Minimum Qualitative Variables to Value Patents by Technology-Based Firms

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Abstract: Since the 1990's, intangible assets such as patents have taken on importance in organizations and, as a result, several stakeholders are increasingly concerned about protecting, valuating, commercializing and negotiating technologies developed by patenting processes. This study aims to establish Minimum Qualitative Variables (MQVs) to support the valuation of patents by technology-based firms. The method to determine the MQVs was qualitative and based on a correlation matrix between MQVs identified in the literature and those suggested by experts. The results indicate that identifying such variables, especially the legal kind, is crucial to the valuation process because they suggest the possibility of producing and commercializing the technology in a given geographical context.

Keywords: minimum qualitative variables; technology valuation; patent valuation; intangible assets; technology-based firms.

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Introduction

A patent is a legal document issued by a government that grants a temporary right limited to a geographic area to inventors for technical solutions to specific problems, new or improved products or processes. It prevents others from copying, using, producing, distributing or selling the solution without the permission of the patentee. In that sense, the World Intellectual Property Organization (WIPO) reported that worldwide patent applications in 2015 presented an approximate growth of 8% with respect to 2014, a figure that continues to rise every year (WIPO, 2016). In turn, Colombia saw a 3.9% growth in the number of patent applications between 2014 and 2015 (WIPO, 2016). In response to the global situation and the context of this study (Medellín, Colombia), a new dynamic has emerged in several technology-based firms to protect, value, negotiate and commercialize their intangible assets.

Patent valuation is greatly important to knowledge- and technology-producing industries, inventors, and higher education institutions. It requires tools or orientation that help determine a value as accurately and objectively as possible. This means that valuating industrial property, such as patents, is required by the patentee as well as those interested in exploiting it in order to make commercial, financial and administrative decisions that lead to profit growth.

Specifically in the field of technology management, the importance of knowing the value of patents has stood out. Values should be established before the negotiation because at that point is when those interested in making profit out of the patented technology request necessary and relevant information to make the decision whether to invest in the right to produce of commercialize such technology. In addition, patentees use this information to know the viability and competitive advantages of the patented technology and negotiate it successfully. In that sense, several stakeholders show their interest in negotiating and commercializing the patents. Therefore, they need to know and follow the existing valuation methods, mainly purely quantitative such as income, costs and real options valuations (Mard, 2000; Pavri, 1999). However, these financial methods, by which obtaining information is apparently easy and which provide greater certainty because they are based on numerical data, have been designed for only some specific areas and technologies. This fact causes difficulties for other types of valuation (Jiménez & Castellanos, 2013). This is the case of patents, because they present high degrees of uncertainty as they are intangible assets (Pitkethly, 1997).

As a result of the considerations above, it is relevant to determine Minimum Qualitative Variables (MQVs) based on a comparison between the qualitative variables in the literature and those used in practice. Thus, by means of a coincidence matrix, the minimum variables for valuating patents by technology-based firms were identified in this study. Based on such variables, inventors will be able to determine the best option to negotiate and commercialize the patent with those interested in developing and exploiting it to generate economic profit.

Theoretical Framework

Gu and Lev (2011) point out that, in the past, the organizations prepared financial statements to know the real situation of firms. However, in accordance with accounting regulations, intangible assets were considered expenses, investment in R&D was neglected, partnerships or collaborative work lacked information for completion, or exposure to risk was not considered. Nevertheless, since the late 20th and early 21st century valuating intangible technological assets has become more relevant in the current economic dynamic because said assets took on importance for organizations (Correa, Arango & Castaño, 2011).

To illustrate this trend, Hall (1992) and Teece (1998) maintain that intangible technological assets, such as patents, promote competitive advantages and value generation. Additionally, King (2003) considers intangible assets to be the most important type of asset for many firms, which results in a competitive advantage. However, they might be underestimated, mismanaged and insufficiently used.

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As a result, third-generation universities[1] and firms are paying more attention to intangible resources, because they represent most of their assets and valuating them contributes to management improvement and decision making (Garcia, Rodríguez, Vallejo & Arregui, 2008). Furthermore, valuating intangible assets, specifically the products of R&D efforts, such as patents, require a follow-up process adopting adequate methods and tools that enable to measure their value (Correa et al., 2011).

