

Technology Transfer and Valuation Methods in Use by University Technology Transfer Offices

A. Rocha[1](✉), F. Romero[2], R. M. Lima[2], M. Amorim[3], and M. Cruz-Cunha[4]

[1] Polytechnic Institute of Cávado and Ave, Barcelos, Portugal
arocha@ipca.pt
[2] Algoritmi Research Center, Department of Production and Systems, School of Engineering, University of Minho, Braga, Portugal
[3] GOVCOPP Governance Competitiveness and Public Policies, University of Aveiro, Aveiro, Portugal
[4] 2Ai Artificial Intelligence Laboratory, Polytechnic Institute of Cávado and Ave, Barcelos, Portugal

Abstract. Valuing research deliverables implies the assessment of knowledge, skills, and solutions that can create benefits for a wide scope of stakeholders, including researchers, research units, universities, businesses, and the larger society. Investing in early-stage technology or technology that is novel and has an inventive step can imply a high-risk investment. High-quality information and advice are needed, and valuation methods are required, to support decision making regarding intellectual property rights protection, define a technology value proposition, devise a roadmap to bring technology into the market, and support negotiations with potential licensees. To provide information and evidence regarding the main technology valuation methods in use by Portuguese University Technology Transfer Offices (TTOs), qualitative and quantitative data have been collected by surveying and interviewing eight Portuguese University TTOs. From the data it was possible to conclude that pre-defined rating/ranking methods and models are the most frequently used valuation methods, followed by market valuation approaches. Previous agreements and discounted cash-flow projections are mainly used when a spin-off firm is under consideration or when there is a manifestation of interest from a potential investor. Royalty standards are used to prepare licensing negotiations, and Real Options, Monte Carlo simulation, rules of thumb, and Auctions are not being used.

Keywords: Technology transfer · Technology valuation and licensing · University and industry relation

1 Introduction

University technology transfer refers to the process of exchanging technical solutions, knowledge, and skills between universities and businesses, with the aim of exploring valuable tangible and intangible assets creating utility for those who benefit from their application [1].

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2023
P. Samarati et al. (Eds.): ICETE 2021, CCIS 1795, pp. 51–66, 2023.
https://doi.org/10.1007/978-3-031-36840-0_3

Technology Transfer Offices (TTOs) act as mediators in the valorization process, by reviewing and assessing invention disclosures in close collaboration with researchers, to define a protection strategy for Intellectual Property Rights (IPR), and to devise a plan to bring scientific and technological research results to the marketplace and the wider society. These possible valorization routes include licensing, selling IPR, establishing research and cooperation agreements, and the creation of a spin-off company or a joint venture.

Throughout this process technical and market assessments are carried out to support IPR decisions, define a technology value proposition, and support negotiations to reach a balanced deal to transfer valuable assets that are novel, have industrial applicability, and involve an inventive step.

Technology transfer creates utility beyond the opportunity of making money, either for universities or businesses, it can lead to the development of new projects and competitive advantages, including the development of new solutions not owned by other companies, updating and improving products, services, or manufacturing processes, or by reducing costs of industrialization and commercialization [2].

To further expand our knowledge regarding valuation processes supporting technology transfer, this article provides information and evidence on what are the main technology valuation methods in use by Portuguese University Technology Transfer Offices.

2 Methodology

This study is integrated into a larger research project [3–5] for the study of management of research, and valorization of technology, which involved an extensive literature review and the collection of complementary information by employing a semi-structured survey and interviewing the heads of staff of eight Portuguese University Technology Transfer Offices (TTOs).

The eight TTOs are linked to eight Portuguese Universities:

(a) TecMinho, University of Minho;
(b) UPIN, University of Porto;
(c) UATEC, University of Aveiro;
(d) DITS, University of Coimbra;
(e) Innovation and Development Office, University of Beira Interior;
(f) RIA, Research and Innovation Accelerator, University Nova of Lisboa;
(g) Technology Transfer Office, University of Évora;
(h) CRIA, University of Algarve;

This sample was purposefully chosen due to the high regional and national influence of the universities, and the experience and ability of the TTOs to provide data that would expand the understanding of technology transfer processes. Five out of the eight universities appear regularly in world rankings of the top 1000 universities [6].

The semi-structured survey was focused on technology valuation methods. A Likert scale has been used to classify the frequency of each method. The higher the value the higher the frequency of use, on a scale between 1 and 5. Since the sample is constrained

to Portuguese universities, a descriptive analysis was adopted to process the data, and a content analysis of the interviews has been performed to gain further insights on which to base the conclusion regarding the frequency of use of different technology valuation methods in use by Portuguese University technology transfer offices.

