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Technology Valuation Thermometer - TVT: A valuation method for technologies in the Brazilian scenario

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ABSTRACT :*This research describes the valuation of technology from the perspective of the Brazilian scenario of technology transfer. Such a scenario is identified by having the technological innovation centers as agents of the relationship between university and business, presenting the difficulties of these agents on the valuation of the technologies. However, the research also surveys the most used valuation methods, and from this referential, establishes the TVT method, which aims to provide a tool that values technologies at intermediate maturity levels, facilitating the valuation of technology at the Brazilian offices of technology transfer.*
KEYWORDS: *valuation, technology transfer, university-business relationship.*

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I. INTRODUCTION

Value, in semantic terms, is associated with the esteem given to someone or to some object. As a historical example, barter stands out, as it is one of the great pillars of the concept of value in human history. Barter represents the method of valuation that took place through the utility of the object to be exchanged: the greater its utility, the greater would be its exchange power.

Since then, man has been accumulating, improving technologies and techniques in his relationship with the world, which is also reflected in the methods of quantifying value. By bringing the subject to the present day and relating it to Science and Technology Institutions (STI), it is notable that these institutions are generating sources of value. Values given by the scientific and professional training of people, by academic production in the sphere of teaching and extension projects, and, mainly, by the generation of research, due to the consequences of technologies.

Technologies originate from scientific production and the techniques related to them are generally given to the protection scrutiny. They are born from research and are constituted by stages of development that demand investment in structure, personnel and appropriate knowledge. In this context, Pitkethly (1997), Etzkowitz and Leydesdorff (2000), Torkomian and Garnica (2009) emphasize that universities are sources of information and training for the development of new technologies.

In contrast, technologies serve the productive sector, as elements - products and services - with potential for innovation and the possibility of generating competitive advantage, so that STIs, in this process, can be suppliers and companies would be consumers of technologies. Through this relationship of interest, raises the expectation of a flow of technical knowledge combined with production factors, which would strengthen technology transfer (TT).

Goldscheider (2002) states that the valuation of technology is a complex process. The valuation of intangible assets cannot be considered a simple task, since it is a set of variables that are difficult to measure. Intellectual property (IP) assets, technologies, for example, do not have structured markets, which makes it difficult for their transfer and, consequently, their valuation.

The literature gives a significant focus on valuation methods from market and income approaches, the so-called usual methods. Methods that, according to several authors, such as Baek et. al (2007), Razgaitis (2007); Vega-González and Blesa (2010); Parr and Smith (1994) and Mard (2000) need structured and mature markets, with information that support technology as a temporal asset, capable of generating future benefits. Such characteristics are not yet present in the Brazilian reality.

For Baek et al. (2007) it is difficult to promote trade and technology transfer with the process of evaluating from the usual methods. In this sense, measuring the value of a technology generates a considerable effort, since the technology market, especially those with high innovative potential, cannot be easily created.

Another complicating factor in the valuation is the degree of development of the technologies: STIs provide technology with the potential to generate a product or service, not ready and finished products or services. The technology transfer process presupposes a continuous work on the developmentof technology by the company in relation to the university. Thereby, research that starts in the academy continues to be developed in the productive sector, however, by not being valued or being valued in a wrong way, TT can be harmed. The analysis and valuation of technology requires interdisciplinary knowledge, it is necessary for the analyst at the time of valuation, a critical capacity that takes place through multidisciplinary knowledge.

Cabrera and Arellano (2019) point out a series of difficulties that universities face when performing the valuation process to transfer technologies. They mainly mention those difficulties linked to the lack of precise information, such as: market, production and marketing costs, degree of development and lack of clarity of the uncertainties involved. Such difficulties can be assimilated in Brazil and understood by the panorama of the Brazilian Technological Innovation Centers (TIC), that is, the difficulties of the TIC, thus demonstrating the Brazilian TT scenario in terms of valuation.

When considering aspects of the Brazilian technology transfer scenario, with a focus on valuation, this paper starts from the following question: how to value technologies, in the technology transfer scenario, based on the reality of the technological innovation centers in Brazil?

To answer this question and as a general objective, it was sought to develop and propose a technology valuation tool that meets the Brazilian scenario of technology transfer.

Valuation Methods

Intangible assets are goods and rights that we can observe but not touch (feel), such as brands, know-how, market interaction, strategies, technological processes, intellectual property and innovation capacity. However, its exploitation generates future benefits (cf. BEUREN AND IGARASHI, 2002; LEV, 2001; SMITH AND PARR, 2000).