Patents

The WIPO (2006) reports that in 1474 in the Republic of Venice the first law to protect the rights of inventors was passed, as this was an important hub for artists, merchants and scientists. This is currently known as the Intellectual Property (IP) law, which is divided into copyright and industrial property. The former protects literary and artistic works, and the latter is a collection of the rights that protect industrial designs, brands and patents. More specifically, a patent is defined as

> "an exclusive right over a product or process that usually provides a new way to do something or offers a new technical solution to a problem. In order to patent something, the technical information about the invention should be disclosed to the public in a patent application. The patentee may grant permission or a license other parties to use the invention under mutually agreed terms. The owner of the patent may also sell the right over the invention to someone else, who in turn becomes the new patent holder. Once the patent expires, the protection ends and the invention enters the public domain, i.e. anyone can commercial exploit the invention without infringing the patent (WIPO, 2018, para. 1).

The World Intellectual Property Organization also mentions that patents disseminate new knowledge, help third-parties solve problems, and foster the advance of technology and science in the territory where they are granted' which enables to promote them as essential elements in value creation for developed economies (Lev, 2000; Plata, 2005). Additionally, patents have been considered to be an indicator of innovation widely used by developed and developing countries (Anduray & Pedroza, 2018; Galasso & Schankerman, 2018; Lee, Kwon, Kim, & Kwon, 2018; Levitt & Pauling, 2018; Wang, 2018)

Technology Valuation

Li and Chen (2006) explain that technology valuation comprises technical and financial elements as well as strategic technology management, which makes it an important component in decision making. The investment decision becomes a matter of judgement because of the uncertainty it produces, the flexibility of the business model and possible changes in the context. These firms tend to fail because they adopted traditional investment valuation methods, such as discounted cash flow (Eichner, Gemünden y Kautzsch, 2007). Likewise, Angelo, Domenico, Luigi and Iacobelli (2008) claim that technology valuation produces a future value that is used to promote technology transfer.

LES (2008) argues that valuation is useful for establishing the specific value of a technological asset, which is different from the process by which the sale price of the product or service is fixed, known as pricing. Additionally, the goal of technology valuation (TV) is providing a value that prevents risks intrinsic to the innovation process (Elói & Santiago, 2008, cited by Jiménez & Castellanos, 2011, 2013). This type of valuation is in constant progress and evolves as new meanings of the words that compose the term are defined: valuation and technology (Jiménez & Castellanos, 2013). In that sense, TV may be seen as a process, thus characteristics of dynamicity, flexibility, temporariness and acceptability can be attributed to it (Jiménez & Castellanos, 2013, 2014). As a consequence, TV is necessary in several scenarios, such as technology analysis and prospecting, technology transfer and technical development strategies (Schuh, Schubert, & Wellensiek, 2012).

According to Jiménez and Castellanos (2011, 2013, 2014), TV can be defined as the value and impact produced by the technology in a specific context, not only in economic, but also in social and environmental terms. Besides, all the hard (tangible) and soft (intangible) components that comprise the technology should be taken into account. The intangible components become essential parts of knowledge valuation as they add value to the new and/or improved product, service or process (PricewaterhouseCoopers, 2007). In addition to the considerations above and according to Jiménez and Castellanos (2011, 2013, and 2014), the methods to value technology are diverse and depend on the variables and the context where they are adopted.

Table 1 lists some patent valuation methods sorted from most to least used in the last decade (Andersen, 1992; Chaplinsky & Payne, 2004; Correa et al., 2011; B. H. Hall, Jaffe, & Trajtenberg, 2001; Hastbacka, 2004; ip4inno, 2008; Vélez, 2013). It also includes the name of the patent valuation method, its definition, when it is used, and some advantages and disadvantages.

(1) Third-generation universities are those whose mission is not only education and research, but also extension and research applied to the public and private sectors to respond to society's challenges and solve its problems (Duarte y Navarro, 2014).

Table 1. Patent valuation methods.