3 Technology and Technology Transfer Offices

It is usual to equate a patent with one technology, but these days such cases are rare. Usually, multiple patents or multiple technical and knowledge solutions are required to obtain a technology and multiple technologies are responsible for a product, so it is prudent to obtain technology from other sources rather than investing time and resources to get a complete product or to find the perfect solution [7].

Technology transfer corresponds to the process of transferring technical solutions and scientific and technological knowledge from one organization to another, intending to take advantage of and exploit research results in favor of the development of the state of the art, science, economy, and the society.

Technology transfer processes are often carried out by inventors or by technology transfer offices or companies.

Technology transfer offices promote the use of R&D results through the assessment and protection of industrial property rights and through the dissemination of information, the negotiation of transfer agreements, and the provision of support services to create spin-off companies (start-up companies created to exploit research results coming out from one organization), they also administer and monitor licensing contracts, the transfer of materials, and the administration of equity participation, collecting and sharing the revenue from technology transfer agreements [8].

The closer the technology transfer offices are to the researchers, the more efficient they tend to be in establishing a relationship of mutual cooperation [9], which is important to encourage researchers to provide regular information about their research activities and results [10].

The disclosure of research results triggers the valuation process, to determine its economic value, define its commercialization strategy, and combine its unique characteristics with the needs and interests of organizations that can take advantage of its use. The acquisition of technology and its transformation into new or improved products and processes allows organizations to acquire competitive advantages, either by offering solutions not owned by other companies, by updating and improving their range of products and services or to answer to specific customer needs or market trends. The acquisition of intellectual property rights also makes it possible to offer better or differentiated solutions or at a more competitive production and distribution costs.

4 Valorization Routes

Possible valorization routes include licensing, selling intellectual property rights, the establishment of research and cooperation agreements, and the participation in the share capital of companies through the creation of spin-offs or the establishment of joint ventures.

A licensing agreement gives access to knowledge and technology that would otherwise be difficult to obtain, given the time, costs, and possibility of obtaining a technology with the same or similar applications.

To license a technology a contract is established in which the technology owner agrees not to enforce its industrial property rights against one or more organizations wanting to exploit the technology, and the licensee may be granted the right to exclude others to use the licensed asset. A licensing agreement creates contractual rights, duties, and obligations between the owner and the licensing entity, which govern their relationship in a legally binding manner [11].

The technology owner can grant exclusive licenses for use (purpose and application) and territorial exploitation or, alternatively, grant non-exclusive licenses for any scope of use or territory where protection has been enforced, the owner, in either case, can reserve for himself the right of exploitation, provided that this possibility is defined in the technology transfer agreement.

Selling the technology should also be considered as an option, when the new technical and knowledge solution is peripheral to the organization's activities and is not necessary for the development of new knowledge and technology, and when there is no interest on the part of the organization and the R&D team in creating a company to explore the technology.

The creation of a spin-off is an adequate option when we have the proof-of-concept of a full commercial product based on new technology and when it is considered that licensing is an unprofitable option given the value of the invention and the strength of the protection or when are having difficulties on getting profitable business proposals to license the technology.

Another way of valuing the R&D results is through the establishment of Cooperation Research And Development Agreement (CRADAS), Material Transfer Agreements (MTAs) (and non-disclosure agreements (NDAs), which allow the owner to maintain the control of technology and at the same time access resources, knowledge and technology from RTD (Research, Technology, and Development) partners to continue or develop new R&D projects.

After reviewing the valorization options, for the disclosed technical solution, we have to decide whether or not we should pursue the protection of intellectual property rights. But, in either case, we must assess its patentability to make decisions regarding the best way to protect the invention and make a profit from it.

The good use of information available in patent directories can reduce the costs and time of R&D projects and give us information about changes that have occurred in the field of the invention and information about patents with the same purpose of the invention if they exist [12].

A patent is a good option to guarantee the exploitation of intellectual property rights of a new technical solution and to protect future revenue [13]. An industrial secret can also be a good option when the claims of the invention do not prevent others from circumventing the invention to obtain similar results or when the field of invention moves so fast that patents may become irrelevant, and when it is very difficult to detect patent infringements, such as the case, of inventions applicable to production methods, where the use of the invention in the final product is not evident [14, 15]. The industrial secret

can even outlast the temporal protection of a patent, but there are no guarantees that this may happen, it also has the advantage of using the invention in different countries without paying fees to enforce territorial rights.

5 Transferring the Technology

To transfer technology, we have to find an opportunity to combine the characteristics and advantages of the technology with the needs and interests of organizations.