According to Litan and Wallison (2003), intangible assets are difficult to value, as they are quite heterogeneous, and they still lack an organized market to trade them. For Andriessen (2004), it is necessary to determine which types of evaluation or measure will be used, Frey and Frey (2002) emphasize that the evaluation of intangibles is complex, mainly due to the influence of variables that are not directly measurable.

Boer (1999) emphasizes that the concept of determining monetary value is valuation, which makes the distinction between assessment and valuation important. According to Frey, Teodoro and Ghesti (2019), the evaluation of a technology is the first criterion that helps to identify which potentialprojects are to be valued, as well as their level of development.

Valuation, in its turn, deals with reference values for a potential negotiation, considering the uncertainties and risks involved in the technology transfer process (SILVA E RUSSO, 2014).

Studies such as those by PARR AND SMITH, 1994; PARK AND PARK, 2004; PITKETHLY, 1997; RAZGAITS, 2003; REILLY AND SCHWEIHS, 1998; BOER, 1999; CHIESA AND GILARDONI, 2005; HASTBACKA, 2004 point out the main approaches used in valuation methods, which are: cost approach, market approach, income approach and real options.

For Smith and Parr (2000), the cost approach is a method based on the calculation of the acquisition reproduction cost or the substitute cost of acquisition of a similar asset. The cost approach offers the value of the technology based only on the cost of development, it does not consider the market potential of the technology. Such an approach has the advantages of a minimum given value, available and reliable information, easy calculations; as a disadvantage, it does not consider future risks and economic factors (cf. CHIESA & GILARDONI, 2005; PARK & PARK, 2004).

Mard (2000), Smith and Parr (2000) explain that the technology value by the market approach is based on other similar technologies in the market. As Bulakowski (2014) emphasizes, however, the technology under analysis can be specific and unique in nature, with no existing similarities. In this case, the comparison can be based on the usefulness of other similar assets. Its advantages are related to simplicity and objectivity, supported by real transaction information, and as a disadvantage, however, it does not apply to intellectual property, as transaction similarities are not frequent or even surrounded by secrecy (xf. MARD 2000; RAZGAITIS 2007; CHIESA AND GILARDONI, 2005; PARK AND PARK, 2004; BAEK et al., 2007).

The income approach refers to an approach that considers the value of the technology to be evaluated, considering its future benefits, discounted by a discount rate (BOER, 1999; MARD, 2000; RAZGAITIS, 2003; SMITH AND PARR, 2000). The advantages of the income approach can be observed by the following factors: these are widely used and recognized tools, the expected monetary value is considered, the cost of capital and the associated risk explained, and the capacity to generate income is considered. As a disadvantage, there is a

high complexity in estimating the discount rate, little applicability in technologies without structured markets (those technologies that may become a radical innovation and those with low levels of development), high need of estimates in dataand information (PARK AND PARK, 2004; CHIESA AND GILARDONI, 2005; BAEK et al., 2007).

Created from criticisms of the discounted cash flow model, the Real Options Theory (ROT) is an approach that has contingent rights as its main core. Basically, ROT is a valuation tool that considers options as a right, not an obligation, so that those who are investing in technology can have the option corrected according to the future environment (cf. DAMODARAN, 2007; DIXIT AND PINDYCK, 1995; SANTOS AND PAMPLONA, 2005; COPELAND AND ANTIKAROV, 2001; VASCONCELLOS, 2015). The following advantages stand out: it considers uncertainty and variability in future results, it is sometimes associated with methods such as Discounted Cash Flow (DCF), but with the difference that the ROT considers the operating environment in which the technology is explored. Its disadvantages are mainly related to the complexity of estimating uncertainties and its calculations (cf. BAEK et al., 2007; CHIESA E GILARDONI, 2005).

Aspects on the brazilian context of Technology Transfer between University and Business

It is observed, according to Guldbrandsen and Smeby (2005), that the benefit environment of university-industry collaborations for companies and universities are reciprocal: in addition to supporting companies' innovation activities, collaboration with the industry has positive effects on the academic research, improving the performance of researchers.

It is in this environment of relationship between science and technology that technology transfer will be discussed. For Rogers, Takegami and Yin (2001, p. 254), technology transfer is “the movement of technological innovation from a Research and Development organization to a receiving organization”. For Stevens, Toneguzzo and Boström (2005), in turn, technology transfer consists of a set of steps that describe the formal transfer of inventions from scientific researches carried out by educational and research institutions to the productive sector. In other words, it is the transfer of technology and knowledge from one organization to another (BOZEMAN, 2000).

