution of all sample patents per technology area

Clustering the sample patents by marketplace and technology area, some variations between the marketplaces are visible, see figure 5. Three out of the four marketplaces have an over-representation of patents in the technology area ”Electrical Engineering”. Furthermore, ”Instruments”, ”Electrical Engineering”, (2)”, and “Mechanical Engineering” are other technology areas with a substantial number of listings across all marketplaces. In contrast, all marketplaces attract very few or no patents at all in the technology areas “Furniture, games”, “Other consumer goods” and “Civil engineering”.

Among the marketplaces, IAM has the most concentrated inventory of available patents with 96% of the patents listed in the two technology areas ”Electrical Engineering”, and ”Instruments”, with the first-mentioned being significantly larger. Ocean Tomo and IPMarketplace have fairly similar distributions with a notable concentration in a few technology areas. Ocean Tomo and IPMarketplace similarly to IAM, primarily attract patents within the technology areas ”Electrical Engineering”, and ”Instruments”.

The patent inventory of Explore differs substantially from the other marketplaces both in terms of the total number of patents and the technology distribution. Explore have both the largest and most evenly distributed mix of patents. One such example is that Explore is the only marketplace that attracts a significant number of patents in the technology areas Biotechnology and Pharmaceuticals.

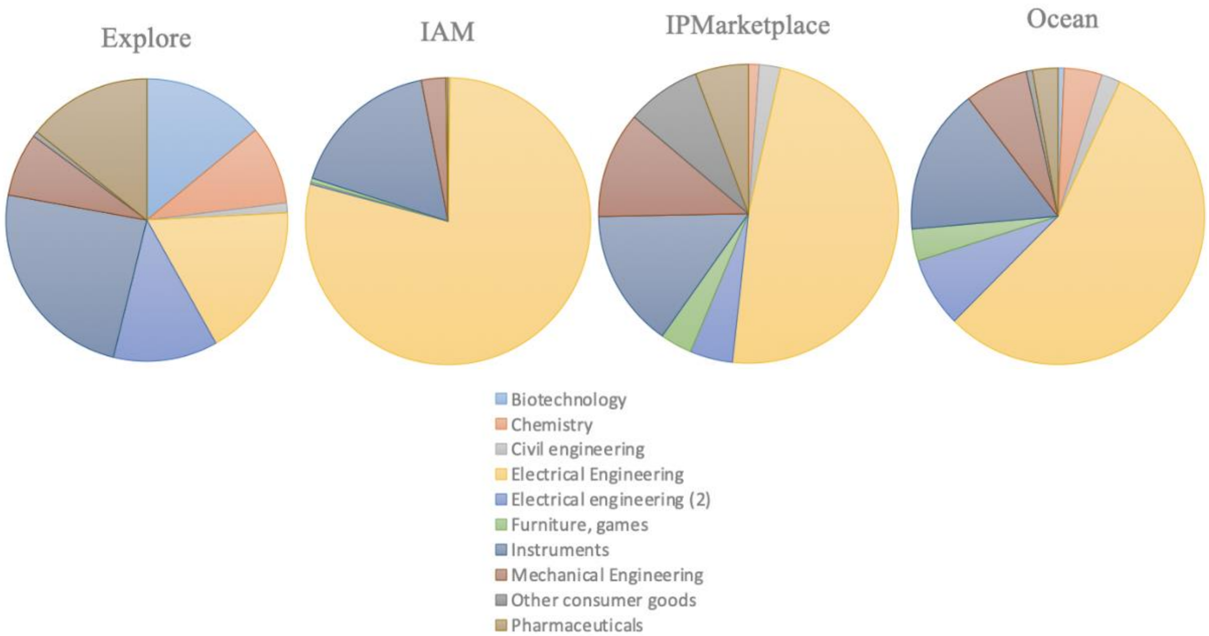

Figure 5. Distribution of sample patents per technology area and marketplace

4.2 Percentile ranking

The percentile ranking method aims to illustrate the relative quality of patents listed on each respective marketplace as compared to the broader population, represented by a reference sample of patents. In this section, we present the result firstly by looking at the differences between the marketplaces and secondly by looking at detailed differences between the technology areas.

4.2.1 Total Patent Score Comparison

As given by the conducted percentile ranking method, both the median and the average TPS of the reference sample equals 0,5 (the 50th percentile). Thus the 50th percentile constitutes the benchmark figure to evaluate the relative quality of the patents listed on the marketplaces. The interesting comparison is the difference between the Mean TPS of the marketplaces and the Median TPS of the reference sample.

The mean TPS for the marketplaces ranges from 0,373 to 0,443. Among the marketplaces, Ocean Tomo has the highest average TPS located in the 45th percentile, followed by Explore with its mean located in the 44th percentile. This means that they perform approximately six percentiles lower than the reference sample. The average quality of the listed patents on the two marketplaces is hence lower than 56% of the population patents.

The mean TPS of IAM and IPMarketplace is located in the 39th and 38th percentile, respectively. Compared to the median of the population, they are located 11,7 and 12,7 percentiles lower than the median of the reference sample. The patents on the two marketplaces are hence of a substantially lower quality than the population. See Table 6 - *Marketplaces sample key descriptive statistics* for summarized key descriptive statistics.

The TPS distribution of the marketplaces has similar characteristics with a majority of the patents having a TPS in the lower percentiles, as illustrated in Figure 6. The observed TPS standard deviations across the marketplaces have a narrow range from 0,148 to 0,173, indicating a similar variation in the quality of the listed patents across the marketplaces. On an aggregated level, the whole sample has a Mean TPS in the 43rd percentile indicating an overall lower quality of patents than the reference sample.

Table 6. Marketplaces sample descriptive statistics

Sample Total Patent Score (TPS)	Patent count	Min	Max	Mean	Diff	Median	Std.dev.
Explore	*1 319*	*0,144*	*0,993*	*0,438*	*-0,062*	*0,427*	0,154
IAM	*432*	*0,145*	*0,870*	*0,383*	*-0,117*	*0,363*	0,148
IPMarketplace	*87*	*0,174*	*0,805*	*0,373*	*-0,127*	*0,313*	0,173
Ocean	*144*	*0,174*	*0,945*	*0,443*	*-0,057*	*0,424*	0,158
Grand Total	***1 982***	***0,144***	***0,993***	***0,424***	***-0,076***	***0,409***	***0,156***

