Assessment and valuation of technologies, development and application of Valorativo software

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Abstract

Purpose – Although Public Research Institutions (PRIs) are large technology producers, they lack automated information tools that follow technical and scientific criteria for assessing and valuing patents. The assessment and valuation processes are stages of technology transfer (TT) that make it possible to obtain productive arrangements and guide the efforts of those involved in the development, maintenance and negotiation. This study aims to analyze the hybrid model of assessment and valuation of technologies by Soares (2018), applying the 'Valorativo' software. In addition to patent value and indicator scores, the methods allow an understanding of the technology portfolio and its management.

Design/methodology/approach – This research is quali-quantitative, following an approach of applied nature and descriptive objectives. The research has bibliographical, documental and case study features based on the software development methodologies described in the study and the theoretical framework.

Findings – The Valorativo software assisted in the analysis of ten patents on PRIs. With the data collection and patent analysis, PAT1 scored highest among engineering patents, PAT3 scored highest among pharmaceutical patents and PAT10 scored highest among biotechnology patents. Five of the assessed patents resulted in a surplus of net present value (NPV), final net present value (NPVF) and royalties; revenue expectations outpaced investments.

Practical implications – The authors based the developed software on Soares's (2018) methodology, with additional calculations and graphs. The Web software and the spreadsheet with Visual Basic for Application (VBA) were developed to deal with the patents assessment and valuation, helping in the analysis of their Legal Value, Technological Value and Market Conditions in the assessment process, and the Discounted Cash Flow and NPV in the valuation process.

Originality/value – The software helps with patent analysis and can generate indicators for traders, technology holders and researchers. Thus, it was necessary to understand and develop a theoretical-applied framework to outline and replicate the methodology clearly and easily.

Keywords Patent valuation, Patent assessment, Public research institutions, Valorativo, Software

Paper type Research paper

1. Introduction

The Brazilian Public Research Institutions (PRIs, IPPs in Portuguese) are production centers of research and technological development. Notably, IPPs are in constant progress and evolution in patent production, the market relevance of their inventions and the potentialization of technologies to reach socially productive arrangements. In the quest to improve technology transfer processes, the PRIs lack methods of assessing and valuing patents that would otherwise allow institutions to understand what they develop, their value

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and leverage the reach of their technologies (Closs, Ferreira, Sampaio, & Perin, 2012; Faria, 2014; Rosa & Frega, 2017; Calzolaio, Spricigo, & Monteiro, 2018; Soares, 2018; Prado, 2018).

Although several approaches exist in the literature on patent assessment and valuation methods, the availability of methods in software format is commonly restricted. In other words, PRIs, which often need punctual answers to their technologies' procedural demands, sometimes study and develop their own methods, which are manual and difficult to replicate.

PRIs are notorious for generating intangible assets with scientific and technological research. To avoid the generated assets' misuse and allocate the resources well, the assessment and valuation of what is produced must be promoted. Therefore, it is essential to monitor the techniques mentioned so that the assets can reach social and productive arrangements. Therefore, it is part of the problematization that PRIs do not have easy access to the execution of assessment and valuation techniques, these stages being constituent of the technology transfer (TT) process (Amaral, Iquiapaza, Correia, Amaral, & Vieira, 2014; Soares, 2018; Prado, 2018; Ferreira, Souza, Silvão, Marques, Faria, & Ribeiro, 2020).

Using patent understanding methods is the foundation for asset traders, allowing them to realize fair value when launching technologies outside PRIs. Therefore, the negotiation process is crucial for the coherent transfer of technology, motivated by the availability of software that assists in the process (Faria, 2014; Soares, 2018; Prado, 2018; Kim, Ahn, Kwon, & Lee, 2019; Khojaste & Ashrafi, 2021).

In this context, it is essential to develop theoretical mechanisms in software format so that the PRIs can use and have indicators to assess and valuate patents. In this sense, this study aimed to analyze the hybrid model of assessment and valuation of technologies developed by Soares (2018) applying the software Valorativo. The patents were assessed and valuated in this regard, as described in the Theoretical Framework section. These patents' assessment and valuation allowed designing a logical format for creating software. Finally, tests were performed to analyze the results obtained.

The following section describes the theoretical framework that guided the present study and the arguments expressed herein.

2. Theoretical framework

Because of the global competitive context, in which organizations seek improvements to current technologies and solutions to existing problems, providing such innovations is essential to achieve a competitive advantage (Christensen, 1997). In this regard, innovation is a strategy to enter new markets or even gain dominance of niche markets with disruptive innovations (Christensen & Raynor, 2003).

Therefore, patents are characterized by the search for the legalization of the innovative process in the technological field, which must obtain characteristics that certify them as an invention. After that, patents must be transformed into marketable products and services with an innovative character so that the generation of economic value occurs, even when the protected exploitation is granted for a certain period (Schumpeter, 1961; Haase, Araújo, & Dias, 2005).

Observing the contexts of innovation and patents, PRIs, IPP in Portuguese, play a relevant role in the production of Intellectual Property in Brazil. The data made available by the Brazilian National Institute of Industrial Property (INPI) show that patent deposits and conceptions for residents have relevant participation of PRIs (INPI, 2017; INPI, 2018). In this vein, the technological development process and the filing and granting of patents are steps to be overcome. In addition, according to the context addressed by Prado (2018), one should respect the stages of assessment and valuation to progress to an eventual TT.

Failure to exploit a granted patent can neutralize the nexus of the process of a technological project that has a commercial capacity (Faria, 2014; Soares, 2018; Prado, 2018;

Kim *et al.*, 2019; Khojaste & Ashrafi, 2021). It is noteworthy that TT can raise funds for feedback research and innovation processes (Closs *et al.*, 2012; Faria, 2014; Rosa & Frega, 2017; Calzolaio, Spricigo, & Monteiro, 2018; Soares, 2018). According to FORMICT, linked to the Ministry of Science and Technology of Brazil, in 2018, the values of TTs carried out by the PRIs that participated in the survey reached approximate values of BRL 1,054,747,338.11.

Given the initial, innovation processes, the definition of technological value, TT and negotiation is necessary to enable the intellectual production of PRIs to be translated into social solutions. Within this context, it is crucial to generate royalties to raise funds for new investments in research (Vasconcellos & Rapini, 2021).

In this sense, the procedures for assessing and valuing patents are crucial for understanding and negotiating technologies, so that the productive arrangements can take advantage of this development. Therefore, the present study seeks to combine theoretical achievements and apply them in practice, analyzing the work carried out by Soares (2018) on patents assessment and valuation.