Technology transfer, according to Siegel et al. (2003), depends on the involvement of several articulating entities for its effectiveness, namely: technology transfer offices (TTO), university scientists and entrepreneurs. In Brazil, there is an agent which, in addition to facilitating the relationship between the university and the company, also ensures the management of the university's intellectual property: the so-called TechnologicalInnovation Centers (TIC). The TICs are responsible for the TT and, consequently, their valuation. These entities are naturally interdisciplinary, as they deal with technology management and protection, valuation, transfer, contact with companies and governments, besides encouraging the culture of entrepreneurship and innovation in universities.

In Brazil, especially in the case of universities, to transfer and value technologies, it is necessary for the TIC to have the knowledge capability in technology valuation.

Therefore, aspects of the Brazilian context of TT can be better understood from the perspective of three studies: National Forum of Innovation and Technology Transfer Managers (FORTEC, 2018), Form for Information on the Intellectual Property Policy of Scientific, Technologies and Innovation Institutions (FORMICT/MCTIC, 2019) and the work of Oliveira (2020), which deals with the ability of TICs to value technologies, based on a Thesis of the Postgraduate Program in Technological and Biopharmaceutical Innovation at the Federal University of Minas Gerais (UFMG).

From these studies, some findings can be made regarding the TIC, such as: limitations to the personnel structure (insufficient number, high turnover, excessive number of scholarship holders and interns, discontinuity of projects, absence of career plans, the need to train people for technology valuation); budget constraints (high dependence on development agencies, restructuring at every change in TIC management); absence of a portfolio of activities related to TT (valuation, university and company cooperation, partnerships with private sectors) – since the focus is directly related to intellectual property management, mainly due to patent management; and finally, the lack of instruments to value technologies.

Oliveira (2020), in relation to the valuation of technologies in the TIC, it was pointed out that: high concentration in the activity of intellectual protection; 70% of technology licenses are concentrated in 5 universities; problems related to personnel are constant (lack of personnel with specific training in valuation); need to outsource activities; 69% of TICs do not adopt any valuation method. Finally, according to the same author, it was identified the existence of a gap in the literature, such gap concerns the investigation of the capacity of Brazilian TICs to value technologies.

Another important information, regarding the Brazilian aspects of technology valuation, refers to the degree of maturity at which technologies are transferred. In this context, in developing countries, according to Vega-Gonzalez and Blesa (2010), universities are responsible for a good part of R&D, so that the degree of

development of technologiesgenerated and transferred by universities are often in an intermediate level of development.

The information presented in this section on valuation of technologies and technological innovation centers, in addition to serving as a theoretical basis and support for discussion and analysis, also contributed directly to the result of this work, as, through them, it was possible to understand the characteristics of the existing technology valuation approaches, as well as to understand the aspects about the Brazilian scenario of Technology Transfer between University and Company, which allowed to raise essential information for the formulation of the proposed valuation tool.

II. METHODOLOGY

The valuation model proposed here will be called technology valuation thermometer - TVT, since the Thermometer, according to physics, is an instrument composed of an element with sensory capabilities that has a thermometric property, that is, a property that varies according to the temperature. Establishing a parallel with valuation, TVT has metrics with analytical properties that provide values that will serve as a technology reference for trading purposes.

The TVT was developed based on studies of valuation models, analysing the advantages and disadvantages of these models, and using the Participant Observation (PO) methodology carried out with a TIC.

Therefore, for the elaboration of the TVT, the following construction steps were followed:

- Investigation of the operationalization of valuation in a consolidated TIC: Participant Observation in the TIC of the Federal University of Minas Gerais (UFMG), the Technological Transfer and Innovation Coordination (CTIT);
- Survey of information for technology analysis;
- Definition of TVT quantification criteria;
- Establishment of analysis criteria that will form the valuation;
- Distribution of the criteria weights.

The Participant Observation at TIC-UFMG

For Paterson, Bottorff and Hewat (2003), Participant Observation is a method of data collection originating from the social sciences and arising from ethnography. Its contribution is to provide knowledge to the researcher through a relationship of trust, which the authors call “backstage reality”. Cano and Sampaio (2007) also reinforce that PO needs scientific rigor, which differs from informal observation.