Finding organizations that are willing to replace, update or diversify their product range is the opportunity we are looking for, and the better the technology is aligned or tailor-made to one organization the higher the odds of licensing it [14, 16].

In determining the attractiveness and commercial potential of an invention we must assess how it fits within the technological space of potential licensees to look for an alignment between the characteristics of the technology and the capabilities and resources held by companies [17]. During this analysis we must strive to (1) identify which technologies have to be integrated with the technical solution to obtain an entire commercial product; (2) analyze the possibility of combining the technology with existing products and systems; (3) Determine which knowledge has to be transferred to companies and whether they are able to use them; (4) Analyze the possibility of producing the technology on a large scale and its robustness to function in different environments [18].

The development of full products and their demonstration on the ground reduces the licensee's perception of risk, but in addition to the risks and costs associated with technology development, there are also risks and costs in the introduction of new industrial products [17]. The ideal is to find licensees who have a positive attitude towards risk. Smaller companies are more likely to adopt technology in the early stages of development, where the risk is higher, or technologies that have disruptive characteristics, which allow for the development of next-generation products based on different scientific and engineering domains [19]. Larger companies, as they have more pre-established commitments, are less flexible in adopting new technology and tend to prefer solutions of an incremental nature, which add something new to a pre-existing invention or that change its design [17, 20]. But regardless of the company's maturity and size, technology adoption is dependent on its strategic orientation.

As growth through the development of new products and processes is more important for companies that are characterized by a pioneering attitude in the introduction of new technologies and business opportunities, these companies are preferred technology licensees that we should look for [17]. Nevertheless, the technology can also be useful to companies that want to remain competitive or that want to compete with companies already installed in the market. We must therefore pay particular attention to existing and overlapping patents in terms of results and who owns them, in order to direct the invention to companies that may require new technology to accompany pioneering ones. We must also observe the rate of growth of patents and articles in a given area, and who has developed them which are the organizations that are applying them, to identify developers and users, and figure out the importance of different subclasses of patents for the industry.

When looking for avenues for technology licensing we must also consider the technology readiness level and its complexity of application and use. Larger companies

generally have more resources and a greater financial capacity to move the technology forward and to deal with its complexity, if the technology is ready for market and industrialization, then it must be, not the size of the company, but the number of consumers in the market targeted by the invention that must dictate the companies we should look for [17].

A good licensee is one that has a significant current market share and a credible brand, but it is not always possible to license the technology to the companies that we consider the most suitable for developing and commercializing the invention, because companies may not be interested in the invention or at that time may not be part of their development strategy to have it.

Once we have clarified which companies, we want to work with. we must devote serious efforts in marketing the technology value proposition.

6 Technology Value Proposition

The size and quality of the researchers and technology transfer offices network of contacts play a critical role in technology transfer [21]. Inventors predominantly reach agreements through contracts with large companies, technology transfer professionals tend to establish a greater number of agreements with small or medium-sized companies. Smaller companies have fewer resources to invest in technological surveillance activities, being more receptive to information disseminated by technology transfer offices, so investing in direct marketing to small companies may generate greater gains compared to marketing actions aimed at large companies [22]. Nevertheless, the greatest number of successful cases in technology licensing occur when technologies are developed for companies or with the participation of companies [23, 24].

Technology transfer offices also use informal contact networks to obtain support, to assess the technology technical and market potential, to identify further resources for new development stages, to get access to financial resources, and to support the creation of spin-off companies. These informal networks made up of different economic, technological, state, and business agents, are contacted whenever the technology justifies it, whether before or after obtaining intellectual property rights.

Based on the information obtained through informal networks of contact, market studies, and the technology transfer office assessment and information provided by the inventors, a technology value proposition is formulated to market the technology.

Technology transfer offices use multiple communication channels to convey the technology value proposition, which must consist, of a brief presentation that identifies the potential consumers, identifies the existing problems. Quantifying them and presenting the reasons why people need the solution, and the solution must be described in quantifiable economic and social benefits for the target audience.

The value proposition should be based on what we know about the overt or hidden problems or desires of end consumers. The value proposition must objectively describe the problem or trend, mentioning how it can be overcome or solved through our offer at a reasonable cost considering its benefits [25].

7 Valuation Methods

7.1 Technology Assessment Methods

Determining the value of an invention involves a high degree of uncertainty, to manage this uncertainty assessment methods are used aimed at minimizing the potential costs with patent protection and leading fair negotiations with potential licensees.

To assess invention disclosures quick evaluation methods, based on checklists and brief assessment reports are used to understand the technology, its market, and potential for profit. At a later stage, more in-depth assessment methods are used including the projection of discounted cash flows.