Soares (2018) developed a patent assessment and valuation model, naming it a hybrid model. The model approaches patent assessment and valuation as dependent methods for advancing a good patent. Technological assessment makes it possible to understand the potential of technology outside the research environment qualitatively. Valuation focuses on appropriate values, often monetary, so that technologies can be analyzed in terms of commercialization and investment risk (Santos & Santiago, 2008a, b).

Although the methods have been approached as a hybrid model, the steps can be performed individually. The authors used this approach herein as a primary source for the design of the Valorativo software, its development, testing and analysis of results. The software Valorativo is a tool built to have methods for assessing and valuing patents and technologies in a logical format.

Soares (2018) defines *patent assessment* as a method based on qualitative criteria, which can be analyzed in quantitative terms. The author uses criteria and sub-criteria, defines weights for the component items and establishes factors for the analysis of qualitative responses based on the analytic hierarchy process (AHP). Tomas L. Saaty developed the AHP method as a multicriteria method to aid decision-making (Saaty, 2008).

Qualitative criteria were defined by adapting a Danish software called *IPscore*®. The European Patent Office (EPO) distributed the technology assessment and valuation tool free of charge. The model proposed by Soares (2018) answers relevant questions adapted from the *IPscore*® software, weighted by dimensions that generate a final score for the patent and the respective dimensions.

The assessed dimensions are Legal Value, Technological Value and Market Conditions. Criteria weights influence the dimensions mentioned above, which are altered in three studied areas. The areas studied were engineering, pharmaceutics and biotechnology. The author collected data from market consultants to define the weights for the dimensions, patent areas and final patent score. The answers obtained were analyzed using the AHP methodology. The patent's weights, areas and questionnaire were then used to build the Valorativo software.

Equation (1) is used to calculate the patent score.

$$Patent\ Score = \left(\sum_{i=1}^{5} w_{iA}x_{iA}\right)w_A + \left(\sum_{I=1}^{6} w_{iB}x_{iB}\right)w_B + \left(\sum_{i=1}^{5} w_{iC}x_{iC}\right)w_C \qquad (1)$$

where,

W_{iA}: weight of sub-criterion i of criterion A (legal value of the patent).

X_{iA}: scale alternative of sub-criterion i of criterion A (legal value of the patent).

W_A: weight of criterion A (legal value of the patent).

W_{iB}: weight of sub-criterion i of criterion B (technological value of the patent).

X_{iB}: scale alternative of sub-criterion i of criterion B (technological value of the patent).

W_B: weight of criterion B (technological value of the patent).

W_{iC}: weight of sub-criterion i of criterion C (market conditions).

X_{iC}: scale alternative of sub-criterion i of criterion C (market conditions).

W_C: weight of criterion C (market conditions).

In turn, Soares (2018) defines *patent valuation* as a quantitative analysis method using the discounted cash flow methodology for a technology exploration period, thus obtaining a NPV to be used as an indicator in possible negotiations. The NPV is a widely used investment decision criterion recommended by financial specialists (Fonseca & Bruni, 2010).

The author used the decision tree analysis scenario to broaden the understanding of NPV. NPV is calculated using equation (2):

$$NPV = \sum_{i=0}^{n} \frac{FC_i}{(1+R_j)^i} \tag{2}$$

To calculate NPV, one needs to understand the calculation of cash flows. Zdanowicz (2004) treats cash flows as the receipt of inflows and outflows of financial income during a given period to compose a future cash flow. The author used comprehensive indicators through the discounted cash flow (DCF), as shown in equation (3). The DCF uses cash flows to establish a present value discounting the risk during the period (Borsatto, Correia, & Gimenes, 2015). Soares (2018) used the DCF to establish the NPV.

$$FCt = (Q \times CAGRt \times P \times TR) - I \tag{3}$$

where:

FCt – Cash flow in period t;

t – Period in years;

Q – Estimated sales quantity for the product's market segment;

CAGRt – Accumulated Compound Annual Growth Rate;

P – Unit price of the product;

TR – Royalty rate;

I – Corresponds to investments and costs related to technology.

The third step to be understood to work out the logical and systematic framework to carry out the calculations is equation (4) of the discount rate (*Rj*).

$$R_j = (R_f + \beta * (R_m - R_f) \tag{4}$$

R_j is the discount rate or expected return for asset j;

R_f is the rate considered to be risk-free;

B is the asset's sensitivity to the market and;

R_m is the return on the market portfolio.

After calculating the NPV, one progresses to scenario analysis. Scenarios are described as optimistic, realistic and pessimistic to simulate risk factors and assist decision-making. Each risk factor's probability is described in a decision tree analysis and expressed in four dimensions. They are as follows: Stage of Technology Development, Market Size, Success of Similar Technologies and Competition. Each risk dimension is analyzed in the scenarios and has its probabilities based on the theoretical framework the author prepared.

The decision trees that have relevance in the design of graphical branches for illustrating technology scenarios (Clemen, 1996; Pitkethly, 1997) can be defined as follows. To create the decision tree, Equations (5) and (6) are used:

$$VPLFR = 0.25 \times VPLO + 0.50 \times VPLR + 0.25 \times VPLP \quad (5)$$

$$VPLFinal = 0.25 \times VPLFR1 + 0.25 \times VPPLFR2 + 0.25 \times VPLFR3 + 0.25 \times VPLFR4 \quad (6)$$

NPVRF – NPV of the risk factor;

NPV – NPV of the optimistic scenario;

NPV – NPV of the realistic scenario;

NPV – NPV of the pessimistic scenario;

NPVFinal – Patent's final NPV;

Lima (2004) defines *TT* as a third-party technology negotiated for use or acquisition. Within the business context, the assessment and valuation of patents or technologies come into play, allowing one to understand the technological characteristics before entering the market. The scientific literature points to obstacles in the TT process in Brazil, which raises discussions about profit and knowledge (Conde, 2003; Andreassi, 2006). The following section presents the methodological aspects used to achieve the proposed objective within the exposed theoretical context.

3. Methodology

Bearing that this study focuses on the qualitative and quantitative analysis of patents using a specific software, the research is described as quali-quantitative, applied and with descriptive objectives. The research has bibliographical, documental and case study features (patent analysis), focusing on the procedures used. The variables investigated are based on the model developed by Soares (2018). Users are considered familiar with the assessment and valuation of technologies that act in technological innovation centers, work with TT and work with technological portfolio management.

As a contribution to the scientific community, the Valorativo software was developed based on a theoretical framework described in the previous section, followed by a patent analysis. First, an Excel® spreadsheet was developed to define logical steps and tests. The development of the spreadsheet can also be used in office environments, providing extra information when carrying out the assessment and valuation procedures. Therefore, using Excel® and the Visual Basic for Application (VBA) programming language, it was possible to develop a software aligned with the objective described in this study.