For the construction of a valuation proposal, it was necessary to understand the functioning of a technological innovation center in person. Thus, thework of the PO was done alongside the TIC of UFMG, the CTIT. The choice of CTIT/UFMG was due to the solidity and maturity in IP management that the university is currently in, and mainly due to the vast experience of this TIC in transferring technologies.

About the PO, the researcher was on the premises of CTIT/UFMG from March 12, 2018 to September 12, 2018, following the technical and administrative procedures related to valuation, totaling 480 hours. For the PO, the work was planned jointly with CTIT, respecting its ethical and operational norms and procedures. In the initial structuring, a documental survey was carried out in which it was possible to study university technologies registered at CTIT between the years 2012 to 2017, within which they had some valuation study, whether by transfer, royalties or technology feasibility study.

Respecting the confidentiality of the restrict information, it was reached the number of 60 technologies that went through the technology transfer process, in which it was possible to analyse the following characteristics in person: Potential for Innovation of UFMG technologies, Level of Protection, Entrepreneurial Participation of professors, Degree of Development (maturity of technologies), Economic useful life of the technology.

Potential of the type of innovation: The PO allowed us to determine how UFMG technologies would be classified in relation to the potential type of innovation they would generate (considering the period 2012-2017), technologies (Traditional/No Innovation) 6.67%, technologies with radical innovation potential 11.67% and technologies with oncremantal innovation potential 81.67%.

Protection level: In terms of valuation, Wang et al. (2015) point out that protection is one of the main value components of a technology. Thus, of the 60 technologies studied, it was verified that 28.33% of the technologies were not patented, while 71.67% were patented (deposited or granted). An important observation is that not all developed technologies are susceptible to patents, such as examples of know-how, cultivation, industrial design, among others.

Entrepreneurial participation of professors in TT: with the encouragement of professor entrepreneurship (in the sense of professors and/or researchers creating their own companies), mainly via new legal devices such as the legal framework, there may be a greater demand for technology transfer. While the demand for TT increases, the need for technology valuation also increases, which justifies this approach for this

study. Regarding this theme, it was observed that, between the years 2012 to 2017, only 7% of professors/researchers at UFMG participated as partners of companies that transferred the technology, that is, 7% of these professors were somehow connected to the technologies in the licensing company, while 93% of these researchers transferred their technology to a third party without their participation after this transfer.

Degree of development (maturity): The concept developed by the National Aeronautics and Space Administration (NASA) was used to understand the maturity level of a technology. Such a notion is called Technology Readiness Level (TRL). According to Mankins (1995), the TRL provides conditions for verifying the level of development of a specific technology, moreover, allows comparing the maturity between different types of technology. In participant observation, the readiness levels of the technologies were also analysed. The average of the technologies was approximately 5.2, in other words, the technologies would be between the establishment of critical function in an analytical or experimental way and/or proof of concept and functional validation of the components in a laboratory environment.

Valuation of technologies and term of contracts (economic useful life of the technology): Regarding the issues of values of the technologies studied at UFMG, for reasons of confidentiality of private information, only the average value and average time of contracts will be presented. In this regard, the average valuation of the 60 technologies, in up front values, is R$ 92,460.71 and the time average of contracts is 10.36 years.

Survey of information for technology analysis.

For Quintella, Teodoro and Frey (2019), technology assessment and analysis is the phase in which it is possible to understand the technology applications, its impacts and business aspects as well. The association of technical issues with business issues generates the ability to value a technology. Therefore, for the technology analysis from the perspective of TVT, the following were pointed out: potentials and uncertainties in the valuation of technology; traceability and diligence of valuation.

Potential and uncertainties in technology valuation: Technologies developed in universities are, at the same time, elements of a high innovative potential, as well as involving high risks and uncertainties. Uncertainty and potential analysis are one of the key issues in evaluating technology projects (cf. THORN et al, 2011; EDQUIST, 2005; RAZGAITIS, 2003; ETZKOWITZ, 2017; PITKETHLY, 1997).

Traceability: According to Frey (2019), traceability in technology valuation methods allows control agencies to verify the technology assessment and how the calculations and analysis were carried out in the technology transfer process, facilitating transparency and showing responsibility with the public asset.

Due Diligence, according to Munari and Oriani (2011), are investigations that make it possible to explore, in depth, aspects of the technology situation. The valuation diligence can be considered a pre-valuation phase. In practical terms, it is a document that will support the information necessary for the analyst to carry out the valuation of the technology. This diligence has the role of studying the technology under the following aspects: technology functionality, level of protection, problem it proposes to solve, uniqueness of the technology (differential), involved team (researchers and partners), market potential, legislation, level of technology development, possible barriers, partnerships, investments made for development, among others.