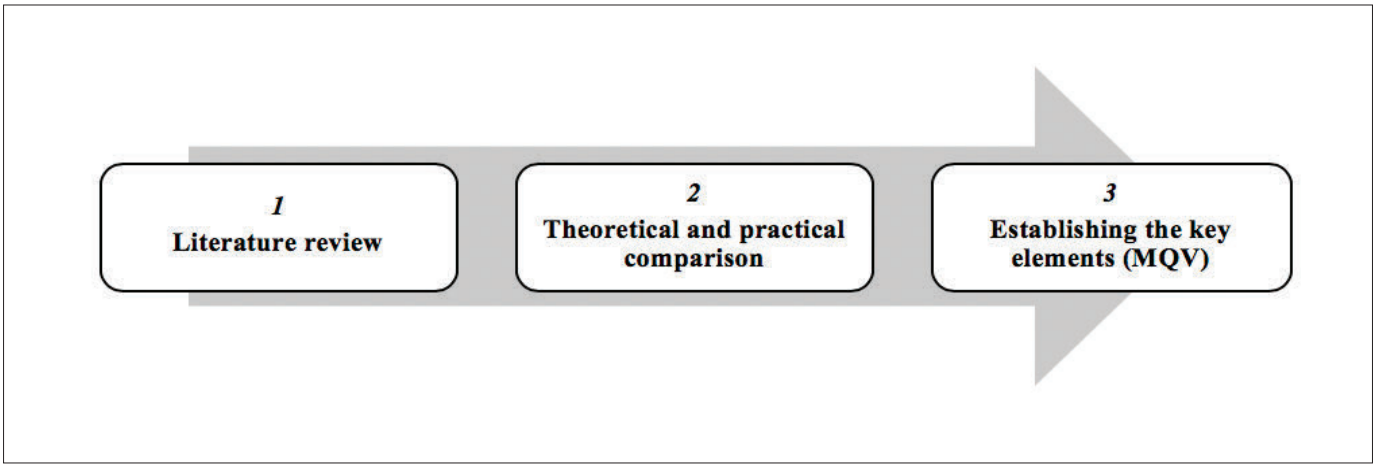
Quantitative	Cost-based (Mard, 2000; Pavri, 1999)	The patent's value is determined based on the internal and external costs for the company during production.	When such internal and external information about the firm is obtained.	• Visible in the company's accounting records. • Raises awareness on the existence of the patent.	• No direct correlation between the development costs and future income. • Historical costs are not reliable because of the fast advance of technology. • Sometimes the costs of the process cannot be forecasted.
Quantitative	Market-based (Mard, 2000; Pavri, 1999)	The value of the patent is determined by comparison with the prices recently reached by similar operations.	When there is a market to compare it to.	• Relatively simple. • Useful to validate other methods. • Potential to be used in the future because of changes in the firm's strategy.	• Sometimes the reference prices are not publicly disclosed. • The royalty rates are the same. • The valuation could be based on the costs and not the patent.
Quantitative	Income-based (Mard, 2000; Pavri, 1999)	The potential income derived from the patent is measured.	When access to financial statements is available.	• Mostly preferred by companies. • Relatively simple if the assets have already been produced. • Cash flows can be identified and predicted. • Separating financial from physical assets is easy.	• Robust. • Difficult to adopt in environments with high uncertainty. • The resulting value may be uncertain as it is based on a hypothesis. • Determining the appropriate rate to pay royalties becomes difficult. • Separating assets from intangible advantages is difficult.
Qualitative	Qualitative valuation (Nielsen, 2004)	Determines a reference value with different scoring and evaluation factors.	When the patent's value is to be classified.	• Relative simplicity. • No complex methods required. • Public access to the information. • Values any type of intellectual property. • Risks and opportunities can be valued.	• Dependent on valuators' expertise. • Relevant indicators need to be identified. • The quality depends on the provided information. • Low market acceptance.

Source: Authors' own work based on the references in the table.

Method

This is a qualitative study supported by conceptual contrastable variables (Tamayo & Tamayo, 1999). Based on the works by Maxwell (2008) and Snow and Thomas (1994), secondary sources related to the subject matter were used to identify and compare several existing valuation methods in the literature, which in turn enabled to reveal their key components. Subsequently, the obtained data were interpreted by triangulation (Stake, 2007); i.e. based on the information in secondary and primary sources, variables' convergence patterns were identified, thus an interpretation of the subject matter was confirmed. Furthermore, according to Patton (2002), using a single strategy is vulnerable to bias and failure, while triangulation enables to see the problem from different angles and increase the validity of the results (Okuda & Gómez-Restrepo, 2005). The minimum qualitative variables for patent valuation processes proposed in this study were based on the interpretation of the data recollected in the methodological process. Figure 1 presents the stages of the project.