Following the logic developed in the spreadsheet, the Web software (World Wide Web) was designed for testing. Heroku® platform hosted the Web software allowing the author to proceed with the research and carry out tests via the internet. The Valorativo software can be accessed at: www.valorativo.herokuapp.com/. Access was made on April 15, 2021.

The Python language was used to create the Web software based on the Django framework, the CSS (Cascading Style Sheets), the Bootstrap framework, the HTML (HyperText Markup Language), the JavaScript language (JS), the Chart.js and AnyChart libraries in its trial version. In the development methods, Design Sprint and Feature Driven-Development (FDD) were applied to speed up the development of the testing tool.

The use case diagram presented below illustrates the development of the software, which is described in the Unified Modeling Language (UML) as a graphic representation of the functionalities graphically proposed for the system (Figure 1). The diagram served to design and guide the development. The tool can carry out the assessment and valuation processes separately in a file format for the spreadsheets.

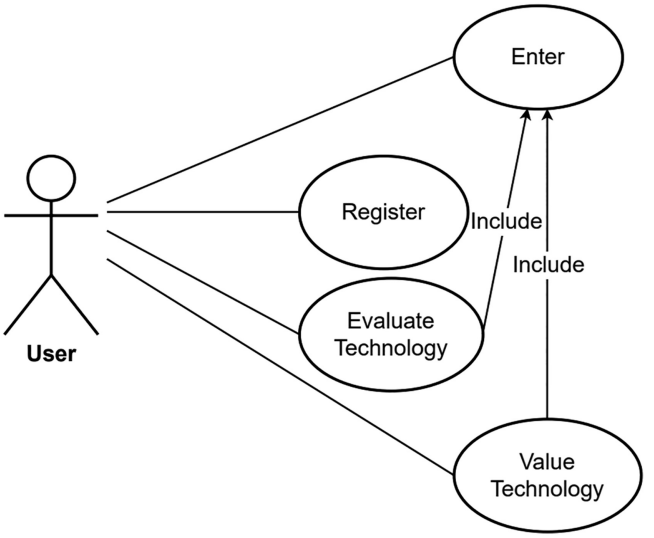
Under the methodological terms for web development, the flowchart in Figure 2 illustrates the site's navigation structure that was designed for the software.

After the software development, ten patents were analyzed. Of the analyzed patents, one originated from the Federal Institute of Education, Science and Technology of Piauí (IFPI) and the others from the Federal University of Sergipe (UFS), after an authorization and confidentiality agreement with the Coordination of Innovation and Technology Transfer (CINTTEC).

For illustration purposes, we detail the process carried out in the patent codenamed PAT1. PAT1 is a technology deposited by IFPI for pathogen disinfection and was developed in the fight against the COVID-19 pandemic. The criterion for choosing the other patents analyzed was whether they belonged to the engineering, pharmaceutical or biotechnology patent groups.

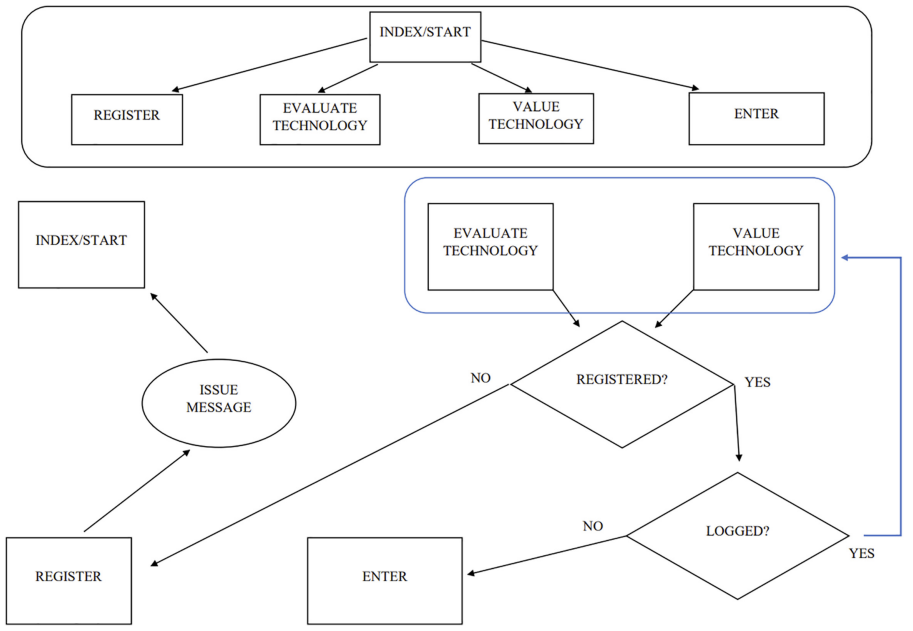
Thus, PAT1 was classified within the area of engineering. Table 1 shows the questions answered in the PAT1 assessment. Each question has five alternatives to be chosen and scored, and the answers are organized in a scalar way to generate the results in points (Soares, 2018).

The variables required to value the technology are described in Table 2.



Source(s): Authors' own compilation

Figure 1.
Use case diagram of the evaluative software



Source(s): Authors' own compilation

Figure 2.
Flow chart of the software Valorativo Web

To obtain the variables of assessment and valuation, we proceeded with a documentary analysis of the patents, comparing similar technologies and interviewing those responsible for the inventions. Ten patents were investigated in a case study to obtain the model variables and the results. In terms of the questionnaire applied, the assessment variables were converted into a 5-point *Likert* scale to calculate the final score. For valuation, the variables were obtained by investigating the criteria of the model developed by Soares (2018) for subsequent insertion in the software.

For a better understanding, we will present the results obtained according to the methodological procedures described.

4. Results and discussion

The presentation of the results begins with the visualization of the initial screens of the developed software. Figure 3 shows the initial screen of the patent assessment software, executed in the form of a spreadsheet.

The screenshot below (Figure 4) refers to the spreadsheet software used to perform the patent valuation.

The next screen is the home page of the Valorativo website (Figure 5). As these are large screens, a clipping of the images was made to show useful information for easier understanding.

After starting the PAT1 analysis, we proceeded with the patent assessment in the spreadsheet and on the website. We entered the following queries: the patent's name, the appraiser's name and the assessment criteria' answers. The answers were presented focusing on the items requested for the qualitative assessment and inserted in a scaled format, in the software so that it was possible to receive the assessment results. Figures 6 and 7 show the results obtained with the PAT1 patent assessment.