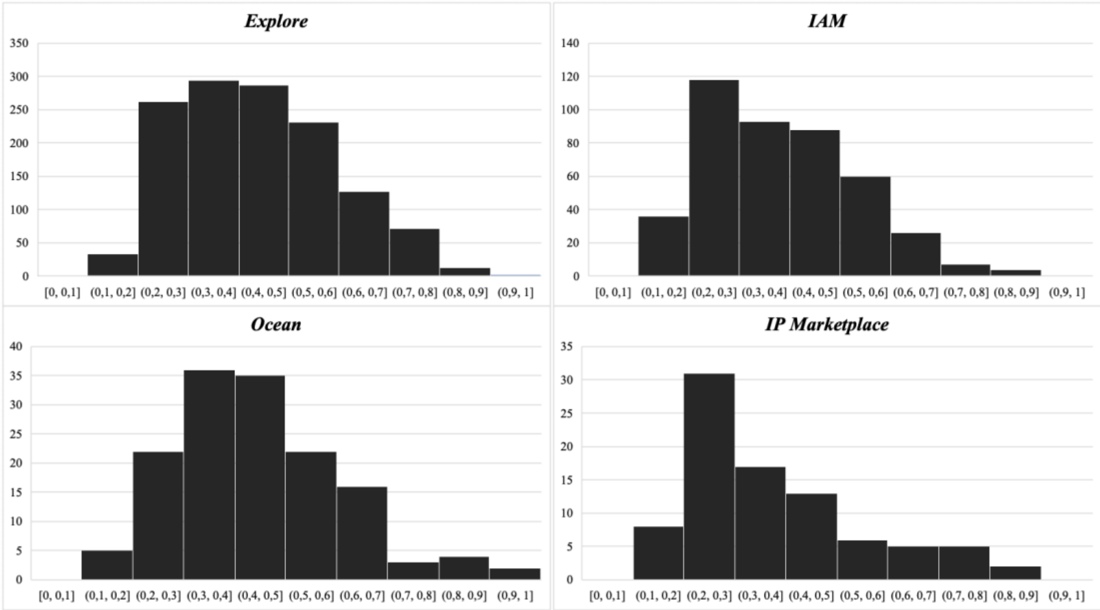

Figure 6. Marketplace sample TPS distribution

4.2.2 Technology area comparison

The number of patents attracted in the different technology areas varies significantly. The result obtained for technology areas with a comparably low number of listings is subject to a higher degree of randomness and should hence be interpreted carefully. This section will hence primarily report the observations for the technology areas with a substantial number of listing on the respective marketplaces.

The result, on a technology level, is interpreted in the same manner as in the previous section. The reported difference is the average difference in the mean TPS of the samples and the median TPS of the reference sample referred to as "Diff TPS", expressed in percentiles.

In Table 7 below the obtained result for the marketplace, Explore is presented. In seven of out of the ten studied technology areas, the observed Mean TPS is lower than the reference population, indicating a lower quality. For the two largest technology areas by the number of listings, the observed quality is substantially worse than the reference population. The technology area "Instruments" does an average rank 12,7 percentiles lower than the reference population. The second-largest technology area, "Electrical Engineering" has an average TPS that is 10,6 percentiles lower than the sample.

For two of the three technology areas with an observed Mean TPS above the 50th percentile, the differences are comparably small. “Biotechnology” and “Chemistry” rank in the 54th and the 52nd percentile, indicating a somewhat higher quality. "Other

Consumer Goods" is the best performing technology area but the number of listings is few limiting the significance of the result.

Table 7. Explore sample key statistics per technology area

Explore Total Patent Score (TPS)	Patent count	Min	Max	Mean	Diff	Median	Std.dev.
Biotechnology	185	0,144	0,834	0,539	0,039	0,539	0,171
Chemistry	119	0,196	0,861	0,512	0,012	0,500	0,171
Civil engineering	15	0,213	0,371	0,277	-0,223	0,281	0,055
Electrical Engineering	233	0,168	0,793	0,394	-0,106	0,371	0,143
Electrical engineering (2)	158	0,209	0,702	0,429	-0,071	0,434	0,109
Instruments	317	0,145	0,623	0,372	-0,128	0,369	0,119
Mechanical Engineering	96	0,202	0,820	0,457	-0,043	0,458	0,147
Other consumer goods	8	0,336	0,760	0,593	0,093	0,601	0,139
Pharmaceuticals	188	0,179	0,993	0,461	-0,039	0,457	0,147
Explore SAMPLE Total	***1 319***	***0,144***	***0,993***	***0,438***	***-0,062***	***0,427***	***0,154***

In Table 8 below the results for the marketplace, IAM is presented. The distribution of listed patents on this marketplace is highly skewed towards the field of “Electrical Engineering”, containing almost 80% of all patent listings. The mean TPS for ”Electrical Engineering”, is 12 percentiles below the reference median, indicating substantially lower patent quality. The second-largest technology area is “Instruments” with 13 percentiles lower mean TPS, notably lower than the reference median. The third-largest technology is “Mechanical Engineering” which mean TPS is the 55th percentile, performing slightly better than the reference median.

Table 8. IAM sample key statistics per technology area

IAM Total Patent Score (TPS)	Patent count	Min	Max	Mean	Diff	Median	Std.dev.
Civil engineering	1	0,219	0,219	0,219	-0,281	0,219	0,000
Electrical Engineering	341	0,175	0,870	0,382	-0,118	0,361	0,147
Electrical engineering (2)	1	0,319	0,319	0,319	-0,181	0,319	0,000
Furniture, games	2	0,172	0,191	0,181	-0,319	0,181	0,009
Instruments	74	0,145	0,615	0,371	-0,129	0,358	0,133
Mechanical Engineering	12	0,206	0,818	0,545	0,045	0,579	0,183
Pharmaceuticals	1	0,381	0,381	0,381	-0,119	0,381	0,000
IAM SAMPLE Total	***432***	***0,145***	***0,870***	***0,383***	***-0,117***	***0,363***	***0,148***

In Table 9 below the results for the marketplace, IPMarketplace is presented. The distribution is relatively evenly distributed between technology areas. However, "Electrical Engineering", stands out, containing 48% of patent listings. The mean TPS of "Electrical Engineering" is 20 percentiles lower than the reference median indicating substantially lower patent quality than the reference sample. "Instruments", is the second-largest technology area at IPMarketplace which also performs 20 percentiles lower than the reference median. The technology area "Mechanical Engineering is the third largest with 11,5% of patent listings with a mean TPS located in the 55th percentile, performing slightly better than the reference median.