Figure 1: *Project stages.*



Source: Authors' own work, based on Martínez (2006).

Results

After the review of the basic concepts, Table 2 was prepared with the collection of theoretical qualitative variables. The first column lists the theoretical qualitative variables; the second, the category the variable belongs to according to IPscore®2.2[2] (European Patent Office, 2010); and the third, the responsible for providing the information of that variable.

(2) IPscore®2.2 is a patent and technology project valuation tool developed by the European Patent Office (2010).

Table 2: *Theoretical qualitative variables.*

Theoretical qualitative variables	Category	Responsible
Number of times the patent is cited in similar intellectual property	Basic information	Inventor
Number of claims		
Quality of the claims		
Size of the patent family		
Number of patent oppositions		
Number of similar technologies		
Patent status (filed or granted)		
Patent's lifecycle		
The term of patent can be extended		
Geographical coverage		
Protects a superior technology	Technical Level	Inventor and patent agent
Uses in other fields		
Degree of validation		
Level of novelty		
Market's demand	Market	Inventor and Marketing Dept.
Reasonable production cost		
Access to commercialization channels		
Increase in the value of the product it is applied to		
Possible substitute products		
Lifecycle in the market		
Time to reach the target market share		
Market growth		
Number of acts and regulations in favor of the patent		
Number of acts and regulations against the patent		
Real market size		
Future market size		
Price the consumer would pay	Profitability	Inventor and Marketing Dept.
Expected cash flow		
Expected benefit(s)		
Technological surveillance skills	Capacity and resources	Marketing Dept. and the Management
Financial capacity to support production abroad		
Resources and capacity to defend the patent from infringing individuals		
Inventors' interest in participating		
Production capacity		
Potential to be offensively used	Entrepreneurial tactics	Marketing Dept. and the Management
Exploitation routes (licenses, sell or direct use)		
Negotiation skills		

Source: Authors' own work, based on Angelo et al. (2008); Correa et al. (2011); Edvinsson and Sullivan (1996); European Patent Office (2010); Gu and Lev (2011); Hastbacka (2004); ip4inno (2008); Lai and Che (2009); Leadbeater (1999); Mard (2000); Nielsen (2004); Park and Park (2004); Pavri (1999); Pitkethly (1997); and Plata (2005), among others.

Besides, interviews were used to collect relevant information and identify the qualitative variables used in practice. Each of the interviewed experts were selected because their profile and occupation were directly related to technology management processes (Table 3).

Table 3. Experts' profiles.

Expert	Profile
1	Eafit University Economics graduate, Specialist in finances and Master in Financial Management. She currently works as a consultant and technology transfer director for the Innovation, Consultancy and Entrepreneurship Center (CICE, by its initials in Spanish) at Eafit University.
2	Lawyer, Specialist in Business Law, consultant with experience in contracting, intellectual property, competition law and consumer rights. Consultant and Professor of Intellectual Property at ITM and UPB. Consultant for the Intellectual Property program in Colombia of the Inter-American Development Bank. Besides, she has been an independent consultant for education institutions and companies in the private sector.
3	Business Administration graduate and Project Management Specialist from Eafit University. Specialist in Technology Innovation Management from UPB and M.Sc. student in Technology Management at UPB. Entrepreneur and businessman with more than 10 years' experience in consulting services regrading technology marketing, sales, administration, strategy and management. He is devoted to developing businesses based on R&D results of big companies as founder and senior consultant for Estratek.
4	Business Administration graduate from Medellín University and Master in Technology Management from UPB, Innovation Manager at Medellín University, experienced in R&D+i project management.
5	Business Administrator, Specialist in Logistics and expert consultant in Technological Surveillance and Competitive Intelligence (TSCI) with more than 7 years' experience in studies conducted in the real sector and the academia regarding TSCI. Advanced knowledge of Intellectual Property. She has worked with the WIPO and the Superintendence of Industry and Commerce. External consultant for Tecnnoca, Immagina and Sapiencia, among other organizations, and consultant in Technology Transfer processes.
6	Product Design Engineer from Eafit University and Industrial Design Associate from ITM with more than 10 years' corporate experience in research, design, development and promotion of new or enhanced technical solutions to diverse problems in metalworking, polymers and elastomers, furniture, and packaging among other fields. He has participated in negotiation and commercialization processes of patented and unpatented products. He currently works as a Professor in the Industrial Design Department at ITM's Faculty of Industrial Design. At the same time, he individually develops technical solutions to daily problems. As a result, he has filed a national patent before the Superintendence of Industry and Commerce SIC and needs to know the value of the patent to be able to negotiate it.

