TECHNOLOGIES VALUATION METHODS APPLICABLE TO TECHNOLOGY TRANSFER IN BRAZILIAN UNIVERSITIES: A REVIEW

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Brazilian universities and science and technology institutes have a great potential in developing new technologies to the market. However, the current technology transfer model used by most of the universities in Brazil has several limitations. One of the key steps in this process, technology valuation, still poorly explored despite being widely debated among the academics. This article, through an exploratory research consists in a survey of the main valuation approaches available in the literature. It also analyzes the strengths and limitations of the methods. The authors conclude that there is no single method that should be used to evaluate all technologies and provide relevant information to assist readers in choosing the most appropriate methods, given their ultimate goals and the desired level of detail. They show the necessity to apply robust valuation methods that maximize financial returns to institutions through the licensing of technologies in order to feeding back the research and development system and contributing to the sustainable development of Brazil. Finally, the authors calls attention to the importance of qualifying and valuing the active labor in the Technology Transfer Offices, as well as recognize the valuable role played by the universities and science and technology institutes in the national innovation system.

Keywords: Valuation, transfer, technology, university
1 Introduction
The process of transferring technology allows the existing knowledge in universities to be transferred to market in order to produce new products, new processes or even production systems. The use of an appropriate valuation method is justified to ensure that universities obtain fair financial return through the downpayments and royalties from the technologies developed by researchers. In this way, universities can invest the money in new research fields, infrastructure and staff, providing a feedback cycle of innovation and contributing to the sustainable technological development of Brazil.
This article aims to discuss the main valuation methods of new technologies, especially those coming from university research, analysing both the point of view of these institutions and the potential licensee. Technology valuation is an important step in the process of technology transfer and is a recurring theme in dialogues between technological transfer offices (TTO's) from universities (the term “university” should be read to include universities, science and technology institutes, and non-profit research institutes).
Determining the value is a complex process, since the expectations of the companies and universities about the technology are numerous. However this is not always possible. Each institution has its own way of thinking and visualizing future applications for technologies. Even experts, when valuating the same technology, will find significant differences. Thus, a critical point of the process is to determine a value that satisfies both buyer (company licensed) and seller (university licensing).
Currently, many techniques are known to determine the value of a technology, each one with its own characteristics, strengths and limiting factors. Moreover, it is necessary to bear in mind that the same technology can have different values, depending on the market context in which the licensee is situated, its profile and business model. There are also cases where the same valuation method can provide distinct values when analyzed from the perspective of the buyer or seller. This article seeks to discuss these and other peculiarities of the process of valuation new technologies, describing and analyzing the methods described in the literature.
This article is structured in four sections. This introduction places the reader in an investigative context. The second section presents the exploratory research methodology adopted by the authors. Section 3 presents the literature review, provides a content analysis of selected books and articles and allows the reader to choose which valuation methods used in each specific situation. The last section presents the authors’ conclusions and makes recommendations for future studies, given the limitations of the current work.

2 Methodology
The methodology used in this article comprises an exploratory and qualitative research. Through this, the authors sought to provide greater familiarity in a still unknown terrain, though often discussed in Brazilian universities, as well as in the company research and development (R & D) centers: technology valuation. The technique of data collection was through systematic observations and literature searches in national and international publications.
The research was conducted in three stages: (i) literature review, (ii) systematic observations and (iii) survey findings.
The literature search comprised a survey of scientific and technical publications related to technology transfer, valuation methods and approaches methods. National and international journals available were reviewed, given that the subject is explored at different levels of details.
In the second phase, which occurred simultaneously to the first one, systematic and unstructured observations were carried as described by Lamnek (1995). The experts did not know they were observed and the authors were a part of the system under analysis. Most of the data was collected in loco, through participation in global events (conferences, workshops, fairs and lectures). Other data were obtained through virtual conversations. These actions allowed the construction of a rich network.
with Brazilian and foreign TTO’s members, which are constantly exposed to situations that span the subject. The conclusion consists of a critical analysis of the data collected and the technology transfer model currently applied by most Brazilian universities.

3 Literature Search

Much effort has been spent to determine the value of an intellectual property. In the case of universities that have a considerable portfolio of technologies and have limited human resources, it is impractical to value all in a timely manner. In such cases, the technologies must first be evaluated to determine their potential for success, and the valuation should be done later, when there is interest of commercialization and licensing of technology.

Battersby and Grimes (2011) argue that there are several methods of valuing an intellectual property and emphasize three main approaches that encompass some of these methods: cost, market and income. In this section, methods of valuation are contained in these three approaches, as proposed by Parr and Smith (1994).