After these notes, it is concluded that, in order to value a technology in the Brazilian reality, it is important that the valuation proposal has: ability to traceability, valuation preceded by analyses, which includes the study of uncertainties and potentialities.

Definition of TVT quantification criteria

In the PO work at UFMG, 60 technologies were studied between the years 2012 to 2017. Four variables were observed in the studies of technologies valuation present in this range: value of the up-front fee (access fee); royalty fee charged; degree of maturity; and the exploration contract time.

Statistics will allow analysing the intensity of the relationship between the variables (the degree of association of the variables). This association, in turn, will make it possible to structure an equation capable of describing the relationship of the variables, aiming to determine the TVT valuation formula. The data was treated using descriptive statistics, using the Microsoft Excel 2013 program.

For TVT, the objective is to highlight the best criteria, therefore, it is necessary to identify only positively related correlations.

Fortec (2018) calculated the licensing in the TIC from the major areas of licensed technologies: 40.5% in engineering, 13.6% in health sciences, 12.6% agricultural sciences, 10.9% in exact sciences and of earth, 10.7% in the biological sciences, 6.4% in the applied social sciences, 5.2% in the humanities, and no agreement in the areas of linguistics, languages, and arts.

It shows that 80% of the TT are in the engineering, exact sciences, biological, agricultural and health areas. This composition by Fortec (2018) suggested an application of the correlation, elaborated via Microsoft Excel, between the up-front value and the degree of development, but segmenting into areas. In this way, the following results were obtained:

Table 1: Correlation Application

Up-front valuation (x)	Result (r)	Interpretation
Biological (y)	0,8490	Strong
Health (y)	0,9015	Very Strong
Agricultural (y)	0,4334	Moderate
Exact sciences (y)	0,8235	Strong
Information Technology (y)	0,4786	Moderate

Source: survey data

From the correlation, it was applied the regression, via Microsoft Excel, and it was possible to structure the equation that provides the value of the technology, and it was presented as follows (according to the segmentation of the major areas of knowledge):

• For the biological sciences area: Y = 16115x-14375;
• The regression, in the case of the health area, demonstrated the equation: Y = 16437x-14679;
• The equation suggested by the regression in the agricultural area was: y = 48932x-82391;
• For exact area, the following equation: y = 25827x – 50981; and
• The value equation for the IT area is: y = 5112.3x – 1484.8.

From the study of correlation and regression, it could be identified that the variable "degree of development" has a greater relationship with the variable "value of the up-front technology". Would this imply that the more developed a technology, or the closer to commercial maturity, the greater could be the technology's trading value? For such an indication to become an inference about thepopulation, it is desirable to know whether the results studied confirm or not such indication of the samples.

According to Da Costa (2008), in the attempt to describe reality, mainly through hypotheses, science, in order to adapt to the future, uses statistics for predictions and inferences. Thus, a hypothesis test was applied to identify whether the degree of development is directly related to the value of the technology and, therefore, confirming whether there is inference from the sample to the population.

The samples studied here are the 60 technologies, as it is a small sample, it was chosen to apply a non-parametric test, which is justified by some characteristics. That said, the non-parametric test chosen for the present study is the Spearman test.

According to Restrepo and González (2007), the name of the test comes from the statistician Charles Spearman, based on factor analysis and it is an alternative model to parametric methods. According to Spearman (1904), the decision rule that defines the acceptance or not of the proposed hypothesis, the so-called test, is defined by the following situations:

Ho=no association between variables;

H1=there is an association between variables.

According to Spearman (1904), after defining the significance level (α), Ho is rejected in favor of H1, whenever that calculated Rsc ≥ tabulated Rs. It was used a free software for the execution of the tests, PSPP.

In this study, the PSPP was applied to the variables of each area of knowledge covered in the technologies studied between 2012 and 2017 in participant observation at the UFMG. According to Siegel (1975), the objective of a hypothesis test is to infer about quantities of interest in a population from a sample observed in a scientific experiment. Here, it was pursued to discover the relationship between the variable "value" and the variable "degree of development", thus being able to affirm or not the existence of inference in the population.

The PSPP was applied to the samples by area of knowledge, and for each of them a significance level (α) of 0.05 was used. So, in order to analyse the inference of this study, the following hypotheses were defined:

• Ho = There is no relationship between the variable "technology value" and the variable "degree of development" of the technology;

• H1 = There is a relationship between the variable "technology value" and the variable "degree of development" of the technology.