Source: Authors' own work.

Additionally, Table 4 presents the qualitative variables identified in the interviews. The first column presents the identified variable and the second, the expert's number.

Table 4. Qualitative variables identified in practice.

Practical qualitative variables	Expert					
	1	2	3	4	5	6
Technology Readiness Level (TRL)[1]	X		X	X	X	X
Intellectual property protection status	X		X			
Dependence on people	X		X	X	X	
Real market	X	X	X	X	X	X
Technology scope (application in other sectors)	X	X	X	X		
Marketing	X	X		X	X	
Potential market	X	X	X	X	X	X
Client's interest	X				X	
Degree of novelty	X	X			X	X
Dependence on suppliers	X			X		X
Legislation and regulations	X		X	X	X	X
Access to financial capital	X		X	X		X
Industrial production likelihood	X		X	X	X	
Number of claims	X	X			X	X
Purchase frequency		X	X		X	
Benefit perception		X		X	X	
What the patent protects		X				
International Trade			X	X	X	
User's acceptance or rejection			X		X	
Technology acquisition			X		X	
Context			X	X	X	
Technical capacity of the applicant	X		X	X	X	
Competitive advantage of the technology			X	X	X	X
Competitors' capacity			X			X
Competitors' resources			X			X
Technological advance likelihood	X		X		X	
Launch time of competing technologies	X		X		X	
Protected geographical areas			X	X		X
PCT protection resources[2]			X			X
Strategic alliances	X		X	X	X	X
Current stage in the commercial lifecycle	X		X	X	X	
Time to complete the PCT				X		X
Knowledge of the PCT process				X		
Commercial lifecycle	X	X	X	X	X	X
Sooner sale				X	X	
Geographic Intellectual Protection	X			X	X	
Social improvement					X	X
Transference capacity	X				X	X
Competitors' market share					X	X
Positioning					X	X
Availability of inventor(s)					X	

Source: Authors' own work based on cited references.

(3) They define the matureness of a piece of technology (Mai, 2015).
(4) The international Patent Cooperation Treaty (PCT) enables to simultaneously request patent protection in several countries. Said Treaty is managed by the World Intellectual Property Organization (WIPO) and was signed by more than 135 countries in the Paris Agreement (SIC, 2008).

Discussion

Based on the crossed matrix between theoretical and practical qualitative variables, the data was triangulated to be compared and thus determine the Minimum Qualitative Variables (MQVs) for patent valuation. Besides, experts' opinions were used to categorize the variables as follows:

i) *Technological.* They refer to the basic information and technical-manufacturing development of the technology and determine the possibility of obtaining the resources and capacity to escalate the technology (financial capital, supplies, machinery and intellectual skills).

ii) *Commercial.* This type of variables is concerned with the satisfaction of the market's needs and commercialization channels to establish the existence of current and potential markets interested in obtaining the technology.

iii) *Competition.* Identifying competitors' capacity to make some technological improvement enables to judge if direct or indirect competitors have the capacity to equal or enhance the technology to be valued.

iv) *Legal.* The ability to produce and commercialize the technology in a given geographical area depends on the acts and/or regulations that allow the legal production and commercialization of the technology.

The resulting MQVs in this study were obtained by observing the most common key elements among experts in patent valuation that matched theoretical variables. Adopting qualitative patent valuation methods has the advantage of analyzing information about the context where the patented technology could be exploited, which influences the values provided by quantitative methods. This enables to make better decisions during the negotiation.

Regarding the level of importance of each variable, some authors in the literature state that the most influential one in any valuation of intangible assets, patents in this case, is the market because it determines the selling success or failure of the developed and patented technology. Nevertheless, and possibly due to the dissimilar profiles of the interviewed experts, the legal and commercial variables may have different importance depending on the patented technology. This is due to the different contexts that may have an influence on the patent (Hunt et al., 2003; Hunt, Thorn, Mitchell, Probert & Phaal, 2007; Shehabuddeen, Probert & Phaal, 2006; Thorn, Hunt, Mitchell, Probert & Phaal, 2011).