Among the assessment practices, which assume greater importance to understand the technology, are [26]:

(a) Analysis and description of the technology readiness level, its attributes, claims, and the identification of all its potential applications.
(b) Characterization of further development stages and the definition of an action plan to gather the necessary resources to bring the technology to market;
(c) Assessing the possibility of the patent being redesigned (at what cost, time, and technical and legal risks);
(d) Analysis of the technology's competitive and differentiating advantages.

At this stage of understanding the technology, we want to get as much information as possible to clarify the tasks needed to get the technology proof-of-concept (if not yet attained) and to determine the most promising applications, with a stronger bond between the technology and its market.

Market research is the starting point for analyzing the relationship between technology, its applications, and its market, identifying end-consumers and their needs, and identifying competing companies and solutions. The information gained with the market study allows, on one hand, to make decisions about which applications can be better accepted and, on the other hand, it allows to define the value proposition and to define a marketing strategy to attract the interest of potential licensees.

To obtain data on the invention and its market potential, there are several methods with different levels of depth that can be applied at different moments in the evaluation process.

The most common approaches for technology assessment are [3, 27–29]: (1) Predefined models and evaluation matrices; (2) TEC algorithm; (3) Economic value assessment; (4) Market value assessment; (5) Valuation based on technology costs; (6) Valuation rules of thumbs; (7) Real Options and Monte Carlo simulation; (8) Valuing through patent auctions.

Pre-defined Models and Evaluation Matrices. Methods based on pre-defined evaluation models make the evaluation process faster and facilitate the evaluation of multiple dimensions of the invention. among these instruments are:

(a) EPO IPscore, from the European Patent Office, is a tool to evaluate patents, technologies, and projects. "This tool can be used to (1) evaluate patent portfolios, individual patent applications, and granted patents; (2) analyze complex patented technologies;

(3) assess research projects before filing a patent application. EPO IPscore has 32 factors grouped in four categories (legal status, technology, Market conditions, and finance), and the results are presented in a ranking radar graph" [3, 45].

(b) IPR Valuation checklist, from the UK Intellectual property Office, including sixty questions to support determining the value of IPR and discussions with potential licensees [3, 46].

(c) COAP – Commercial Opportunities Appraisal Process, from the Warwick University, in which ten evaluation criteria are scored (1) Uniqueness of the technology; (2) Technology readiness level; (3) Market value; (4) Anticipated profit margins; (5) Intensity of competition; (6) Technology competitive; (7) Ease of access to market; (8) Customer conservatism; (9) Team commitment; (10) Team commercial experience [3].

(d) Quicklook Commercialization Assessment, developed by the University of Texas, consists of a four-step procedure (1) Market characterization; (Identification of end-users and potential licensees; (3) Contact experts and companies; (4) Prepare a valorization report. This report is structured in nine steps: (1) Technology Description; (2) Benefits; (3) Commercial Markets; (4) Market Interest; (5) Technology readiness; (6) Protection strategy and status; (7) Competing technologies and companies; (8) Barriers to market entry; (9) Recommendations [3].

(e) Checklist of 100 criteria to value a and license a technology, by Tom Arnold and Tim Headley, presented by (Razgaities, 2007) [28]. This checklist includes an assessment in nine categories: (1) Intrinsic quality; (2) Protections and threats of protection; (3) Market; (4) Competitiveness; (5) Value brought to the table by the licensee; (6) Finance; (7) Risk; (8) Legal issues; (9) Government regulatory considerations [3].

Pre-defined models and evaluation matrices designed to rate, rank, and describe technologies and their markets are being used by more than half of the Portuguese Technology Transfer Offices.

7.2 TEC Algorithm

TEC algorithm, developed by the University of North Carolina, aims to find the strongest T-P-M (Technology-Product-Market) connections. A market study is carried out to verify whether the product concepts derived from the technology are viable and have the potential to be licensed and valued [33].

TEC algorithm is started by idealizing multiple product concepts for the technology and them on the analysis of the strongest bonds between the Technology, the Product, and its Market (TPM analysis), to determine which product alternatives have the strongest linkages to gain value from the technology.

This analysis leads us to study the following components [30, 31]:

(1) Technology: Its potential (whether the technology provides better performance, is easier to use, reduces costs, or is easier to access) and its unique characteristics (claims that define the technology).

(2) The products or processes: When describing application attributes, it is important to state the essential properties of the commercial object that differentiates it, creating value for consumers. This differentiation can result from unique attributes and from

attributes that have a greater weight in relation to attributes of other alternatives (if any).

(3) The market: The market corresponds to a large area of business in a given economic sector and may contain several market segments.