The calculations in the PSPP program applying the Spearman test to each area (agricultural,biological, health, exact science, and information technology) it was possible to find the following results, as shown in Board 1:

Board 1: Hypothesis testing

Areas/ calculations	Calculated Rsc	Tabulated Rs	Rs - Rsc	
Agricultural	0,799	0,566	0,233	Rejects Ho
Biological	0,866	0,591	0,275	Rejects Ho
Health	0,900	0,591	0,309	Rejects Ho

Exact Sciences	0,977	0,566	0,411	Rejects Ho
T.I.	0,140	0,683	-0,543	Accept Ho

Source: survey data

According to the defined hypotheses and, according to Board 1, of the five areas tested, four are configured in the rejection of Ho, which means, for these four, that there is a relationship between the degree of development and the value of the technology. For IT, the null hypothesis was accepted. It is worth noting that this area does not follow a logical relationship of intensity between degree of development and valuation. For example, on average, a software has a high degree of development/readiness, but there is a range of traded values that weaken the correlation between these variables. A software can be configured in grade 9 of the TRL but be traded for a low amount or even free of charge.

Thus, as expected, there is a chance (degree of development and value) between the agricultural, biological, health and exact science areas, which accounts for 85% of the studied sample. Thus, it is justified that each area has a value formulation, according to its statistical reality, allowing the inference that the more developed the technology, the greater its valuation by the TVT analysis.

Establishment of analysis criteria that will form the valuation and distribution of criteria weights.

To determine the degree of technology development, TVT uses the qualitative to achieve at the quantitative, that is, it uses technology analysis to reach the proposed indicators (royalties, up-front and technology value).

Scoring, according to Razgaitis (2007), is a technique that uses several technology analysis and evaluation parameters. For TVT, the scoring criteria, defined according to the assumptions (analysis ofuncertainties and potentials, traceability and technology functionality), are divided into 4 categories: technical capacity, differential, market and feasibility.

The score that the evaluator assigns to each analysis question is followed by a referenced justification, that is, such justification must contain the reasons for the score, as determined from the sources of information. It is expected that the more information about the technology there is, the better the analysis will be, and, consequently, the more robust and reliable the valuation will be.

The justifications for each score are supported by the documentary information gathered by the valuation diligence, thus, through this document, it is possible to substantiate the reason why an issue had a high or low score.

The Technical Capacity criterion, considering the contributions of Razgaitis (2002), Cabrera and Arellano (2018), Breschi, Lissoni and Montobbio (2008), is responsible for the technology analysis part, based on the scrutiny of the technology developers.

From the observation of the technology "Differential" criterion, it will be possible for the evaluator to analyse the technical aspects and the potential for innovation of the technology studied, that is, how much the technology really stands as an element capable of contributing to the process of innovation.

The "Market" criterion will allow the analyst to mitigate the uncertainties and potentials of the technology in the context of commercialization in a business environment and the "Feasibility" criterion considers the analysis of the present value of cash flows, as this allows the analyst to identify how the technology can generate future gains.

For each question, the analyst must observe in the criteria the scores (based on studies by Razgaitis, 2007): 0, 10, 20, 30 and 40. The scores are marked based on the stage of technology development and the justifications explain the score according to the surveys of the valuation diligence. The higher the score, the more developed the technology, and consequently, the higher its degree of maturity and the closer it is to commercialization. To perform the score, the analyst must always justify and point out the fidelity of the information.

It was noted that the four criteria (Technical Capacity, Differential, Market and Feasibility) have issues with the same score variation, but this cannot reflect in a homogeneous distribution of points, as TVT is a methodology created specifically for the reality of technology transfer in Brazil. This impliesrespecting the need to value technologies at an intermediate or incomplete level of development.

Authors such as Vega-Gonzalez and Blesa (2010), Cabrera and Arellano (2019), Razgaitis (2007), Oliveira et al. (2020) point out that, in developing countries, most technology transfers take place at an intermediate level of development, between 3 and 6 in relation to the TRL. In this study, considering the Participant Observation at UFMG, the average TRL of the technologies found was 5.2. This indicates that, on

average, the technologies were in the functional validation phase of the components in a laboratory environment.