For a better understanding of the context, studies will be initiated by the cost approach, since its methods are less complicated to apply. Subsequently, will be detailed the market approach, whose methods tend to have a relatively larger complexity as compared with the methods of the prior approach. Finally, the authors present the income approach, which is more complex than the others and tend to be more robust. Table 1 lists some of the main technology valuation methods that will be discussed, separated by approaches and sorted by complexity.

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Source: Authors 2013

3.1 Cost Approach

For some authors such as Drews (2004), Santos and Santiago (2008) and Battersby and Grimes (2011), the cost approach evaluates intellectual property according to the amount of money needed to generate it. Two common methods are highlighted: the reproduction cost and replacement cost. The reproduction cost, from the point of view of the developer (University), is the amount required to exactly replicate the product. In this case, the goal is to recover the investments made. But the replacement cost, from the point of view of the purchaser (licensed), is the amount needed to create something that could be used similarly, or which displays similar functionality.

This valuation method from the point of view of the university can be considered simple if researchers monitor costs during the development of technology. Also, efficient measuring can be made by licensed if this dominates the development process. However, depending on the complexity (usually high in technological innovation projects), it is not trivial for the company to use this approach. Another limitation of this method lies in the fact of not considering the future economic benefits arising from the commercialization of the technology. Thus, Souza (2009) suggests that the method should only be used when there is no information about the market or future income.
3.2 Market Approach

In the case of the market approach, it is assumed that the market value of a company represents the total value of tangible assets and intangible assets (Stewart, 2001). Hence, the difference between the total market value and the accounting value of the company would be an approximate measure of the value of their intellectual capital. The model proposed by the author is shown below.

Thus, this approach becomes effective only for companies with a single product or service, which is not common practice nowadays. Otherwise, it would be required to have access to recent similar transactions involving intellectual property, which is not trivial. If universities have access to transactions, they can compare their technologies with other similar which are being traded in the market. For example, if a university has developed a vaccine against prostate cancer, downpayments and royalties values can be used as a basis for licensing involving a vaccine against colon cancer.

Damodaram (2006) suggests that comparative valuation is performed in three steps:

i) Find a similar business or asset that was traded in the market. The valuation should be performed directly into real assets. For business analysts typically use companies in the same industry. However, as stated earlier, this information is not easily to obtain.

ii) Find a scale to distinguish assets with different proportions through a common variable. Normally it uses the Earning Multiple Approach, dividing the business value by a similar variable. Then, this multiple is used to obtain the final expected value (Copeland et al. 2005).

iii) Adjust other differences between assets or businesses, for instance, the market growth estimate. In this case, the valuation should consider a larger or smaller multiple, depending on the case.

In this context of technological innovation in which the universities are situated, mainly in the case of research that originates radical innovations, it is often difficult to find similar technologies and variables that can be used for comparison. Another limitation of the method is related to the possibility of a technological innovation generate more than one product (Shane and Elgar, 2004). Despite its limitations, the market approach is very useful in determining the royalty rates for technologies. This is justified by the fact that royalty rates follow industry standards. However, the application the method for determining downpayments is compromised since the estimates are intrinsic to technologies. The report released annually by the Licensing Economics Review (LER) provides rates of royalties applied to various industries and is an important source of secondary data that can be used to beacon the rates to be applied to a particular technology under evaluation.

3.3 Income Approach

The income approach analyzes the potential for intellectual property to generate net revenues during the term of the patent, which can consider the associated risks with investing.
Several valuation methods have been used by companies and universities to determine the future potential of their technologies. The four main methods will be focused, by complexity: Discounted Cash Flow (DCF), Risk-adjustment Net Present Value (rNPV), NPV with Monte Carlo Simulation, and Real Options Theory (ROT).

3.3.1 Discounted Cash Flow

The most common method of valuation is the discounted cash flow (DCF), originally developed for the analysis of assets such as government securities (bonds) and stocks. Such DCF models serve also as a basis for calculating the Internal Rate of Return (IRR) and the payback time (Payback), widely adopted by managers (Brealey and Myers, 1998). According to Martins (2001) “the DCF is seen as one that shows the effective capacity to generate wealth for a specific project.” Neto (2003) conceptualizes the FCD as “the greatest conceptual strictness and consistency with the modern theory of finance.”

The DCF is quite simple in its essence and use, requiring only discounting the projected cash flow of a company to its present value. However, in practice the method is more complex and has been shown to be difficult to use, more than one can imagine initially (Rogers, 2004).

For Rogers (2004), the complexity of the DCF arises then to estimate the future cash flow of a company, it’s necessary to estimate the overall behaviour of the economy. Thus, the difficulty would be present in determining a discount rate consistent with the reality of the project. In practice, good discount rates can be obtained by using the considerations of the CAPM (Capital Asset Pricing Model) and checking companies that have cash flows with equivalents risk (Souza, 2009).