A legal value	Criteria
A1 – Patent Status	What is the status of the patent?
A2 – Strength of Legal Position	How strong is the legal status of the patent?
A3 – Patent Validity	For how long the patent will remain valid?
A4 – Scope of the Claims	What is the breadth and scope of the patent claims?
A5 – Geographical Coverage	Does the geographical coverage of the patent include the relevant markets?
B – Technological value	**Criteria**
B1 – Uniqueness of Technology	Is the invention a unique technology?
B2 – Superiority to Replacement Technology	Is the invention technically superior to the substitute technology?
B3 – Testing level	How well has the invention been tested?
B4 – Time to Market	How long does it take before patented technology can be commercially viable?
B5 – Production of Copies, Tampering	Are tamper copy products easy to identify and produce?
B6 – License Agreement Dependency	Does the deployment of the technology depend on license agreements with third parties?
C – Market conditions	**Criteria**
C1 – Market Options	What are the market options for the technology?
C2 – Market growth rate	What is the market growth rate of the business area where the patent is used?
C3 – Life Expectancy of the Patent	What is the life expectancy of the patent in the market?
C4 – Competitive Products	Are there competitive substitute products active on the market?
C5 – Permission/Licences	Do commercial activities require special permits/licenses?

Source(s): Soares (2018)

Table 1.
Dimensions and questions for patent assessment

Order of criteria	Investment information
1	FUNDING BODY
2	PURCHASE OF MATERIALS
3	EXISTING FACILITIES
4	PERSONNEL COSTS
Order of criteria	**Cash flow information**
1	VALUATION PERIOD
2	SALES ESTIMATE
3	CUMULATIVE GROWTH RATE
4	PRODUCT PRICE
5	ROYALTY RATE
Order of criteria	**Information for discount rate**
1	RISK-FREE RATE
2	ASSET SENSITIVITY
3	PORTFOLIO RETURN
4	RISK ADJUSTMENT
5	IPCA RATE

Source(s): Soares (2018)

Table 2.
Variables for patent valuation

PATENT NAME:	
NAME OF EVALUATOR:	
PATENT AREA:	
A - Legal Value	
A1-Patent Status	What is the status of the patent?
1. The patent wasn't deposited. 2. The patent was deposited. 3. Assessment of the novelty and patentability concluded. 4. Patent issued. 5. Opposition period expired	
A2-Strength of legal position	What is the strength of the legal status of the patent?
1. No novelty research carried out. 2. Quick search carried out (search in simple database). 3. Novelty search in national offices or similar. 4. Search of international novelty. 5. Search of novelty and violations	
A3-Patent validity	For how long will the patent remain valid?
1. The patent has a remaining term of 0-2 years. 2. The patent has a remaining term of 2-4 years. 3. The patent has a remaining term of 4-8 years. 4. The patent has a term of 8-12 years. 5. The patent has a term of over 12 remaining years	

Source(s): Authors' own compilation

Figure 3.
Screenshot of the Valorativo software in a spreadsheet format for patent assessment

Figure 6 shows an example of the graphs generated in the assessment spreadsheet. The results obtained in the spreadsheet include details in some scenarios so that the appraiser can carry out a more in-depth analysis of the patent, allowing the indication of weaknesses. With this analysis, the appraiser receives suggestions to improve the patent score, if possible.

The appraiser needs to register in the *Web* software. After the assessment, a list of the patents they have already assessed is issued and can be detailed. With the detailed information, the appraiser has access to the criteria, their answers and a graphical view of the patents scores, as shown in Figure 7. Figure 8 shows the list of assessed patents and the ranking of portfolios by the score obtained.

Subsequently, the analysis of the PAT1 patent sought the variables necessary to carry out the patent valuation. Table 3 presents the variables and their respective values.

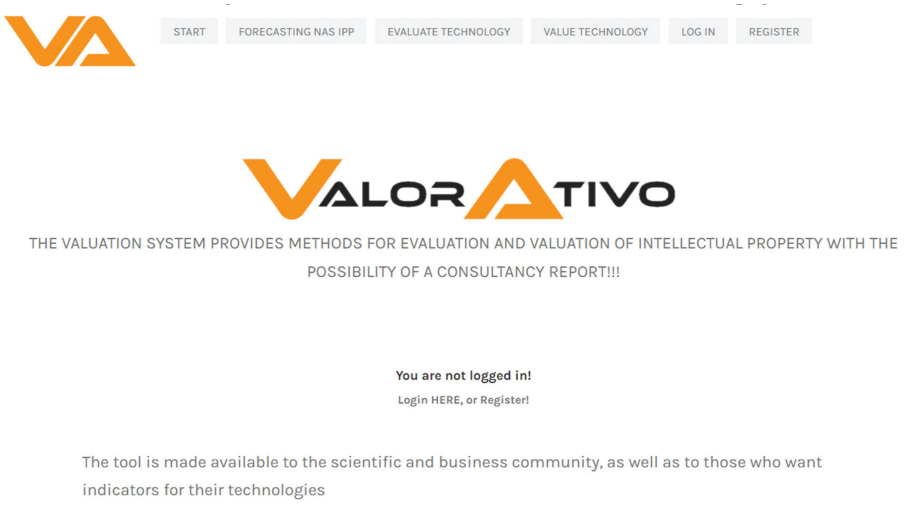
In the PAT1 case, the amount allocated by the funding agency, the investment required to develop the technology, was collected from the public approval log. For valuation purposes, the values obtained in developing technologies by funding agencies should be recorded as investments and included in the calculation. Personnel expenses relate to the gross salary paid to employees involved in the development process during the months that the product was developed and collected on the Transparency Portal of the Brazilian Federal Government. To establish personnel costs, the appraiser can calculate the employee's working hours, the number of hours dedicated to technology development and the amounts paid in scholarships to those involved in the project.