(4) Market segments: Market segments correspond to homogeneous groups of consumers who share similar needs, motivations, and perceptions. We can segment the market into two major dimensions: (1) Consumer market segments, where we must consider: (a) The geographical area and population size; (b) Demographics: age group, gender, income, occupation, education, religion, ethnicity, household size; (c) Psychography: lifestyle, behaviour patterns, beliefs, values and attitudes towards self, family and society. (2) Institutional market segments, where we must consider: (a) Demographic variables: industrial sectors, company size, location; (b) Operational variables: technologies offered and degree of technology use; (c) Procurement variables: the centralization or decentralization of procurement; the acquisition criteria, such as quality, price, or differentiation; if companies are conservative, followers or innovative; (d) Specialization variables: the concentration of efforts on specific applications or multiple applications; (e) Personal variables: the similarities between the technology its buyer and sellers; the attitude towards risk and loyalty to suppliers or brands. Segmentation by institutional markets is particularly useful to analyze and identify potential licensees.

(5) Consumers: They are the potential buyers of the product or process within a sector or market segment that shares well-defined characteristics.

(6) Needs: These are what drive consumers to choose a particular product or process. Knowing the consumer and their needs, especially those not completely satisfied, their attitudes, and their motivations are the key element for the commercialization of products or processes derived from technology.

The analysis and study of these concepts are useful to identify the strongest bonds between the technology, the product, and its market, to focus marketing and commercialization efforts.

7.3 Economic Value Assessment

The economic approach consists of forecasting the technology profits to derive financial metrics, such as return on investment, payback period, internal rate of return, and net-present value, considering specific hurdle rates, that in some cases can be as high as 30% due to investment risk [3, 27].

The economic approach uses the discounted cash-flow method to deal with and license technology [3, 32, 33]. Discounted cash flows are important to prepare for negotiations to reach a fair deal and to have a basis on which the technology transfer payments structure can be defined. They are also relevant when the deal involves a single lump sum payment or when the creation of a firm is under consideration, providing a basis for equity participation [3, 34].

The interview results let us know that half of the interviewees use discounted cash flows and some do subcontract these when a potential licensee shows interest in licensing the technology. When negotiations come, it is useful to have one or more scenarios based

on a cash-flow projection to support discussions “We are currently negotiating with a company where we are going to see three scenarios, we have the best and then we have two other alternative scenarios. We usually try to outline several scenarios, in the negotiation, we only talk about one scenario, but we have two other scenarios up our sleeve to put on top of the table." DITS.

Cash flow projections are also useful to support the creation of a spin-off company “When researchers are interested in setting up a company, we estimate for five years to assess expected net profit, that is going to support the company business plan and potential return for investors.” UATEC. They are also valuable to work on a basis of credibility “We provide the study to companies to work on a basis of credibility and they give the value they give, good or bad, but so far the experience I have is that companies use those numbers but then they can make a detour from them, as to negotiate the deal.” GAAPI.

The discounted cash flow method is used according to Kemmerer and Jiaquing [32], by more than half of the entities that license the technology.

Market Value Assessment. The market approach consists in the analysis of market information, including the analysis of competitive alternatives and in the observation of comparable agreements and standard payments practiced in the industrial sector. This approach is very frequently used alongside ranking and rating methods.

The analysis of previous licensing agreements and payment values practiced in the industry, known as royalty standards, may provide guidance to define and defend the payments’ structure and their value during the negotiation of a licensing agreement [3, 7, 35–38]. The search for comparable agreements and royalty standards is an effort that usually pays-off [28], although the specificity of each technology may not call for standard agreements, we should not expect to find an agreement that meets all the wanted specifications. Nevertheless, it is important for the TTOs to build and maintain a portfolio of reference agreements that can be used if needed [9].

Comparable agreements and royalty standards are used by more than half of the Portuguese technology transfer offices. UPIN testimony is an explicit example of the use of previous licensing agreements and royalty standards – “We do establish a range for royalties, we do it based on previous agreements that we know, but it all depends on the company we are dealing with and then it is a process of negotiation between what we are offered, which is the minimum, and what we want, which can be the maximum. Industry royalty standard varies a lot, it has to do with the implementation time of the technology in that sector and not only with the sector itself, it has to do with the costs that the company will have to develop that technology or if it is already a ready-made solution, therefore, according to the risk that the company will have, we also have to adjust our royalties. The information about royalty standards is always useful to give us a reference in terms of the minimum and maximum values we were talking about. We also use other models. We have a database where we have agreements that we already had the opportunity to analyze and from which we rely upon. We also have other databases where we can get these useful agreements.”