Starting from the discounted cash flow models is possible to obtain the Net Present Value (NPV) of the technology. In this context, it follows that NPV is a method of investment analysis that determines the present value of future income. This method is obtained by subtracting the initial investment in a project (I) from the present value of cash flows (FCt), for a time (t), discounted at a benchmark rate (k).

The basic formula of NPV is shown in equation 1.

\[
NPV = I + \sum_{t=1}^{n} \frac{FC_t}{(1+k)^t}
\]  

(1)

If NPV is positive, it indicates that the project can be economically viable and should be accepted. If equal zero, it indicates that the initial cost will be recovered and the required fee will be paid. Yet if NPV is negative, the project is deemed unfeasible, therefore it should be rejected.

With the NPV it is possible to obtain the Internal Rate of Return (IRR) and payback. According to Rozenfeld (2009), the IRR is the economic rate needed to match the value of an investment with its future returns. In other words, it’s the rate of return that must be provided by the project so that this project can match its investment, after a period. The IRR is calculated by using the same formula as described above, but with NPV equal to zero.

The same author also states that, subsequently, the IRR is compared with the Minimum Acceptable Rate of Return (MARR) estimated to verify the performance of the project. The IRR can be: i) greater than the MARR, meaning that the investment is economically attractive, ii) equal to the MARR, in a situation of indifference and iii) smaller than the MARR, indicating that investment is not economically attractive, because its return is outweighed by the return of a riskless investment. He also highlights that, among various investments, the best is the one that has the highest IRR.

In the same context, Rozenfeld (2009) says that the payback consists, basically, in determining the number of periods required to recover the capital invested. Having this assessment, the manager decides to accept or reject the project. The easiest way to calculate it is simply accumulating inflows and outflows of money and determining the period in which there was a transition from a positive value to negative one.

The method has, however, some limitations. Dixit and Pyndick (1994) make some criticisms, claiming that the problem of the DCF lies in the fact that it isn’t able to capture the value of managerial flexibility. Another feature is that its components are static, not considering the uncertainties in future
cash flow and computing the risks only in the discount rate. Santos and Pamplona (2001) show the need for additional studies into the method, emphasizing:

Executives, realizing that the DCF tool is very poor at capturing relevant project possibilities, rely on the intuition of business, not investing immediately in projects just because a static analysis has indicated a positive NPV, or reject strategic projects because of a report indicating negative NPVs for such projects (Santos and Pamplona, 2001).

3.3.2 Risk-Adjusted Net Present Value

Technologies developed by universities are mostly embryonic or are in early or intermediate stage of development. In these cases, the valuation methods to be used should consider the risks and uncertainties associated with technology. Razgaitis (2009) highlights four potential sources of risk that should be considered in studies:

i) Technology itself: depending on its stage of development, risks associated with R&D activities, product development, and design for manufacture and rising costs of raw material.

ii) The market: forecasting market need, the product acceptance, product lifecycle and purchasing power.

iii) IP issues: protection scope and protection of trade secret.

iv) Government and society: government policy, or societal values, can make it difficult or impossible to realize commercial value.

The calculation of risk-adjusted Net Present Value (rNPV) is probably the most used valuation method for determine the value of new technologies. This method has, besides the traditional discount rate, other risk rates that are adjusted to each stage of technology development. The pharmaceutical industry, particularly, tends to adopt this method since many studies have associated probability of success of a drug according to its stage of development.

In general, the method comprises five stages: i) determination of cash flow in the technology development phase, ii) determination of cash flow in the market phase, iii) application of the discount rate in the cash flow; iv) risk adjustment for each stage of development and v) sum of cash flows.

3.3.3 Net Present Value with Monte Carlo Simulation

As previously stated, there are many sources of risk associated with the development of a new technology. Thus, the treatment of risk is extremely important to a more robust valuation. However, in all valuation methods discussed so far treat risks statically either through the discount rate or through adjustment proposed by the previous model. This ends up creating a problem since, by assign a single value to the risk, the probability of hitting is smaller than assign an interval in which the extreme values are known. A likely way to handle this limitation of the models would be modeling risks with Monte Carlo simulation.

The Monte Carlo Method (MCM) is probably one of the most recognized probabilistic techniques with broad application in various fields of study. The basic idea behind the MCM is that instead of assigning one specific value to a variable of DCF model will be assigned a probability distribution function associated with that variable. In the case of valuation of new technologies, in particular, the MCM allows modelling the traditional DCF, associating probability distributions to the variables in which the risk is present and returning a distribution of possible future results of the technology’s NPV. In this way it is possible to make decisions based on the expected results, adopting risk mitigation strategies, and not focusing on a single number.

In a simplified form, the method comprises five steps: i) estimate of DCF ii) determining the NPV of technology, iii) modelling of uncertain variables in terms of its probability distributions, iv) analysis of the model with Monte Carlo Simulation and v) decision making based on different scenarios generated.