Figure 4.
Screenshot of the Valorativo software in a spreadsheet format for patent valuation

PATENTS DEVELOPMENT COSTS/INVESTMENTS

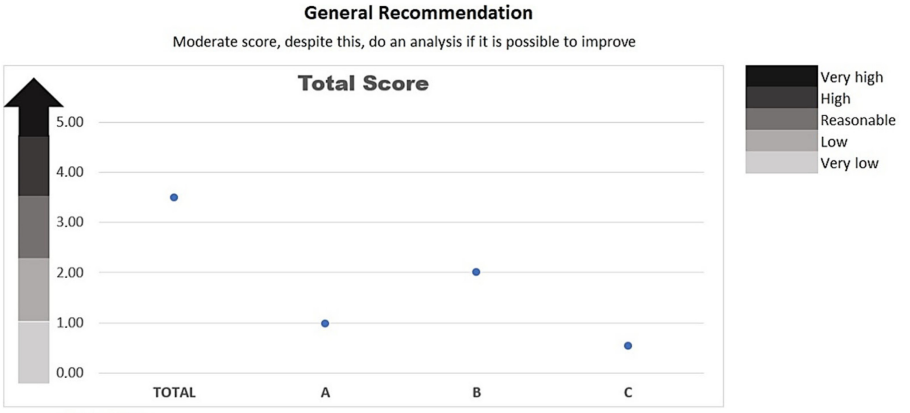
PATENT NAME:			
EVALUATOR'S NAME:			
Initial Cash Flow:		NOTE: FILL IN THE FIELDS MARKED IN RED BASED ON WHAT IS REQUESTED.	
Discount rate:			
Net present value:		CALCULATE THE NPV	
Was there Research Funding?			**1-VARIABLES FOR CASH FLOW**
YES	What is the funding body?	Estimated Value (in R$, enter only the value):	What is the sales estimate for the entire period?
NO			
			What is the cumulative growth rate in the year(s) (CAGR)?
Was there material acquisition? Describe the materials and estimated values. It is not necessary to fill in all spaces.			
Acquisition/Purchases	Description	Estimated value (in BRL, enter only the amount):	What is the unit price of the Product?
			What is the royalty rate (in %)?
			What technology investments?
			What period of years do you want to value?
			2-VARIABLES FOR CALCULATION OF THE DISCOUNT RATE

Source(s): Authors' own compilation



Source(s): Authors' own compilation

Figure 5.
Software Valorativo *Web* version in its home page



TOTAL SCORE

Criterion	Note	Recommendations
TOTAL	3.50	Technology with a great score, it can be difficult to leverage the questions, however, it is recommended to look for questions to improve
A	0,98	Nota que carece de muita atenção. Verifique os pontos críticos para que possa vislumbrar maneiras de ampliar os quesitos
B	2.00	Improvements can be made to the items with low ratings, however, check whether there is room for this
C	0,53	Note that it needs a lot of attention. Check the pain points so you can envision ways to broaden the stakes

Source(s): Authors' own compilation

Figure 6.
PAT1 patent assessment score in the spreadsheet of the Valorativo software

As PAT1 was under analysis by INPI, and it is an innovative technology, the term valued is 20 years, which is the patent validity period, when it is granted. The PAT1 sales estimate was established with data from 2018, according to information from IBGE (PIA-Product, 2018),

on equipment intended for sterilization. The compound growth rate (CAGR) was established with data from specialized agencies that estimate the rate of the health equipment sector for 2020.

The product estimated price was established based on the average of equivalent products. The royalty rate was estimated based on literature reports (Parr, 2007). The risk-free rate was adopted using the Selic rate of the Central Bank of Brazil. The Beta sensitivity analysis of the asset was established in specialized sites and considering the product as being from the healthcare products industry. In this case, the data used were extracted from the Damodaran website, which includes reports for emerging countries.

The Bovespa Index collected from the Brazilian Stock Exchange website determined the portfolio return, considering the patent technology. Risk adequacy was stipulated with the technology framing indicated in the literature (Soares, 2018; Faria, 2014; Razgaitis, 2003). The IPCA used was defined by the Brazilian Institute of Geography and Statistics (IBGE) for March 2021.

The PAT1 patent valuation result screen presents the final NPV of BRL 2,453,086.13. The initial cash flow was BRL -91,092.71. Based on PAT1's analysis and properties, it is impossible to exceed the investments made with the expectation of sales at the beginning of its commercialization. The calculated discount rate was −0.04%, as shown in Figure 9.

Figure 10 shows the variables obtained to perform the remaining calculations, as shown in Table 3.

Web software was employed to generate the results as the valuation process progressed. By inserting and saving variables into the form, the user can access their valued portfolio and proceed to the detailed visualization of relevant estimates (Figure 11).

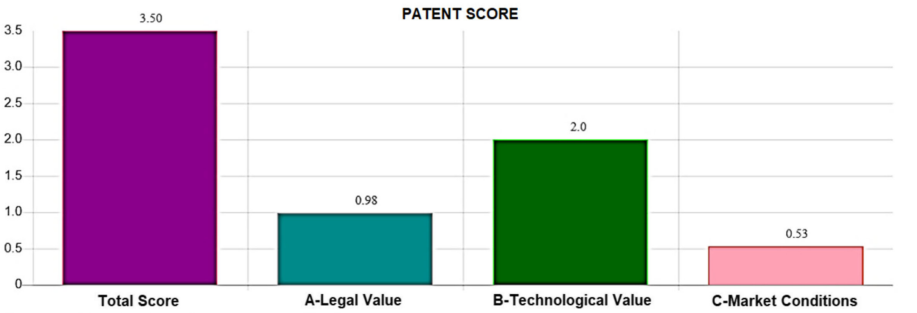


Figure 7.
Score obtained by PAT1 patent in the assessment carried out in Valorativo *Web*

Source(s): Authors' own compilation

Figure 8.
List of patents in the portfolio assessed in the Valorativo *Web*

Source(s): Authors' own compilation

Investment information	Values
FUNDING BODY	BRL 9,950.00
PURCHASE OF MATERIALS	BRL 0
EXISTING FACILITIES	BRL 0
PERSONNEL COSTS	BRL 195,892.71
Cash flow information	**Values**
VALUATION PERIOD	20 years
SALES ESTIMATE (ENTIRE PERIOD)	200000
CUMULATIVE GROWTH RATE	7.5%
PRODUCT PRICE	BRL 3,000.00
ROYALTY RATE	5.1%
Information for discount rate	**Values**
RISK-FREE RATE	2.75
ASSET SENSITIVITY	0.83
PORTFOLIO RETURN	2.59%
RISK ADJUSTMENT	30%
IPCA RATE	0.93%

Source(s): Authors' own compilation

Table 3. Variables used for the valuation of PAT1

	PATENTS DEVELOPMENT COSTS/INVESTMENTS		
PATENT NAME:	PAT1		
EVALUATOR'S NAME:	#		
Initial Cash Flow:	–R$ 91.092.710,00		NOTE: FILL IN
Discount rate:	–0,04116%		
Net present value:	R$ 2.453.086,13	CALCULATE THE NPV	
	Was there Research Funding?		
YES	What is the funding body?		Estimated Value (i
NO	YES IFPI		
	Was there material acquisition? Describe the materials and estimated values. It is not necessary to fill in all spa		
Acquisition/Purchases	Description		

Source(s): Authors' own compilation

Figure 9. Spreadsheet of the Valorativo software and the results after inserting the valuation data

The Valorativo software prints a discounted cash flow diagram for the analyzed period, which allows observing the variation in values over the exploration period, as shown in Figure 12.