Table 9. IPMarketplace sample key statistics per technology area

IPMarketplace Total Patent Score (TPS)	Patent count	Min	Max	Mean	Diff	Median	Std.dev.
Chemistry	*1*	*0,661*	*0,661*	*0,661*	*0,161*	*0,661*	*0,000*
Civil engineering	*2*	*0,232*	*0,353*	*0,292*	*-0,208*	*0,292*	*0,060*
Electrical Engineering	*42*	*0,180*	*0,805*	*0,301*	*-0,199*	*0,266*	*0,120*
Electrical engineering (2)	*4*	*0,209*	*0,399*	*0,295*	*-0,205*	*0,286*	*0,071*
Furniture, games	*3*	*0,357*	*0,473*	*0,417*	*-0,083*	*0,421*	*0,047*
Instruments	*13*	*0,174*	*0,604*	*0,295*	*-0,205*	*0,238*	*0,126*
Mechanical Engineering	*10*	*0,246*	*0,739*	*0,549*	*0,049*	*0,563*	*0,167*
Other consumer goods	*7*	*0,484*	*0,737*	*0,619*	*0,119*	*0,631*	*0,088*
Pharmaceuticals	*5*	*0,223*	*0,801*	*0,484*	*-0,016*	*0,447*	*0,197*
IPMarketplace SAMPLE Total	***87***	***0,174***	***0,805***	***0,373***	***-0,127***	***0,313***	***0,173***

In Table 10 below the results for the marketplace, Ocean Tomo is presented. As for the other marketplaces, the technology area, "Electrical Engineering", stands out, containing 55% of all patents, with a mean TPS, four percentiles lower than the reference median. "Instruments", is the second-largest technology area, with 16% of all patents, with a mean TPS that is eight percentiles lower than the reference median. "Electrical engineering (2)" is the third larger technology area in terms of listed patents, with a mean TPS that is 11 percentiles below the reference median.

Table 10. Ocean sample key statistics per technology area

Ocean Total Patent Score (TPS)	Patent count	Min	Max	Mean	Diff	Median	Std.dev.
Biotechnology	*1*	*0,620*	*0,620*	*0,620*	*0,120*	*0,620*	*0,000*
Chemistry	*6*	*0,324*	*0,640*	*0,426*	*-0,074*	*0,398*	*0,100*
Civil engineering	*3*	*0,207*	*0,207*	*0,207*	*-0,294*	*0,207*	*0,000*
Electrical Engineering	*80*	*0,194*	*0,945*	*0,462*	*-0,038*	*0,448*	*0,168*
Electrical engineering (2)	*11*	*0,222*	*0,530*	*0,392*	*-0,108*	*0,414*	*0,093*
Furniture, games	*5*	*0,181*	*0,583*	*0,400*	*-0,100*	*0,374*	*0,161*
Instruments	*23*	*0,174*	*0,678*	*0,421*	*-0,079*	*0,429*	*0,143*
Mechanical Engineering	*10*	*0,277*	*0,638*	*0,480*	*-0,020*	*0,490*	*0,096*
Other consumer goods	*1*	*0,811*	*0,811*	*0,811*	*0,311*	*0,811*	*0,000*
Pharmaceuticals	*4*	*0,326*	*0,419*	*0,354*	*-0,146*	*0,336*	*0,038*
Ocean SAMPLE Total	***144***	***0,174***	***0,945***	***0,443***	***-0,057***	***0,424***	***0,158***

Following the findings on an aggregated level, the above sections present results, indicating that all marketplaces perform worse than the reference population in a majority of the technology areas when compared separately. Descriptive evidence is found, showing that the largest technology area, in terms of listings on an aggregated level, "Electrical engineering" perform worse than reference population across all marketplace. Similar evidence is also found for the second-largest technology area "Instruments" that perform substantially worse than the reference population across all marketplaces. "Other consumer goods" is the only technology area that consistently ranks better than the reference population. However, very few patents are listed in this technology area; hence the results risk being affected by a high degree of randomness. In connecting the findings on an individual technology area with the findings on a marketplace level, the results are relatively unanimous. The average TPS of the marketplaces is, in general, a consequence of relatively poor performance across all technology areas.

4.3 Kruskal Wallis H test

The distributions of the patents scores were inspected both with a histogram (see figure 6 and 7 in the section "4.2.1 Total Patent Score Comparison") and a boxplot diagram presented in Figure 7. The distributions of the patents scores among the samples are deemed to be similarly shaped, however not perfectly similar for all groups. As a result, the Kruskal Wallis H test will be used to establish whether there are significant differences in the median value of the total patent scores within the samples.

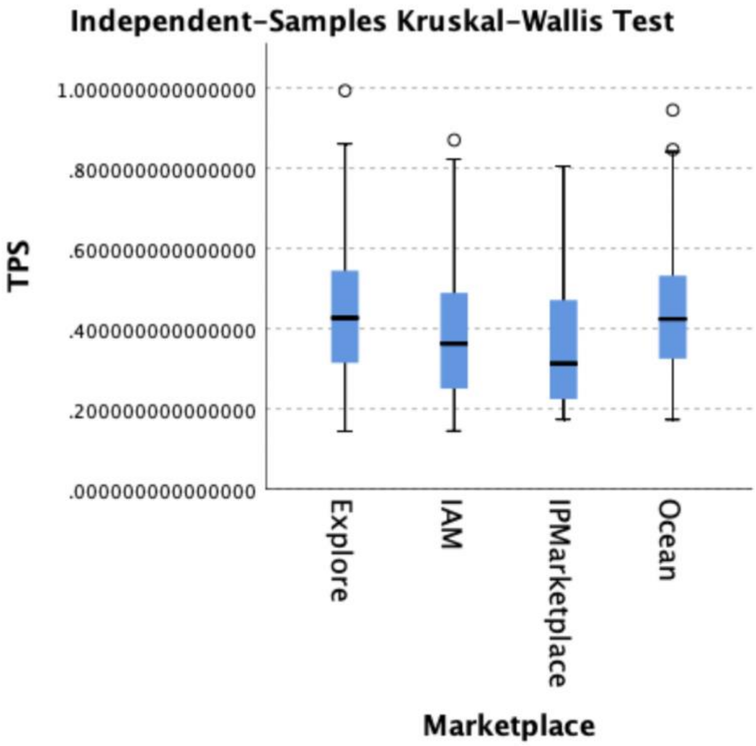

Figure 7 - Box Plot diagram over distributions of total patent scores

A Kruskal-Wallis test was conducted to determine if there are differences in Total Patent Scores (TPS) scores between the samples: Explore, IAM, IPMarketplace, and Ocean. The distributions of TPS scores were similar for all groups, as assessed by visual inspection mentioned above. The median TPS scores were significantly different between the groups, $\chi_2(3) = 57.109$, $p = .000$. See *Table 15 - Hypothesis Test Summary.*

Table 11 - Hypothesis Test Summary

Null Hypothesis	Test	Test statistic	Sig.	Descision
The distribution of PATENT SCORE is the same across categories of samples	Independent-Samples Kruskal-Wallis Test	57.109	.000	Reject the null hypothesis.