Keeping a database of agreements is, according to Dodds and Somersalo [9], an important part of the work of a technology transfer manager – “Producing and analyzing licensing agreements is a big part of the work of a technology transfer manager. In this

sense, it is important to establish a portfolio of reference agreements that can be used when necessary."

Publications with licensing agreements and royalty are a good source of agreements that we can turn to. The most well-known and continuously updated database is the US Securities and Exchange Commission (SEC) «Royaltystat», which is based on the Edgar Archive – Edgar is an archive of the North American Administration that gathers quarterly reports of all activities and economic and financial results of companies listed on the New York Stock Exchange.

By subscribing to the «Royaltystat» database at the following URL: http://www.royaltystat.com/, subscribers have access to the most recent agreements and statistical data on the structure of payments and royalties, being able to make searches through several queries and the SIC classification – Standard Industrial Classification.

The analysis of comparable license agreements and the observation of royalties standards can provide us with useful information, but it is still a very limited approach given the unique structure of each license agreement, hence the importance of not using this approach in isolation, we must combine it with other valuation methods always paying attention to the technology readiness level and performing a market assessment and, for example, using the TEC Algorithm, to identify the competitive advantages and the appropriate price for the technology to be transferred.

Valuation Based on Technology Costs. The cost approach quantifies the costs of obtaining the technology, it can be particularly valuable to determine if it is worth licensing a technology instead of further developing it, or to consider the creation of a spin-off company to value the investment done or to be done.

Evaluation based on development costs is rarely a base on which firms negotiate licensing agreements [3, 28, 39]. Companies are interested in obtaining technology easily and more cheaply than it would cost if they were to develop it by themselves, and the cost of creating a technology may have little to do with its market value [17].

Portuguese Technology Transfer offices frequently try to determine how much did it cost to develop the technology – "We calculate the development costs and estimate their market value, if they are incompatible it is because the business does not make sense, if they are compatible, we assume the market value, therefore, the development costs serve to verify if it makes sense to go ahead with a project." INOV.

The market value of the technology is the appropriate metric to define the price of the invention – "It is always the market value that determines the value of the technology, regardless of all the costs that the University had during the research until the discovery and further development, we are not going to show how much we spent, we always make our calculations based on «this is what you will earn». Our objective is always to put technologies on the market with better or worse deals. From the moment a company is involved, and new phases of development are needed, we try to articulate with the company a way to co-finance these costs either by the company or through an incentive scheme, if these costs have already occurred, have already occurred, our objective is to

try to place our product on the market and from there to create added value, not only economically but also for society." UPIN.

Valuation Rules of Thumb. The 25% rule splits the value of a technology into four parts, according to Razgaities [3, 28]: (1) the technology creation, (2) the steps required for industrial manufacturing, (3) the manufacturing itself, and (4) the technology sales by itself or within a larger product or platform. Each part represents a quarter of the technology value, the creation of the technology is just one of four parts (25%) through which value is created. if the technology is ready for manufacturing, a value of 33% or higher may be defined, this argument is that the technology has already reached a portion of the manufacturing process, so the manufacturing itself and the sales are the next two big steps ahead, so the technology is two-thirds of the way. In the case of software, values can ascend to 50%, if the technology is ready for sales.

The 25% rule is frequently applied to the EBIT – Earnings before interests and taxes [3, 32], and the licensee pays a fee equivalent to 25% of the technology contribution to the operational results gained by the solution that embeds the technology.

The use of rules of thumb is not a frequent practice among Portuguese Technology transfer offices.

Real Options and Monte Carlo Simulation. The real options method is used to assess multiple assumptions in a cash-flow projection, each assumption having different degrees of uncertainty for which risk-adjusted hurdle rates must be defined. This is a time-consuming approach, but it may bring a more complete analysis to determine the investment return [3, 40, 41]. Authors like Speser [3, 17] refer to real options as unnecessarily complicated, not providing an accurate and precise assessment of technology value, real options can be better used in planning R&D or developing IP strategies, and not to prepare negotiations. The Monte Carlo allows to account for risk in quantitative analysis and decision making and multiple scenarios are generated to simulate the potential investment return.

The real options and Monte Carlo simulation are not being used by any of the Portuguese Technology Transfer Offices.

Valuation Through Auctions. Patent auctions can be used to transfer technology by interacting with multiple investors in a bidding process [3]. Patent auctions are gaining increasing importance in technology transfer processes [3, 42]. Auctions can be a practical way of making value out of patents, provided they are of high quality [43]. Auctions are particularly relevant to transfer inventive solutions that otherwise would fall in absence of payments of patent fees. Planning auction events requires considerable organization and advertising, and it is not likely to have several bids for a technology [44]. Portuguese Technology Transfer Offices never used auctions to transfer technology.