The cash flow allows observing changes in the patent value over the analyzed period, making it possible to estimate the NPV of the patent under study. Therefore, the diagram expresses the discounted cash flow over the period. The method is based on the generation of royalties and the technology's growth in terms of market share. Additionally, the method considers a discount rate based on variables related to the financial market. Furthermore, the method considers investments made for technological development to estimate the technology's potential to outperform investments in revenue generation.

The software generates a graph with values calculated in single and cumulative periods to track the royalty's evolution. Figure 13 shows the graph of royalties accumulated in the period, which supports the decision-making process.

1-VARIABLES FOR CASH FLOW
What is the sales estimate for the entire period?
200000,00
What is the cumulative growth rate in the year(s) (CAGR)?
7,50%
What is the unit price of the Product?
R$ 3.000,00
What is the royalty rate (in %)?
5,10%
What technology investments?
R$ 205.842,71
What period of years do you want to value?
20
2-VARIABLES FOR CALCULATION OF THE DISCOUNT RATE
What is the risk-free rate (%)?
2,75%
How sensitive is the asset to the market?
0,83
What is the return on the market portfolio (%)?
2,59%
What is the risk adjustment according to the stage of development (%)?
30,00%
3-What is the IPCA rate to correct the price in years?
0,93%

Source(s): Authors' own compilation

Figure 10.
Variables inserted in the Valorativo software in spreadsheet format

PATENT NAME:	INVESTMENTS:	INITIAL CASH FLOW:	DISCOUNT RATE:	VALUATION PERIOD:	SALES ESTIMATE FOR THE PERIOD:	ROYALTIES FEE:	GROWTH RATE:	UNIT PRICE ESTIMATE:	IPCA RATE:
PAT1	205842.71	−91092.7100	−0.000411600000000002	20	200000	5.1	7.5	3000.0	0.9300

Source(s): Authors' own compilation

Figure 11.
Results of the first stage of valuation in the software Valorativo *Web*

Regarding patent exploitation, when commercialized, the software develops a graph with the estimated sales value in the period. Figure 14 shows the cumulative gross sales chart.

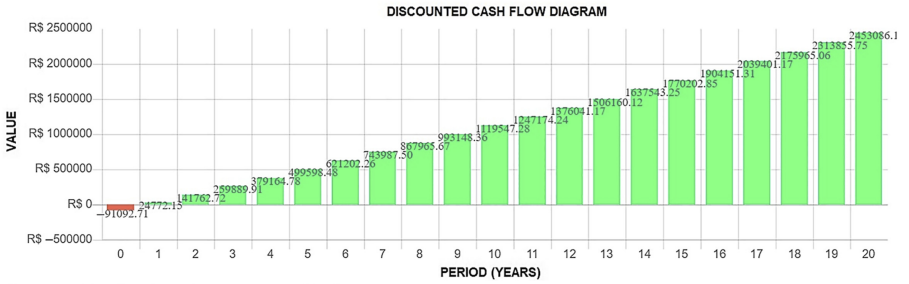
After obtaining the patent NPV, the software performs the scenario analysis with a decision tree. With the tree defined from its roots and branches, it is possible to illustrate the scenarios proposed in the methodology and analyze the scenarios in which the patent value

may vary. Through this scenario analysis, the patent negotiator can outline a strategy to realize a fair value based on the parameters resulting from the methodology expressed by the Valorativo software.

Figure 15 presents the decision tree and scenarios so that the appraiser has a range of situations and factors to consider in their strategy.

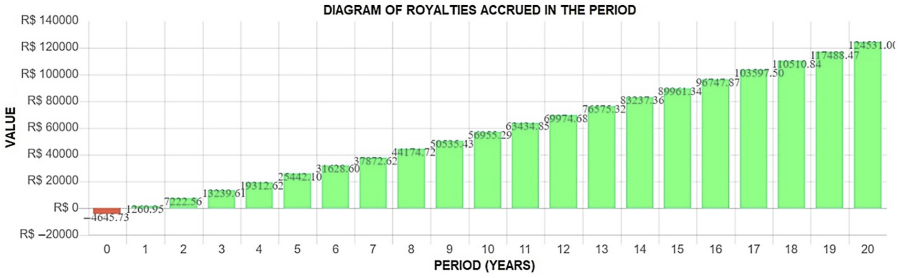
Figure 16 illustrates the decision tree and scenarios issued by the Valorativo Web software.

Among the values illustrated in the scenario analysis through the decision tree, the patent's final NPV stands out, which is the NPV considering the weights calculated by the valuation methodology. The NPV is calculated according to equation (6), described in the theoretical framework. Depending on the trader's interpretation of the data during the