Subsequently, pairwise comparisons were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons. This comparison incorporates a comparison between all possible, unique combinations of marketplaces by using all TPS in each marketplace as variables. The generated results entail if there are significant differences in the quality of patents listed on the different marketplaces, as compared to another marketplace. Adjusted p-values are presented in Table 16 - Pairwise Comparisons of Samples. The post hoc analysis revealed statistically significant differences in median TPP scores between; IPMarketplace (mean rank = 770.92) and Ocean (mean rank = 1080.22) (adj. p = .000); IPMarketplace (mean rank = 770.92) and Explore (mean rank = 1047.51) (adj. p = .000); Explore (mean rank = 1047.51) and IAM (mean rank = 842.01) (adj. p = .000); IAM (mean rank = 842.01) and Ocean (mean rank = 1080.22) (adj. p = .000).

Furthermore the post hoc analysis reveals that there are two distinct pairs within which no statistically significant difference is present, namely between; Ocean (mean rank = 1080.22) and Explore (mean rank = 1047.51) (adj. p = 1.000) or between IPMarketplace (mean rank = 770.92) and IAM (mean rank = 842.01) (adj. p = 1.000). For detailed descriptive statistics, see *Table 12 - Pairwise Comparisons of Samples* and *Table 13 - Pairwise Comparisons mean ranks.*

Table 12. Pairwise Comparisons of Samples TPS

Sample 1 - Sample 2	Sig. (p-value)	Adj. Sig. (p-value)
IPMarketplace - Ocean	.000	.001
IPMarketplace - IAM	.290	1.000
IPMarketplace - Explore	.000	.000
Explore - Ocean	.800	1.000
Explore - IAM	.000	.000
IAM - Ocean	.000	.000

Table 13. Pairwise Comparisons mean ranks TPS

Sample	N	Mean rank
Explore	1319	1047.51
IAM	432	842.01
IPMarketplace	87	770.92
Ocean	144	1080.22
Total	*1982*	

Following the results obtained from the Kruskal-Wallis test, we can reject the null hypothesis (H0: the medians of patent scores of the groups are equal). We thereby conclude that the TPS of patents listed on the marketplaces varies with statistical significance.

The conducted Kruskal-Wallis reveals statistically significant differences in the quality of the attracted patents across the marketplaces. Explore, and Ocean attracts listings of significantly better quality than IAM and IPMarketplace when compared one on one. Within the two pairs, e.g. Explore - Ocean, no significant difference is observed. Given the descriptive evidence on a technology area level above, the result is likely not explained by the difference in technology distribution; thus the marketplaces seemingly have different ability to attract high-quality patents.

5 Discussion

Following the results presented in the previous section, descriptive evidence suggests that the patents attracted on all of the four marketplaces on average are below the average quality of the wider population. The conducted Kruskal Wallis allow rejection of the null hypothesis "the medians TPS of the marketplaces are equal". This means that the quality of the attracted patents differs significantly between the marketplaces. Furthermore, the pairwise comparison reveals that patents listed on IP Marketplace and IAM are of significantly lower quality than patents listed on Ocean or Explore. Between the two pairs IAM and IP Marketplace and Ocean and Explore however, no statistically significant differences are observed.

The patent distribution by technology area shows that "Electrical Engineering", followed by "Instruments", are the two technology areas with the most patents available for a transaction on the marketplaces. This skewed technology distribution is visible at all marketplaces except Explore. The observed distribution is expected as a similar distribution is visible also in the patent population, as illustrated in the worldwide patent publication data (WIPO, 2017). Furthermore, a more concentrated inventory at the IAM marketplace was also expected. From the vendor list of IAM, it is evident that the majority of the vendors in the market are active within industries technology areas that are encompassed under the technology area "Electrical Engineering". The concentrated technology distribution is hence likely a result of the vendor concentration following IAM markets vendor screening.

Ocean and IPMarketplace have no such pronounced vendor screening; thus, the technology distribution could be expected to be similar to the distribution of the underlying population. The overall distributions of the two marketplaces share many of the characteristics of the population with "Electrical Engineering", "Instruments" and "Mechanical Engineering" being the largest technology areas. The main deviation observed in the two marketplaces' is the share of "Instruments", the proportion of patents listed being significantly larger than in the patent population. The underlying reason for this distribution cannot be determined by the conducted method. A potential reason for the overrepresentation of patents in "Electrical Engineering", could be the rapid growth and the increased market interest of the ICT industry under the years in scope for the study.

Explore is the marketplace with the most evenly distributed technology distribution. The conducted study provides no answers to the underlying reason for this distribution, but the diverse research being conducted by universities and governmental organization serves as a potential reason. In the absence of reliable transaction data for the full field of patent transactions, no conclusions can be drawn on whether or not the marketplaces patent inventory resembles the transaction rates across the technical fields. This would naturally serve as an interesting area for further investigation to develop an understanding of the marketplaces ability to attract patents suitable for a transaction.

As discussed by the literature, the desired technology distribution is not only a result of the underlying patent population. The desired distribution depends on the participants in the market and their reason for participating. The tradeoff between search cost and diversity in the technology listings discussed by A. Natalicchio et al. (2014) naturally means that the preferred distribution depends on the interest of the buyers and primarily the uncertainty they face as discussed by Boudreau et al. (2011). Transacting patents the knowledge seekers can be expected to face a reasonably low degree of uncertainty and search cost for patents specifically within one technical field hence benefiting from a concentrated inventory in the technical field of interest.

As discussed the three marketplaces IAM, Ocean and IP Marketplace offers relatively concentrated inventories with the inventory of IAM being the most concentrated. The concentrated inventory of patents means that knowledge seekers looking to acquire patents within the technical field "Electrical Engineering" would benefit from a decreased search cost in respect to technology diversity at the three marketplaces and especially at IAM. Explore has the most diverse inventory of patents. The in terms of technology high diversity of listings at Explore increase the search cost of the knowledge seekers as they have to navigate through patents from multiple technical fields to find the patents of interest for the specific transaction. To mitigate the increased search cost imposed by technology diversity, Explore as the other marketplaces divide the patents available for transactions into different technology fields. In the data collection, however, it was found that multiple patents are listed within multiple technology fields limiting the effect of such a mechanism. In terms of technology diversity, one can conclude that the inventory of IAM is best suited to decrease the search cost and enable an efficient market while the diversity observed at Explore risk to increase the search cost an result in a less efficient market.

The study finds descriptive evidence that all four marketplaces under study attract patents of below-average quality as compared to the wider population. The patents listed on the marketplaces Ocean and Explore are of similar quality, or at least no statistically significant difference is found. For IAM and IPMarketplace the attracted patents are of significantly lower quality than the patents listed on Ocean and Explore and as indicated by the descriptive statistics, the quality is substantially worse than the population.