The MQVs to value patents were divided into four types: Technological, Competition, Commercial and Legal. However, the Legal dimension is not introduced in Table 5 of the MQVs because it is of a filter kind. In other words, if the patent is viable production-wise in the selected territory, there may be people interested in exploiting it. Conversely, if the legal variable is negative, there would be no possibility to exploit the patent and its value would be zero. Finally, each variable was assigned a score that will support decision making for adequate technology transfer.

Table 5: Minimum Qualitative Variables (MQVs).

Minimum Qualitative Variables (MQVs)			
Type	Variable	Question	Score 1 Low - 2 Medium - 3 High
Technology	Number of claims	How protected is the patent?	1: Less than half of the claims have a broad scope 2: Half of the claims have a broad scope 3: All the claims have a broad scope
	Industrial production potential	Can the technology be mass produced?	1: No 2: Only a part can be manufactured 3: Yes
	Technical capacity of the applicant	Does the applicant have the technical capacity to develop the technology?	1: No 2: Some 3: Yes
	Strategic alliances	Are there strategic alliances to scale the technology?	1: No 3: Yes
	Access to financial capital	Are financial support from co-financing entities, loans or funding available?	1: No 3: Yes
	Degree of novelty	What is its degree of novelty?	2: Incremental 3: Disruptive
	Technology Readiness Level[3]	What stage is the technology in?	1: Concept - idea 2: Model - prototype 3: Validation
	Dependence on suppliers	Are the supplies necessary to develop the technology available?	1: Imported supplies 2: National supplies 3: The supplies are available.
	Dependence on people	How many people have the technical and/or scientific knowledge contained in the patent?	1: One 3: Two or more

Competition	Competitors' capacity	Do competitors have the capacity to rival the new technology?	1: High 2: Medium 3: Low or none
	Competitors' resources	Do competitors have the resources to rival the new technology?	1: Yes 2: Partially 3: No
	Competitors' market share	What is the market share of the strongest competitor?	1: Between 70 and 100% 2: Between 40 and 69% 3: Less than 40%
	International Trade	Are there trade agreements that enable new competitors to enter the market?	1: Yes 3: No
Commercial	Real market	What is the size of the real market?	1: Small 2: Medium 3: Large
	Potential market	What is the size of the potential market?	1: Small 2: Medium 3: Large
	Technology scope	What economic sectors is the patent applicable in?	1: 1 sector 2: 2 sectors 3: 3 sectors
	Commercial lifecycle	How long is the commercial life of the technology?	1: Less than 2 years 2: Between 2 and 5 years 3: More than 5 years
	Social improvement	Does it contribute to the improvement of society's quality of life?	1: No 3: Yes
	Transference capacity	How easy is it to commercialize or transfer the patent?	1: Hard 2: Easy 3: Very easy
	Competitive advantage of the technology	Does the technology offer more competitive advantages?	1: Low 2: Medium 3: High

Source: Authors' own work based on data triangulation.

Conclusions

Qualitative methods are not disconnected from quantitative techniques. On the contrary, they work together to increase certainty in the valuation, because a monetary value could be positively or negatively affected by a qualitative value, and the other way around. In that sense, Minimum Qualitative Variables (MQVs) are decisive to establish a patent's valuation. They contain information regarding where patents are to be exploited and, as a consequence, increase certainty in the monetary value provided by quantitative methods.

Furthermore, MQVs to value patents are divided into four types: Technological, Competition, Commercial and Legal. This study concluded that the legal type is a filter because the patent is valuable only if it is viable production-wise in the selected territory. Additionally, the Commercial type enables to establish the possibility of obtaining profit from producing, commercializing or acquiring the patented technology. The Competition variables determine if the patent could have a stable permanence in the market in spite of competitors' capacity and resources. Lastly, the Technology kind deal with the manufacture or production of the patented technology, i.e. its industrial application.

Regarding the levels of importance of the variables, they depend on the context of the valued technology. However, this study assumes the Commercial type to have a higher relevance than Competition and Technology, because if there is no market interested in the patent, its value is low or nonexistent.

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(5) The three levels proposed to assess the maturity of a technology are based on the nine Technology Readiness Levels (TRLs) (Mai, 2015).

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