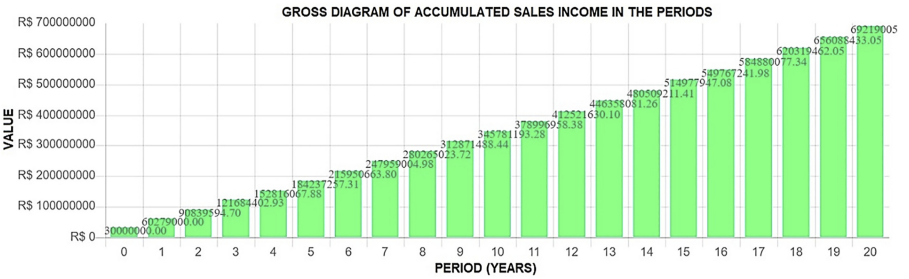
Source(s): Authors' own compilation

Figure 12.
Diagram of discounted cash flow over the valuation period



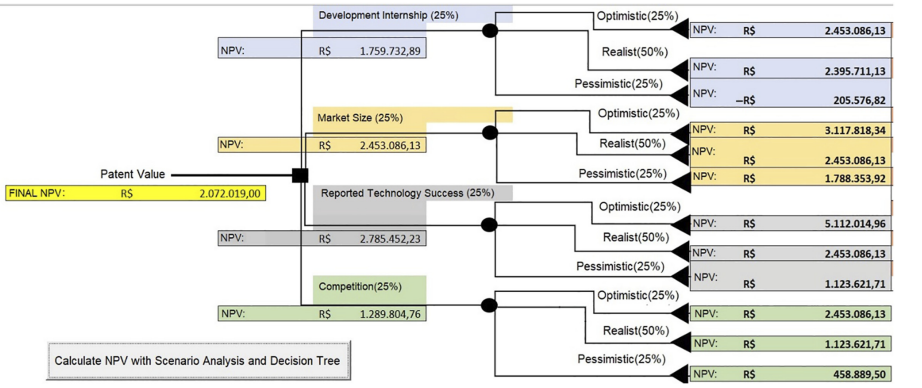
Source(s): Authors' own compilation

Figure 13.
Flowchart of cumulative royalties over the period



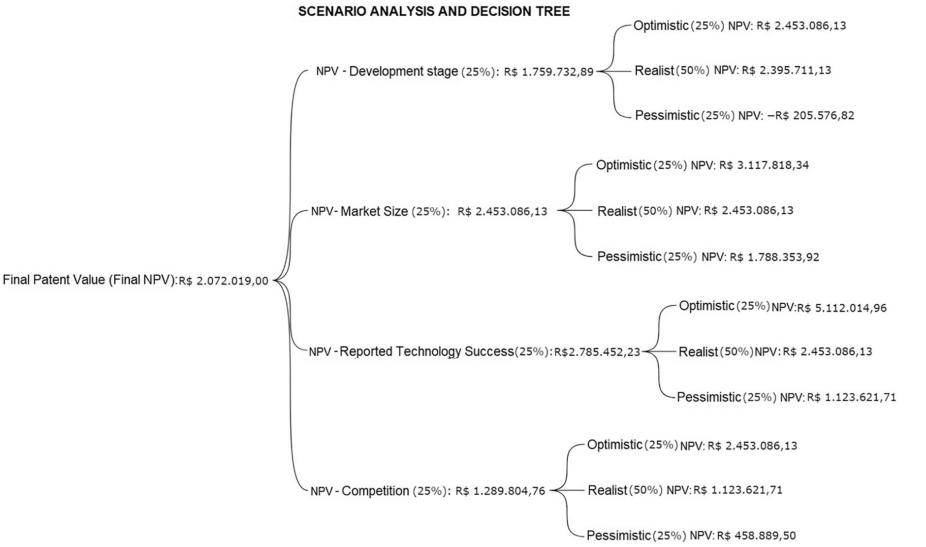
Source(s): Authors' own compilation

Figure 14.
Cumulative gross sales revenue diagram for the period



Source(s): Authors' own compilation

Figure 15.
Decision tree and scenario analysis obtained in the valuation spreadsheet version



Source(s): Authors' own compilation

Figure 16.
Decision tree and scenario analysis obtained with Valorativo *Web*

assessment, the NPV can be considered along with the illustrated scenarios; if the trader observes that the competitor's NPV must weigh the patent, the patent value can be considered equal to BRL 1,289,804.76 for PAT1.

However, the main factor considered in the Valorativo software methodology is the experience and analysis power of the appraiser or the team that intends to analyze a patent.

As previously mentioned, this study looked over the assessment and valuation of ten patents. The PAT1 results have been comprehensively detailed to illustrate the case studies. Table 4 presents the assessment data of the ten patents studied. The total score is numbered on a scale of 1 to 5 points. It can be observed that within the portfolio analyzed, PAT1 obtained the highest score among engineering patents, PAT3 obtained the highest score among pharmaceutical patents and PAT10 obtained the highest score among biotechnology patents.

The dimension scores calculated in the assessment should be factored into the patent analysis and improved whenever possible. The dimensions make it easier to see any potential strengths and weaknesses of the technological portfolio assessed.

Table 5 displays the results found for the ten patents valued in the valuation process. The period refers to the remaining time of legal exploitation for the patent, which seeks to obtain a current view of the patent value. Table 5 presents the potential accumulated value of royalties and total gross sales. The value of royalties is negative whenever the exploitation of the technology does not generate revenue over the investments. Moreover, the NPV and NPVF are negative when revenue generation within cash flows does not exceed investments made.

Total gross sales can be obtained by calculating the gross sales multiplied by the adjusted price over the period. This obtained value is an indicator of the values moved by the technology without considering costs and investments, being a way to observe the financial capacity that the technology can yield. With this indicator, it is possible to re-assess the royalty values charged or negotiate participation in the revenues generated.

Five of the patents valued resulted in surplus NPV, NPVF and royalties: PAT1, PAT2, PAT5, PAT6 and PAT7. The amounts invested for development and the remaining time for patent exploitation are relevant to the final values found since revenues must exceed investments. Thus, depending on the technologies and the current market, the remaining years for exploitation may not be enough to provide this support.

Patent name	Area	Total score	Score on the legal value dimension	Technological value dimension score	Score on market conditions dimension
PAT1	Engineering	3.505	0.976	2.002	0.527
PAT2	Pharmacist	3.134	0.882	1.157	1.095
PAT3	Pharmacist	3.609	0.849	1.447	1.313
PAT4	Pharmacist	2.685	0.774	0.933	0.978
PAT5	Engineering	2.881	1.061	1.34	0.481
PAT6	Engineering	2.687	1.018	1.187	0.481
PAT7	Engineering	3.261	0.997	1.829	0.435
PAT8	Biotechnology	3.051	1.204	0.811	1.036
PAT9	Biotechnology	3.19	1.018	1.66	0.511
PAT10	Biotechnology	3.518	1.46	0.818	1.24

Source(s): Authors' own compilation

Table 4.
–Patents assessed in the Valorativo software and their scores

Patent name	Period	NPV (BRL)	Final NPV (BRL)	Total royalties in the accumulated (BRL)	Total gross sales (BRL)	Investments (BRL)
PAT1	20 years	2,453,086.13	2,072,019.00	124,531.00	692,190,055.48	205,842.71
PAT2	9 years	237,545.78	142,787.95	12,216.25	93,436,992.72	408,544.60
PAT3	16 years	−536,638.04	−581,954.51	−27,223.24	43,624,886.19	851,934.00
PAT4	19 years	−161,038.63	−215,196.72	−8,901.39	54,145,950.10	538,910.32
PAT5	16 years	907,705.39	720,934.16	43,305.02	358,852,860.72	389,884.60
PAT6	15 years	78,800.37	13,890.75	3,616.17	119,249,480.71	371,133.12
PAT7	19 years	2,053,900.56	1,749,434.70	80,427.22	3,248,757,005.98	68,524.00
PAT8	15 years	−297,450.33	−297,865.85	−14,830.82	851,782.01	300,308.90
PAT9	16 years	−197,368.52	−210,955.74	−10,343.98	29,083,257.46	291,818.00
PAT10	13 years	−183,302.41	−206,435.67	−9,660.21	17,737,149.53	343,197.04

Source(s): Authors' own compilation

Table 5.
–Patents valued in Valorativo software and their values

PAT2 is a pharmaceutical patent focused on healing. PAT5, PAT6 and PAT7 are engineering patents, a technology for wind power generation, a technology for obtaining protein concentrate and a technology for paving. As previously stated, the NPV indicates that the values of a periodic exploitation estimate exceed the investments. However, a patent may have a high evaluative technological potential, but present negative values in its valuation. It is so because investment and technology markets, as well as the delay in exploiting the patent, can negatively influence the patent NPV. Table 6 shows the patents scores, areas and respective NPVs.