As the model output it is expected to obtain a probability distribution of possible values for the NPV of the technology, indicating its more likely value and those generated by the pessimistic and optimistic scenarios. Additionally, it is expected to identify the variables that most influence the model, so that licensees can adopt mitigation measures, reducing the risks of the new venture.
3.3.4 Real Options Theory

The Real Options Theory (ROT) is a method of pricing real assets articulated with the managerial flexibility, for decision making on investment projects. The great advantage of ROT, when compared to other methods such as Discounted Cash Flow (DCF), is to be able to value the assets of the project taking into account the moments of market uncertainty, providing support for the manager to decide the best time to start the project.

Dixit & Pindyck (1994) conceptualize Real Option as flexibility that manager has in make the best investment decisions. As market information is very dynamic, changing over time, managers can use it to identify the best time, decreasing the uncertainties, to decide on an investment. The same authors criticize the traditional methods of investment analysis, arguing that these methods, such as NPV and IRR can lead to erroneous decisions by not considering three important features that are taken into account in investments: irreversibility, uncertainty and timing. These pillars are important to the manager in decision-making as he/she can, for example, define whether or not to delay an investment. Brealey and Myers (2003) recalls that for a long time the economics scholars worked on the development of a practical formula for valuing options (as cited in Brandão, 2006). The traditional steps for evaluating investments (estimative of cash flows and its present value discount) did not work for options the way in which was originally designed. The most widely used models are the binomial model and the Black-Scholes model.

HULL (1998) characterizes the binomial model as able to represent the different paths that can be followed by the price of the underlying asset during the life of the derivative. Another feature of the model is that the asset can go only in two specific trajectories, up or down, in each moment of time (as cited in Brandão, 2006).

A practical example of the possible application of the ROT in valuation of technologies, by companies, would be the decision making of investments in new drugs, since the agent interested in licensing the technology may choose to acquire it, watching its stage of development. It can, for example, decide on investment in an early-stage technology, visualizing a larger gain in the future and paying a lower premium for it, instead of acquiring it more developed, paying a much higher value by being in a more advanced stage of research and development. Universities can use this method to make the decision if it is better licensing the technology in this moment or postpone the license aimed future applications more profitable (additional research can occur).

Despite the numerous advantages, Santos and Santiago (2008) highlight some limitations of the model. The first is that the analysis is more complex and time consuming than other methods, because it is necessary to collect more information. In addition, the mathematical techniques used are more sophisticated than those used by DCF. Nevertheless, the authors stress that these additional information will provide a more accurate analysis of managerial flexibility. They further conclude that:

The valuation using this technique is justified only when it is necessary to take an important decision (e.g., significant financing or licensing), and especially in the case of projects in which the value estimated by the discounted cash flow method is near zero (Santos and Santiago, 2008).

4 Conclusion

It is possible to say that there is not one method that should be indicated to determine the value of all technologies after all, each technology is unique. The most prudent is to identify the level of detail desired, collect as many information as possible and, from this data, choose which method or set of methods will be applied.

Different approaches and methods of valuation are available in the literature and present its own assumptions and limitations, as detailed throughout this article. However there is still few information in the state of the art about which method is most commonly used by companies and universities. It can be inferred that the most common valuation method in the companies is the DCF since it is very discussed in higher education courses and allows calculating the internal rate of return and payback that are widely adopted by managers in its decision making.
With regard to excellence universities abroad, the most used method to determine the value of its technologies has been the rNPV. It is known, however, that the method has limitations, as outlined in this study. The authors believe that one reason for its adoption may be related to the inability of the TTO’s in using more complex methods of valuation, mainly due to time and skilled labor constraints. It is suggested that in the absence of the possibility of using methods more robust, implementation is performed along with other approaches, e.g., the market approach (comparing licensing values of similar technology).

Regarding the methods used by Brazilian universities the information is even rarer. The few universities that are more advanced have its own strategies for technologies trading and have used some robust valuation methods. However, most of the TTOs are being structured and there isn’t an effective management of its portfolios, whether in relation to technology assessment or valuation for licensure. Thus, many technologies with potential are not properly offered to companies. The value of many technologies is underestimated, the royalty rates are not consistent with those prevailing in the market and some technologies are forgotten. These technologies, in addition to not generate economic benefits to the institution, contribute to the high cost for maintenance the patent portfolio.

To reverse this scenario, the authors suggest that should be studied robust methods of valuation that maximize financial returns to universities, through licensing of technology, in order to feeding back the research and development (R&D) system and contributing to the sustainable development of Brazil. For that happen, it is necessary the training and recognition the labor in the TTO’s, as well as recognize the valuable role played by the universities in the national innovation system.

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