Regarding the weight distribution relationship between the analysis criteria, the Analytic Hierarchy Process (AHP) methodology was used. Developed at the University of Pennsylvania in the 1970s by Professor Thomas Saaty, AHP is a technique for analysing multi-criteria decisions. Its applicability is quite wide, especially in complex issues, in which the subjectivity of human analysis (judgments) generates long-term consequences and repercussions (BHUSHAN AND RAI, 2004).

For Saaty (2009), the decision-making process is mental and cognitive, based on tangible and intangible criteria. In scenarios of uncertainties involved, such as the technology valuation process, reliable information becomes a differential, but it is important that there is weighting (a distribution of weights in the analysis criteria).

With the AHP results in hand, it was possible to distribute the weights of the TVT criteria:

Board 2 – Distribution of weights by criterion

Criteria	AHP	TVT WEIGHTS
Technical Skills	38%	5
Differential	30%	4
Market	24%	3
Feasibility	6%	1

Source: Elaborated by the author (2020)

To calculate the weights, the AHP distribution served as a reference. The feasibility criterion, being the smallest, served as a basis for comparison with the others. Example: Differential/Viability = 30%/6% = 4.

The distribution of weights in TVT sought to align the analysis with the degree of development of the technologies. To reach the level of development, solid and accurate information is needed. From the perspective of AHP, it was possible to define which of the criteria obtained the best information.

III. RESULTS

TVT is a valuation tool that proposes to deliver three pieces of information about the technology to support TICs in negotiating the technology transfer process:

1 – Up-front value; 2 – Royalty Fee and 3 – Technology Value.

Determining the royalty rate can often be an obstacle in the technology transfer. Each TIC has a way to determine these rates, to follow international standards (paid), historical of the negotiations themselves or are even defined arbitrarily.

In the case of TVT, the criterion used is the tax one, that is, the Ministerial Ordinance that establishes how much of the expenses with royalties are deductible, in accordance with the Brazilian legislation.

The aforementioned regulation concerns the ministerial ordinance No. 436/58, which establishes maximum percentage coefficients for the deduction of royalties, for the exploitation of trademarks and patents, technical, scientific, administrative or similar assistance, amortization, considering the types of production, according to the degree of essentiality. (BRASIL, PM 436, 1958).

More clearly, this implies on how much will be the deduction limits as operating expenses in relation to royalty amounts for the exploitation of intellectual property, such as patents, use of trademarks, know-how and even for scientific technical assistance.

Values are calculated from the net revenue. According to Law No. 6.404/76 in its article 183, net revenue is understood to be gross revenue (total) reduced by: returns and canceled sales, discounts granted unconditionally, proportional taxes levied on it and amounts resulting from the adjustment to present value.

Therefore, at TVT, the determined royalty rates follow the only current legislation on the subject in Brazil, which guarantees legal protection, traceability and security for the TICs.

Thus, the valuation of technologies by TVT is carried out in stages:

1. Surveys of information about technology: valuation diligence.

2. Completion of initial information: ownership, large area of knowledge and classification according to the table in PM 436/1958.

3. Scoring and justification of each valuation criterion: multiplication of the overall score of each criterion by the respective weights, allowing the identification of the degree of development of the technology under study.

4. Application of the degree of technology development in the valuation formula: That's where the up-front value is obtained; the technology value is the multiplication of the up-front value by the average of the exploration contract time, that is, up front value x 10.36.

TVT Validation

TVT is a valuation tool developed from the need of brazilian TICs to have a methodology capable of helping transfer technology. Validation is the application of TVT in a real environment in Brazilian universities. The visits were made in person. Due to cost reasons, TICs were chosen from entities (Universities and Federation of Industries of the State of Minas Gerais - FIEMG) that were in the operational stage in the state of Minas Gerais.

The choice of the technology was designated by each TIC, always observing the respect for the confidential issues of each validation study. Therefore, for reasons of confidentiality, the trading values indicated by TVT will not be presented here, but rather the opinion of each TIC on the method.

Validations were made in the following entities:

• Intellect Agency, TIC of the Federal University of Uberlândia;

• Permanent Committee on Intellectual Property – CPPI, TIC of the Federal University of Viçosa;

• Regional Center for Innovation and Technology Transfer – CRITT, TIC of the Federal University of Juiz de Fora;

• Technological Innovation Center of the Federation of Industry of the State of Minas Gerais – FIEMG;

• Innovation, Technology Transfer and Entrepreneurship Center at the Federal University of Itajubá;

• General Coordination of Technological Innovation and Intellectual Property of the Federal Center for Technological Education of Minas Gerais – CEFET-MG.