The fact that no marketplaces attract patents of equal or greater quality than the population is a problem that might limit the transaction rates and the emergence of a liquid market for patents. This result is worrisome for anyone with interest in a functioning market for patents. As discussed by Terwiesch and Ulrich (2009), knowledge seekers prefer a few high-quality assets rather than multiple assets of average quality. The four marketplaces studied, show the opposite quality distribution with a high-ratio of low-quality patents and only a few of high quality. The observed quality distribution is thus the opposite of what the knowledge seekers prefer. The quality distribution risks to impose an increased search cost on the knowledge seeker hence limiting the functionality and the efficiency of the markets.

The market intermediaries role in decreasing the search cost is emphasized by Dushnitsky and Klueter (2011) and Hagiu and Yoffie (2013). Attracting primarily patents of below-average quality the value created and the efficiency of the markets under study can be questioned. The quality of the patents listed on the marketplaces implies that the marketplaces cannot be expected to decrease the search costs associated with patent transactions to any greater extent. In fact, the high ratio of low-quality patents risks increasing the search cost of the knowledge seekers as it is hard to distinguish the patents of high-quality in a clutter of low-quality patents. These findings strengthen the relationship between online marketplaces and a clutter of low-quality assets discussed by the literature (Hagiu and Yoffie, 2013).

The observed quality distribution showcase that the four marketplaces under study suffer from some of the inefficiency issues discussed by the MfT literature. The high ratio of low-quality patents implies that the marketplaces do not decrease the search cost. Given the complementary role in the transaction of the marketplaces, a failure to reduce the search cost means that the only value contribution of the marketplaces is to let the knowledge seeker know that a patent is for sale. In the absence of data on the number of facilitated patent transactions on the respective marketplaces, no conclusions can be drawn on whether the clutter of low-quality patents and affects the participant's willingness to engage in the market. With a foundation in previous literature, one can, however, clearly state that the observed quality distribution is worrisome and there is a risk that the market fails to deliver on one of their intended purposes, namely reducing the search cost. There is hence a risk that the four markets under study are inefficient and possibly constitute markets for lemons.

The statistically significant difference in the quality attracted by the different marketplaces is an interesting finding. The underlying reason for the difference in quality among the marketplaces cannot be justified with the used method. Without further research, one can, at this point, merely speculate in the underlying reason. The observed result could be a result of the marketplaces perceived attractiveness to the knowledge owners, it could be a result of the type of actors they attract, or it could be entirely driven by randomness or other factors at this point unknown to the authors. Irrespective of the underlying reason the result is interesting and serves as an interesting area for future research. A deeper understanding of the factors impacting the marketplaces ability to attract high-quality patents is needed. This study confirms some of the efficiency issues raised by the MfT literature and contribute with the findings that current marketplace initiatives fail to attract patents of high-quality. The authors, however, leave it to later contributors to further investigate the underlying reason and to contribute with findings on how markets for patents should be constructed to avoid the observed problem.

This report attempts to explain one part of the puzzle of illiquidity on the markets for patents, namely patent quality issues. The results and conclusion of this report should be interpreted, acknowledging patent quality as one of the multiple cornerstones for an efficient patent market.

Patent quality used as the critical variable and measurement in this report builds on a thorough literature review and well thought through the selection process of patent value indicators. The authors are confident that the chosen matrix for patent value assessment is scientifically justifiable but acknowledge that alternative value indicators exist and might have produced alternative and varying results. One such alternative approach could be to assess the score for each patent value indicator separately instead of aggregating them, resulting in a total patent score as proposed by Zeebroeck (2007). Furthermore, patents are evaluated on an individual patent family level but not seldom are patent sold in bundles or multi-patent lots (Fischer and Leidinger, 2014). Valuing these bundles could paint a different picture of the quality of the sold objects on marketplaces.

6 Conclusion

This section revisits the research question addressed in this study and answers them by pinpointing the most valuable findings.

The first research question; *"In what technology areas are IP marketplaces attracting patents?*", is answered based on data presented in section 5.1.1. The answer to this question is relatively straightforward. Firstly, the pattern is relatively unambiguous, namely that the marketplaces mainly attract patents in the field of ”Electrical Engineering”, and ”Instruments”. This observation is expected, and the technology distribution share similarities with the patenting activity and the broader patent landscape. We can conclude that the marketplaces under study attract patents within relevant technology areas.

The answer to the second research question; *"Do the marketplaces attract patents of relatively high quality?*", is; No, descriptive evidence suggests that the marketplaces do not attract patents of relatively high quality. Our results indicate the opposite, namely that the marketplaces are attracting patents of relatively low quality, or at best patents near average quality. With the role of marketplaces as search costs optimizers and facilitators of transactions, this is a worrying result. To defend the existence of the marketplaces under study, one would have hoped to see that they attracted patents of relatively high quality.

The answer to the third research question; *"Does the quality of patents vary between marketplaces?"*, can be answered with statistical significance. Yes, the quality of patents varies between marketplaces, not between all but between two distinct pairs of marketplaces. This result is exciting and, according to the authors, the most interesting area for future research stemming from this report is; by which means can patent marketplaces influence the patents that they attract from a quality perspective?

In conclusion, the short answer to the main research question; *"Do IP marketplaces attract high-quality patents and thereby create prerequisites to remedy the liquidity problem?"*, is "no". The findings indicate that the marketplaces attract a clutter of patents of below-average quality; thus, there is a risk that the markets constitute markets for lemons rather than potential solutions to the illiquid patent market. We believe that marketplaces have to put their effort into actively working to attract high-quality patent listings to maximize their potential as intermediaries in a complex market structure.

7 Appendices

7.1.1 Appendix 1. Distribution of sample patents per technology area and marketplace

Explore	
Number of patents	Technology area
185	Biotechnology
119	Chemistry
15	Civil engineering
233	Electrical Engineering
158	Electrical engineering (2)
317	Instruments
96	Mechanical Engineering
8	Other consumer goods
188	Pharmaceuticals
0	Furniture, games

IAM	
Number of patents	Technology area
0	Biotechnology
0	Chemistry
1	Civil engineering
341	Electrical Engineering
1	Electrical engineering (2)
74	Instruments
12	Mechanical Engineering
0	Other consumer goods
1	Pharmaceuticals
2	Furniture, games

IPMarketplace	
Number of patents	Technology area
0	Biotechnology
1	Chemistry
2	Civil engineering
42	Electrical Engineering
4	Electrical engineering (2)
13	Instruments
10	Mechanical Engineering
7	Other consumer goods
5	Pharmaceuticals
3	Furniture, games

Ocean	
Number of patents	Technology area
1	Biotechnology
6	Chemistry
3	Civil engineering
80	Electrical Engineering
11	Electrical engineering (2)
23	Instruments
10	Mechanical Engineering
1	Other consumer goods
4	Pharmaceuticals
5	Furniture, games