It can be seen that some patents present a good final score. However, market factors or even cost control during development can lead to low NPV values, highlighting the importance of establishing effective technological development methods for technologies with good scores and good prospects for entering the productive market.

According to the literature, the final stage of technological production is the conquest of technologies in social and productive arrangements. Thus, discussing the analysis of patents (Closs *et al.*, 2012; Faria, 2014; Amaral *et al.*, 2014; Rosa and Frega, 2017; Calzolaio, Spricigo, & Monteiro, 2018; Soares, 2018; Prado, 2018; Kim *et al.*, 2019; Ferreira *et al.*, 2020; Khojaste & Ashrafi, 2021). To this end, the methods for assessing and valuating patents must be present and available for the innovation centers.

The method Soares (2018) developed is a scientific effort to provide mechanisms for PRIs and their technological innovation centers in conducting TTs and patent portfolio management. In this regard, the software was developed with relevant algorithmic contributions to ensure that the proposed method and its purpose would work correctly. In addition, royalties and sales calculations have been added in flowchart format in the technology exploitation, which initially was not foreseen in the author's model.

The Valorativo software also aims to help patent traders, whether they are institutions, companies or independent traders. However, the use of software and methodology is broader than these subjects, and patent negotiations depend on the assessment and valuation process to ensure fair values. In this regard, the Valorative software becomes an alternative for those who need help for the purposes mentioned herein, highlighting the improvement in the TT processes (Closs *et al.*, 2012; Faria, 2014; Amaral *et al.*, 2014; Rosa & Frega, 2017; Calzolaio, Spricigo, & Monteiro, 2018; Soares, 2018; Prado, 2018; Kim *et al.*, 2019; Freitas, Martins, & Melo, 2020; Ferreira *et al.*, 2020; Khojaste and Ashrafi, 2021).

5. Final considerations

The present study addressed the assessment and valuation of patents using the Valorativo software and its theoretical methodologies. Therefore, it was necessary to understand and

Patent name	NPV (BRL)	Area	Total score
PAT1	2,567,836.13	Engineering	3,505
PAT2	237,545.78	Pharmacist	3,134
PAT3	−536,638.04	Pharmacist	3,609
PAT4	−161,038.63	Pharmacist	2,685
PAT5	907,705.39	Engineering	2,881
PAT6	78,800.37	Engineering	2,687
PAT7	2,053,900.56	Engineering	3,261
PAT8	−297,450.33	Biotechnology	3,051
PAT9	−197,368.52	Biotechnology	3,19
PAT10	−183,302.41	Biotechnology	3,518

Source(s): Authors' own compilation

Table 6.
Patents, their areas, scores and NPV

develop a theoretical-applied framework so that the methodology could be clearly outlined and easily replicated. The patent PAT1 was considered an illustrative example, allowing us to observe the behavior of the methodology and generate discussions. Besides PAT1, another 9 (nine) patents were assessed and valued.

Support in the patent analysis is not only helpful in establishing a fair patent value. It can also be used to understand the assessed patent's scope and to search for possible qualitative improvements that can influence its commercial and social value. The NPV methodology addressed in the study is aimed at analyzing whether the technology can give a financial return to the PRI by generating higher royalties than the amount invested during the patent exploitation period. Such higher royalties can support decision-making, yielding financial indicators in the exploitation of technologies, aiding their negotiation by the PRI.

The developed software was based on the methodology of Soares (2018), with additional calculations and graphs. The Web software and the spreadsheet with VBA were developed to deal with the assessment and valuation of patents, helping in the analysis of their Legal Value, Technological Value, and Market Conditions in the assessment process, and the Discounted Cash Flow and NPV in the valuation process.

The software can contribute to managers who work in the various branches of Intellectual Property, in aiding decision-making by providing graphical analysis and suggestions for improvements and classification of patents. More specifically, the valuation process presents information for the analysis of Discounted Cash Flow and NPV with scenario analysis, which provides branching possibilities (scenarios) in a decision tree format. Graphical information is based on the reference methodologies.

Given the number of patents generated by PRIs, portfolio management and Intellectual Property management as a whole can be assisted using the results of the tool studied here. For instance, (1) the total score of the assessment of the patents and generated recommendations, (2) the classification of the patents, which provides portfolio management, (3) the visualization of the stages of the discounted cash flow, (4) the gross sales diagram and (5) the flexibility in using office software or website for technological knowledge procedures.

Information on sales, generation of royalty and NPV in scenarios can help to understand the value of a patent, in addition to supporting a TT negotiation. It is worth emphasizing that in the technological negotiation stages, the values calculated for royalties at the time of valuation must include the PRI share and the inventors' share in the total value. Therefore, royalties must be negotiated with the technology owner and its contractor, and the PRI must pay the royalty amounts to the inventors. Future research should focus on studying the effectiveness and usability of the Valorativo software and expanding the number of patents analyzed.

Determining the necessary variables for patent valuation is a difficult task. In addition, there is a need for more evidence from the data collection of practical patent valuation experiments. The interviews and data collection showed that the inventors' involvement in establishing variables is crucial for efficiently carrying out the process. When there is no involvement of those responsible for the technology, the appraiser needs access to secondary data sources to determine the patent value and perform an efficient technological assessment.

The values obtained by the patents categorize them in numerical terms and can indicate their potential as technologies. The software can help with suggestions in cases where variables can be improved. The managers' subjective nature can improve the assessment and valuation of patents through the variables studied.

This study aimed to contribute to the implementation of methodologies in a software format. It involved inserting some functionalities into the tool, using the methodology in the PRI patents investigation, and analyzing the patent assessment and valuation results.

Patent assessment seeks to understand the potential technology, advantages and disadvantages to assist portfolio management. At the same time, the NPV looks at the potential value that can be generated by the patent based on the royalties generation and the market share growth. Valorativo software generates graphs with estimated calculations to expand the visualization of values generated in product sales. Such graphs help in the analysis of technologies in addition to providing an overview of scientific and technical support. This way PRIs can seek the exploitation of their assets with TT, facilitating the application of the methods described herein.

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