The experiences of visits carried out at the TIC are reported below:

- Intellect/UFU: The proposal meets the reality of the team;
- CPPI/UFV: This is a feasible and usable methodology;
- CRITT/UFJF: Very easy, practical, agile and meets CRITT's valuation demands very well.
- FIEMG: Little applicable to the private sector, industries, as it is very focused on university TIC.
- TIC UNIFEI: Accessible, any TIC professional can do the valuation.
- TIC CEFET MG: Addresses an emergency
- TIC issue as it can help speed up licensing negotiations.

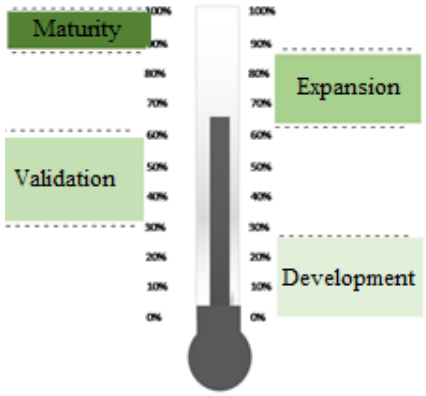

Fig. 1. TVT illustrative figure

IV. CONCLUSION

This research developed a technology valuation proposal for the Brazilian scenario of technology transfer between TIC and business. Along this path (and where the originality of this work emerges), it is possible to understand the Brazilian scenario (TIC overview), the main technology valuation models, analysis premises, traceability, degree of technological development and relevant tax legislation for the definition of royalties. In terms of TIC and valuation, the research contributed to the understanding of the TIC's capacity to value technologies, data that are still fragmented in the literature.

In addition to studying the advantages and disadvantages of various valuation methodologies, the role of valuation as a facilitating agent in the technology transfer process, it was possible to develop a valuation proposal, the Technology Valuation Thermometer, which pays attention to the difficulties of brazilian TICs.

The usual methodologies (those linked to traditional approaches, mainly market and income), as highlighted by Razgaitis (2007), Vega-Gonzalez and Blesa (2010), Baek et al. (2007), among others, are applied to technologies with a high degree of development, in the commercial phase. In developing countries, as already highlighted by Vega-Gonzalez and Blesa (2010), universities are responsible for a good part of R&D, so that the degree of development of technologies generated and transferred by universities is often in an intermediate level of development. TVT, then, serves a valuation of this type of technology.

One of the great difficulties of the TIC is related to issues associated to collaborators such as: high turnover, lack of career plan, insufficient number given the demand, need for outsourcing, lowqualification or specialization related to the valuation of technologies. All these characteristics are reflected in the valuation of technologies, which strengthens the premise that a technology valuation model is practical and pays attention to the personnel structures found in Brazilian TICs.

Of the TICs in operation, 100% of them work with the management of Intellectual Property (IP) in TICs, which implies having very specific data and information on technology assessment. For example, when constructing a technology patenting process, it is necessary to survey a range of information, ranging from technical application, to inventors and even market studies to analyse its originality and competitiveness. This information fully meets TVT's need for analytical data. Thus, the employee who already works in IP management at TIC can, in addition to helping the valuation sector, effectively participate in the valuation of a technology in the technology transfer process.

The data and information that will serve as a basis for analysis and will also serve, from the Diligence of Valuation, to support the valuation. Thus, TVT provides tracking and accountability capabilities so that regulatory bodies (internal or external) can observe the valuation path and its transparency in the technology transfer process.

Unlike valuation tools based on approaches such as market and income, TVT can be applied to technology valuation at an intermediate level of technological development. This implies that such technologies may, at this stage, not yet have a structured market and, thus, the use of methodologies, based on market and income, would not be applicable to them.

In terms of future perspectives, it is expected that the findings of this work serve as a basis for discussions that foster the valuation of technology and, consequently, the transfer of technology, stimulating public policies that strengthen development through innovation and entrepreneurship.

Ultimately, it was highlighted the importance that issues related to the valuation of technologies are continued and explored in future works, especially those that envision the technology associated with Stokes' (1996) concept of Pasteur's quadrant, in which the researches developed by universities contribute to the development of knowledge in a practical way, in order to provide general gains for society, universities and companies.

Therefore, by facilitating the technology valuation process through a practical methodology, the trend is that the context of technology transfer isimproved, and, with this, everyone can win: universities with the development of applicable technologies, contributing to the society's quality of life, and companies obtaining competitive advantages, being able to share R&D structures.

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