7.1.2 Appendix 2. Distribution of total sample patents per technology area

Technology area	Patent count	% ot total distribution
Biotechnology	186	9,38%
Chemistry	126	6,36%
Civil engineering	21	1,06%
Electrical Engineering	696	35,12%
Electrical engineering (2)	174	8,78%
Instruments	427	21,54%
Mechanical Engineering	128	6,46%
Other consumer goods	16	0,81%
Pharmaceuticals	198	9,99%
Furniture, games	10	0,50%
Total	***1982***	

7.1.3 Appendix 3. Sample Export Format

The following data were extracted for every patent number:

- Questel unique family ID (FAN)
- Patent family number
- Main IPC class
- All IPC classes
- Technology domain
- Non-self-citing patents - by examiner (value indicator variable)
- Citing patents - Relevancy categories (value indicator variable)
- Countries/authorities - Count (value indicator variable)
- Litigation (value indicator variable)
- Opposition (value indicator variable)
- Earliest priority date

Ref Sample Export Format

- Questel unique family ID (FAN)
- Non-self-citing patents - by examiner (value indicator variable)
- Citing patents - Relevancy categories (value indicator variable)
- Countries/authorities - Count (value indicator variable)
- Litigation (value indicator variable)
- Opposition (value indicator variable)

- Earliest Priority date

7.1.4 Appendix 4. Abbreviations

Generic

CIT - raw number citations
OR - raw number office rejections
NFM - raw number family members
LIT - raw number litigations

a - technology area
t - year of first priority
i - denotes sample patent
u - denotes reference patent
m - denotes marketplace sample
r - denotes reference sample

Sample marketplaces

SPm - e.g - ”SP,explore” - Marketplace sample
SPm,a, - e.g - ”SP,explore,chemistry,” - One technology area within a specific marketplace sample
SPi,m,a,t - e.g- ”SP01,explore,chemistry,2001” - Sample patent number 01 from market place explore within technology area chemistry from year 2001

LITip - e.g. ”LIT01” - Percent rank score for litigations for sample patent 01
CITip - e.g. ”CIT01” - Percent rank score for citations for sample patent 01
ORip - e.g. ”OR01” - Percent rank score for office rejections for sample patent 01
NFMip - e.g. ”NFM01” - Percent rank score for number of family members for sample patent 01

TPS SPi,m,a,t - e.g. ”TPS SP01,explore,chemistry,2001” - Total patent score for sample patent 01 within chemistry
TPS SPi,m,a,t = AVERAGE(SUM LITip, CITip, ORip, NFMip)

Reference sample

RSa - e.g. ”RS,chemistry” - Reference sample for chemistry all years
RSa,t - e.g. ”RS,chemistry,2001” - Reference sample chemistry for year 2001
RPu,a,t - e.g. ”RP01,chemistry,2001” - Reference patent 01 within chemistry from 2001

LITup - e.g. ”LIT11” - Percent rank score for litigations for reference patent 11

CITup - e.g. ”CIT11” - Percent rank score for citations for reference patent 11
ORup - e.g. ”OR11” - Percent rank score for office rejections for reference patent 11
NFMup - e.g. ”NFM11” - Percent rank score for number of family members for reference patent 11

TPS RPu,a,t - e.g. ”TPS RP01,chemistry,2001” - Total patent score for reference patent 11
TPS RPu,a,t = AVERAGE(SUM LITup, CITup, ORup, NFMup)

7.1.5 Appendix 5. IPC and technology concordance table

Table 2: New concept of technology classification, update: May 2008

	Area, field	IPC code
I	**Electrical engineering**	
1	Electrical machinery, apparatus, energy	F21#, H01B, H01C, H01F, H01G, H01H, H01J, H01K, H01M, H01R, H01T, H02#, H05B, H05C, H05F, H99Z
2	Audio-visual technology	G09F, G09G, G11B, H04N-003, H04N-005, H04N-009, H04N-013, H04N-015, H04N-017, H04R, H04S, H05K
3	Telecommunications	G08C, H01P, H01Q, H04B, H04H, H04J, H04K, H04M, H04N-001, H04N-007, H04N-011, H04Q
4	Digital communication	H04L
5	Basic communication processes	H03#
6	Computer technology	(G06# not G06Q), G11C, G10L
7	IT methods for management	G06Q
8	Semiconductors	H01L
II	**Instruments**	
9	Optics	G02#, G03B, G03C, G03D, G03F, G03G, G03H, H01S
10	Measurement	G01B, G01C, G01D, G01F, G01G, G01H, G01J, G01K, G01L, G01M, (G01N not G01N-033), G01P, G01R, G01S; G01V, G01W, G04#, G12B, G99Z
11	Analysis of biological materials	G01N-033
12	Control	G05B, G05D, G05F, G07#, G08B, G08G, G09B, G09C, G09D
13	Medical technology	A61B, A61C, A61D, A61F, A61G, A61H, A61J, A61L, A61M, A61N, H05G
III	**Chemistry**	
14	Organic fine chemistry	(C07B, C07C, C07D, C07F, C07H, C07J, C40B) not A61K, A61K-008, A61Q
15	Biotechnology	(C07G, C07K, C12M, C12N, C12P, C12Q, C12R, C12S) not A61K
16	Pharmaceuticals	A61K not A61K-008
17	Macromolecular chemistry, polymers	C08B, C08C, C08F, C08G, C08H, C08K, C08L
18	Food chemistry	A01H, A21D, A23B, A23C, A23D, A23F, A23G, A23J, A23K, A23L, C12C, C12F, C12G, C12H, C12J, C13D, C13F, C13J, C13K