8 Conclusion

Technology assessment methods are useful to understand the invention, identify resources and skills, understand the risk associated with the investment, support the invention's marketing strategy, and above all prepare and guide the negotiation process.

At an initial stage, preparatory to filing a patent application, patent databases are used to determine the novelty, inventive step, and industrial applicability, and predefined evaluation models and matrices, are used to make a quick assessment of the technology market and commercialization potential.

At a later stage, usually when there is a manifestation of interest from a company arises or to make a presentation to a potential investor, Portuguese technology transfer offices, tend to look for comparable agreements (if any), to the observation of royalty standards, and cash-flow projections can be done to support the negotiation process or the creation of a new spin-off company.

Transversal to these two phases, contacts are developed with industry and with formal or informal networks of partners to obtain advice, financing, or access to technical and market information, or to facilitate access to equipment and materials external to the institution. The resources gained through the interaction with formal and informal networks are also used to further invest in the technology to get its proof of concept and/or proof of market.

The application of technology assessment methods can serve as a baseline to design a balanced agreement that both parties consider equitable in the division of potential gains, to bring the technology into its industrialization stage and market.

Rules of thumb are not being used, since there are doubts regarding its reliability and because every agreement is unique, values can vary according to the rights granted, the technology development stage, manufacturing and distribution requirements, and other constraints. Real options and Monte Carlo simulation are also not in use, technology transfer professionals prefer valuation methods that are simpler and faster to assess the technology value.

To reinforce these conclusions, and to better understand how technology transfer offices use different valuation practices and methods, one avenue of research would be to expand this study to include technology transfer offices from Portuguese universities and also from other countries within the European Union. Furthermore, the study of the value created by licensing agreements should be explored in search of a possible correlation between technology licensing and its impact on research teams and technology transfer offices performance and financial profitability. These research lines would create the opportunity to better understand the application of technology valuation methods and the overall impact of university-industry relations on the outcomes of research teams and technology transfer offices.

Acknowledgment. This work was funded by national funds, through the FCT – Fundação para a Ciência e Tecnologia and FCT/MCTES in the scope of projects UIDB/05549/2020 and UIDB/00319/2020.

References

1. HERA: Higher education and research act 2017. UK Public General Acts. 2017 c. 29. Part 3. Research and innovation functions. Section 93 (2017). https://www.legislation.gov.uk/ukpga/2017/29/section/93/enacted

2. Hockaday, T.: University Technology Transfer: What It Is and How to Do It. Johns Hopkins University Press (2020). ISBN-13: 978-1421437057
3. Rocha, A., Romero, F., Cunha, M., Lima, R., Amorim, M.: A preliminary analysis of the use of valuation methods by technology transfer offices. In: Proceedings of the 18th International Conference on e-Business - ICE-B, pp. 136–143 (2021). https://doi.org/10.5220/0010599901360143. ISBN 978-989-758-527-2; ISSN 2184-772X
4. Rocha, A.: Gestão de projetos de Investigação, Desenvolvimento e Inovação: Práticas e definição de um modelo para a valorização de tecnologia. Escola de Engenharia, Departamento de Produção e Sistemas, Universidade do Minho, Tese de Doutoramento em Engenharia Industrial e de Sistemas (2018)
5. Rocha, A., Lima, R., Marlene, A., Romero, F.: Payment types included on technology licensing agreements and earnings distribution among Portuguese universities. Tékhne - Review of Applied Management Studies. Elsevier. SOURCE-WORK-ID: cv-prod-id-687275 (2017). https://doi.org/10.1016/j.tekhne.2017.11.001. Part of ISSN: 1645-9911
6. CWUR: Center for World University Rankings (2019). https://cwur.org/2018-19.php
7. WIPO/ITC: Exchanging value: negotiating technology licensing agreements. A training Manual. World Intellectual Property Organization (2005)
8. COM: 182 final. Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation. Voluntary guidelines for universities and other research institutions to improve their links with industry across Europe. Comunicação da Comissão das Comunidades Europeias. SEC, 2007, p. 449 (2007)
9. Dodds, J., Somersalo, S.: Practical considerations for the establishment of a technology transfer office. In: Krattiger, A., Mahoney, R.T., Nelsen, L., et al. (eds.) Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices. MIHR, Oxford, U.K., and PIPRA, Davis, U.S.A. (2007)
10. Sante, D.: The role of the inventor in the technology transfer process. In: Krattiger, A., Mahoney, R.T., Nelsen, L., et al. (eds.).Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices. MIHR: Oxford, U.K. and PIPRA (2007)
11. Thalhammen-Reyero: Transfer and valuation of biomedical intellectual property. Chapter 22. In: Taxation and Valuation of Technology: Theory, Practice and the Law. Horvath and Chiidikoff Editors (2008)
12. Smith, H.: What innovation is – How companies develop operating systems for innovation. CSC White Paper. European Office of Technology and Innovation (2005)
13. Howell, S.: Financing innovation: evidence from R&D grants. Am. Econ. Rev. **107**(4), 1136–1164 (2017). https://doi.org/10.1257/aer.20150808
14. Dolfsma, W.: Patent strategizing. J. Intellect. Capital **12**(2). Emerald Group Publishing Limited (2011). https://doi.org/10.1108/14691931111123377
15. Nelsen, L.: The rise of intellectual property protection in the American University. Sci. Mag. **279**(5356), 1460–1461 (1998). https://doi.org/10.1126/science.279.5356.1460
16. Gatignon, H., Robertson, Fein, A.: Incumbent defence strategies against new product entry. Int. J. Res. Market. **14**(2), 163–176 (1997)
17. Speser, S.: The Art & Transfer of Technology Transfer. John Wiley & Sons Inc, Hoboken, New Jersey (2006)
18. Rocha, A.: Avaliação e licenciamento de tecnologia em Universidades. Dissertação de Mestrado em Engenharia Industrial, na área da Avaliação e Gestão de Projetos e da Inovação. University of Minho. SOURCE-WORK-ID: cv-prod-id-687537 (2009)
19. Shane, S.: Encouraging university entrepreneurship? the effect of the Bayh-Dole act on university patenting in the United States. J. Bus. Ventur. **19**(1), 127–151 (2004)
20. Thursby, J., Jensen, R., Thursby, M.: Objectives, characteristics and outcomes of university licensing: a survey of major U.S Universities. J. Technol. Trans. **26**, 59–72 (2001)