	Area, field	IPC code
I	**Electrical engineering**	
19	Basic materials chemistry	A01N, A01P, C05#, C06#, C09B, C09C, C09F, C09G, C09H, C09K, C09D, C09J, C10B, C10C, C10F, C10G, C10H, C10J, C10K, C10L, C10M, C10N, C11B, C11C, C11D, C99Z
20	Materials, metallurgy	C01#, C03C, C04#, C21#, C22#, B22#
21	Surface technology, coating	B05C, B05D, B32#, C23#, C25#, C30#
22	Micro-structure and nano-technology	B81#, B82#
23	Chemical engineering	B01B, B01D-000#, B01D-01##, B01D-02##, B01D-03##, B01D-041, B01D-043, B01D-057, B01D-059, B01D-06##, B01D-07##, B01F, B01J, B01L, B02C, B03#, B04#, B05B, B06B, B07#, B08#, D06B, D06C, D06L, F25J, F26#, C14C, H05H
24	Environmental technology	A62D, B01D-045, B01D-046, B01D-047, B01D-049, B01D-050, B01D-051, B01D-052, B01D-053, B09#, B65F, C02#, F01N, F23G, F23J, G01T, E01F-008, A62C
IV	**Mechanical engineering**	
25	Handling	B25J, B65B, B65C, B65D, B65G, B65H, B66#, B67#
26	Machine tools	B21#, B23#, B24#, B26D, B26F, B27#, B30#, B25B, B25C, B25D, B25F, B25G, B25H, B26B
27	Engines, pumps, turbines	F01B, F01C, F01D, F01K, F01L, F01M, F01P, F02#, F03#, F04#, F23R, G21#, F99Z
28	Textile and paper machines	A41H, A43D, A46D, C14B, D01#, D02#, D03#, D04B, D04C, D04G, D04H, D05#, D06G, D06H, D06J, D06M, D06P, D06Q, D99Z, B31#, D21#, B41#
29	Other special machines	A01B, A01C, A01D, A01F, A01G, A01J, A01K, A01L, A01M, A21B, A21C, A22#, A23N, A23P, B02B, C12L, C13C, C13G, C13H, B28#, B29#, C03B, C08J, B99Z, F41#, F42#
30	Thermal processes and apparatus	F22#, F23B, F23C, F23D, F23H, F23K, F23L, F23M, F23N, F23Q, F24#, F25B, F25C, F27#, F28#
31	Mechanical elements	F15#, F16#, F17#, G05G
32	Transport	B60#, B61#, B62#, B63B, B63C, B63G, B63H, B63J, B64#
V	**Other fields**	
33	Furniture, games	A47#, A63#
34	Other consumer goods	A24#, A41B, A41C, A41D, A41F, A41G, A42#, A43B, A43C, A44#, A45#, A46B, A62B, B42#, B43#, D04D, D07#, G10B, G10C, G10D, G10F, G10G, G10H, G10K, B44#, B68#, D06F, D06N, F25D, A99Z
35	Civil engineering	E02#, E01B, E01C, E01D, E01F-001, E01F-003, E01F-005, E01F-007, E01F-009, E01F-01#, E01H, E03#, E04#, E05#, E06#, E21#, E99Z

Note: This table is available in Excel format on: www.wipo.int/ipstats/en/statistics/patents
Users are requested cite WIPO as the source in the following manner: "Source: WIPO IPC-Technology Concordance Table".

7.1.6 Appendix 6. Published patent applications worldwide by field of technology

Published patent applications worldwide by field of technology

Field of technology	2005	2010	2015	Share (%) of 2015	Average growth (%) 2005-15
Electrical Engineering					
Electrical machinery, apparatus, energy	89,962	110,667	176,457	7.0	7.0
Audio-visual technology	87,442	72,811	75,133	3.0	-1.5
Telecommunications	60,638	54,162	50,786	2.0	-1.8
Digital communication	53,654	75,728	123,258	4.9	8.7
Basic communication processes	17,632	15,471	15,661	0.6	-1.2
Computer technology	105,158	121,224	187,007	7.4	5.9
IT methods for management	18,125	22,829	42,270	1.7	8.8
Semiconductors	67,453	71,547	77,542	3.1	1.4
Instruments					
Optics	69,650	60,613	63,590	2.5	-0.9
Measurement	61,548	75,815	123,986	4.9	7.3
Analysis of biological materials	12,524	11,422	15,200	0.6	2.0
Control	26,676	28,099	49,593	2.0	6.4
Medical technology	69,527	77,944	110,109	4.4	4.7
Chemistry					
Organic fine chemistry	57,323	54,253	63,603	2.5	1.0
Biotechnology	38,296	39,068	55,499	2.2	3.8
Pharmaceuticals	73,701	71,276	102,790	4.1	3.4
Macromolecular chemistry, polymers	27,965	28,531	45,576	1.8	5.0
Food chemistry	22,391	27,659	63,150	2.5	10.9
Basic materials chemistry	39,075	44,451	82,202	3.3	7.7
Materials, metallurgy	29,406	37,377	63,835	2.5	8.1
Surface technology, coating	27,962	32,222	42,671	1.7	4.3
Micro-structural and nano-technology	2,145	3,366	4,725	0.2	8.2
Chemical engineering	33,619	36,887	60,479	2.4	6.0
Environmental technology	20,880	25,776	42,979	1.7	7.5
Mechanical Engineering					
Handling	43,339	42,382	68,535	2.7	4.7
Machine tools	36,024	42,237	76,060	3.0	7.8
Engines, pumps, turbines	41,418	48,133	65,336	2.6	4.7
Textile and paper machines	38,280	30,643	38,380	1.5	0.0
Other special machines	46,948	49,107	89,750	3.6	6.7
Thermal processes and apparatus	24,238	29,092	42,876	1.7	5.9
Mechanical elements	42,620	45,746	69,589	2.8	5.0
Transport	65,748	66,359	105,294	4.2	4.8
Other fields					
Furniture, games	42,116	41,695	61,930	2.5	3.9
Other consumer goods	33,450	31,915	50,882	2.0	4.3
Civil engineering	51,225	56,268	90,185	3.6	5.8
Unknown	20,298	29,537	20,305	0.8	0.0
Total	**1,598,456**	**1,712,312**	**2,517,223**	**100.0**	**4.6**

Note: Data refer to published patent applications. There is a minimum delay of 18 months between the application date and the publication date. WIPO's IPC technology concordance table was used to convert IPC symbols into 35 corresponding fields of technology (see Annex A for details).

Sources: WIPO Statistics Database and EPO PATSTAT database, October 2017.

8 Sources

8.1 Journals

AON, 2019. 2019 Intangible Assets Financial Statement Impact Comparison Report GLOBAL EDITION.

Archontopoulos, E., D. Guellec, N. Stevnsborg, B. van Pottelsberghe de la Potterie, N. van Zeebroeck. 2007. When Small is Beautiful: Measuring the Evolution and Consequences of the Voluminosity of Patent Applications at the EPO. Information Economics and Policy Vol. 19 (2): 103-132.

Arora, A. and Gambardella, A., 2010. Ideas for rent: an overview of markets for technology. Industrial and Corporate Change, 19(3), pp.775-803.

Bell, E., Bryman, A., Harley, B. and Bryman, A., 2019. Business Research Methods. Oxford: Oxford University Press.

Bessen, J., 2008. The value of U.S. patents by owner and patent characteristics. Research Policy, 37(5), pp.932-945.

Boudreau, K.J.,Lacetera,N.,Lakhani,K.R.,2011.Incentives and problem uncertainty in innovation contests: an empirical analysis.Manage.Sci.57,843–863.

Boudreau, K.J.,Lakhani,K.R.,2009. How to manage outside innovation. MIT Sloan Manage. Rev.50,69–76.

Bressel M. and King K. Banking on IP? The role of intellectual property and intangible assets in facilitating business finance. The Intellectual Property Office 2013.

Bronwyn H. Hall. 2005. Market value and patent citations. UC Berkeley, NBER, and IFS UC Berkeley, NBER, and IFS; Department of Economics 549

CAMPBELL, R. S. AND NIEVES, A. L. "Technology Indicators Based on Patent Data: The Case of Catalytic Converters--Phase I Report: Design and Demonstration." Battelle, Pacific Northwest Laboratories, Sept. 1979.

Chesbrough, H. and E. Smith, 2000, Patent and license exchange: Enabling a global IP marketplace. Harvard Business School Case No. 601019.

Cotropia, C. and Schwartz, D., 2018. Patents Used in Patent Office Rejections as Indicators of Value. SSRN Electronic Journal,.

de Rassenfosse, G., 2010. How SMEs Exploit Their Intellectual Property Assets: Evidence from Survey Data. SSRN Electronic Journal,.

Dunn, O., 1964. Multiple Comparisons Using Rank Sums. Technometrics, 6(3), pp.241-252.

DUSHNITSKY, G. and KLUETER, T., 2011. Is There an eBay for Ideas? Insights from Online Knowledge Marketplaces. European Management Review, 8(1), pp.17-32.

Dushnitsky, G. and Klueter, T., 2017. Which industries are served by online marketplaces for technology?. Research Policy, 46(3), pp.651-666.

Fischer, T. and Leidinger, J., 2013. Testing patent value indicators on directly observed patent value—An empirical analysis of Ocean Tomo patent auctions. Research Policy, 43(3), pp.519-529.

Frey, K., Lüthje, C. and Haag, S., 2011. Whom Should Firms Attract to Open Innovation Platforms? The Role of Knowledge Diversity and Motivation. Long Range Planning, 44(5-6), pp.397-420.

Gambardella et. al (2008). The value of European patents. European Management Review (2006) 5,69-84 0 2008 EURAM Palgrave Macrnillan Ltd. All rights reserved 1740-4754/08

Gans, J. and Stern, S., 2009. Is There a Market for Ideas?. SSRN Electronic Journal,.

GEORGE A. AKERLOF. 1970. The market for “lemons”: Quality uncertainty and the market mechanism. Quarterly Journal of Economics. Aug70, Vol. 84 Issue 3, p488-500. 13p

Hagiu, A. and Yoffie, D., 2013. The New Patent Intermediaries: Platforms, Defensive Aggregators, and Super-Aggregators. Journal of Economic Perspectives, 27(1), pp.45-66.

Harhoff, D., F.M. Scherer and K. Vopel (2002), Citations, Family Size, Opposition and the

Harhoff, D., Narin, F., Scherer, F., Vopel, K., 1999. Citation frequency and thevalue of patented innovation. Review of Economics and Statistics 81, 511–515.

James Bessen (2005) The value of U.S. patents by owner and patent characteristics

Justus Baron, Henry Delcamp. (2012). Patent quality and value in discrete and cumulative innovation. Scien-tometrics, Springer Verlag, 2012, 90 (2), pp.581-606. 10.

Lanjouw, J. and M. Schankerman. 2004. Patent Quality and Research Productivity: Measuring Innovation with Multiple Indicators. The Economic Journal 114: 441–465.

Lerner, J. (1994) The importance of patent scope: an empirical analysis

Love, B., Richardson, K., Oliver, E. and Costa, M., 2019. An Empirical Look at the 'Brokered' Market for Patents. SSRN Electronic Journal,.

Murphy, W. (2012). Patent valuation : Improving Decision Making Through Analysis. Hoboken, N.J: Wiley. https://ebookcentral.proquest.com/lib/chalmers/reader.action?docID=821768

Nambisan, S., Sawhney, M., 2007. The Global Brain: Your Roadmap for Innovating Faster and Smarter in a Networked World. Wharton School Publishing, Philadelphia.

Natalicchio, A., Messeni Petruzzelli, A. and Garavelli, A., 2014. A literature review on markets for ideas: Emerging characteristics and unanswered questions. Technovation, 34(2), pp.65-76.

OECD (2009), OECD Patent Statistics Manual, OECD Publishing, Paris,https://doi.org/10.1787/9789264056442-en.

Parchomovsky, Gideon, and Richard Polk Wagner. 2005. "Patent Portfolios." University of Pennsylvania Law Review 154(1): 1–78.

Rivette, K., Kline, D., 2000. Discovering new value in intellectual property. Harv.Bus. Rev. 78 (1), 54–146.

Roth, A., 2008. What Have We Learned from Market Design?. The Economic Journal, 118(527), pp.285-310.

Solomon, D. and Marcowitz-Bitton, M., 2014. Intellectual Property Securitization. SSRN Electronic Journal,.

Terwiesch, C., Ulrich, K.T., 2009. Innovation Tournaments: Creating and Selecting Exceptional Opportunities. Harvard Business School Publishing, Boston.

Terwiesch, C., Xu, Y., 2008. Innovation contests, openinnovation, and multiagent problem solving. Manage.Sci.54,1529–1543. USPTO. 2020. Increase in patenting activity https://www.uspto.gov/web/offices/ac/ido/oeip/taf/us_stat.htm van Zeebroeck, N., 2007. The puzzle of patent value indicators. Economics of Innovation and New Technology, 20(1), pp.33-62.

WIPO, 2017. WORLD INTELLECTUAL PROPERTY INDICATORS 2017

8.2 Electronic sources

Import.io. 2020. Web Data Integration - Import.Io - Data Extraction, Web Data, Web Harvesting, Data Preparation, Data Integration. [online] Available at: <https://www.import.io> [Accessed 14 May 2020].

Innovation, S. and Innovation, S., 2020. [online] Ised-isde.canada.ca. Available at: <https://ised-isde.canada.ca/ipm-mcpi/about-apropos?lang=en> [Accessed 14 May 2020].

Ip-marketplace.org. 2020. IP-Marketplace. [online] Available at: <https://ip-marketplace.org> [Accessed 14 May 2020].

Ocean Tomo. 2020. Ocean Tomo | The Intellectual Capital Merchant Banc™ Firm. [online] Available at: <https://www.oceantomo.com> [Accessed 14 May 2020].

Oecd.org. 2015. Enquiries Into Intellectual Property'S Economic Impact. [online] Available at: <http://www.oecd.org/sti/ieconomy/KBC2-IP.Final.pdf> [Accessed 23 March 2020].

Office EPO., 2020. B-X, 9.2.1 Particularly Relevant Documents - Guidelines For Examination. [online] Epo.org. Available at: <https://www.epo.org/law-practice/legal-texts/html/guidelines/e/b_x_9_2_1.htm> [Accessed 14 May 2020].

Orbit.com. 2020. Orbit. [online] Available at: <https://www.orbit.com/?nocache=1589460065186#PatentRegularAdvancedSearchPage> [Accessed 14 May 2020].

Wipo.int. 2008. IPC And Technology Concordance Table. [online] Available at: <https://www.wipo.int/meetings/en/doc_details.jsp?doc_id=117672> [Accessed 14 May 2020].

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