21. Kolchinsky, P.: The entrepreneur's guide to a biotech startup. Evelexa.com (2004)
22. Ramakrishnan, V., Chen, J., Balakrishnan, K.: Effective strategies for marketing biomedical inventions: lessons learnt from NIH license leads. J. Med. Mark. **5**(4), 342–352. Henry Stewart Publications 1745–7904 (2005)
23. Harmon, B., Ardishvili, A., Cardozo, R., Elder, T., Leuthold, J., Parshall, J.: Mapping the university technology transfer process. J. Bus. Ventur. **12**(6) (1997)
24. Hsu, D., Shen, Y., Yuan, B., Chou, C.: Toward successful commercialization of university technology: performance drivers of university technology transfer in Taiwan. Technol. Forecast. Soc. Change **92** (2015). https://doi.org/10.1016/j.techfore.2014.11.002
25. CONNECT Sweden: How to succeed in market and sales: advice to start-ups (2004)
26. Rocha, A.: Gestão de projetos de investigação, desenvolvimento e inovação: práticas e definição de um modelo de integração para a valorização de tecnologia. Tese de Doutoramento em Engenharia Industrial e de Sistemas. Universidade do Minho (2018). http://hdl.handle.net/1822/58967
27. Razgaitis, R.: Pricing the intellectual property of early-stage technologies: a primer of basic valuation tools and considerations. In: Krattiger, A., Mahoney, R.T., Nelsen, L., et al. (eds.) Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices. MIHR, Oxford, U.K., and PIPRA, Davis, U.S.A (2007)
28. Razgaities, R.: Valuation and Princing of Technology-Based Intellectual Property. John Wiley & Sons Inc, Hoboken, New Jersey (2003)
29. Schiltz, E.: How can high-growth business opportunities for a cutting-edge technology be discovered? Master degree in management from the NOVA – School of Business and Economics. University Nova of Lisbon (2019)
30. Cruz, E.: Criar uma empresa de sucesso. Edições Sílabo, Lda, Lisboa (2006)
31. Schenck, B.: Marketing das PMEs. Porto Editora, lda, Porto (2005)
32. Kemmerer, J., Jiaquing, E.: Profitibility and royalty rates across industries: some preliminary evidence. J. Acad. Bus. Econ. (2008)
33. Degnan, S., Horton, C.: A survey of licensed royalties. Les Nouvelles, pp. 91–96 (1997)
34. Wirz, C., Rabie, M., Tanami, M., Hajjar, L., Gardner, J., Little, D.: Invention disclosure system using blockchain. Customer: Dave Knuteson, Milestone 3. CSCI E-599 – Harvard Extension School (2019)
35. Nabulsi, B., Belt, E.: The patent is dead; long live the royalties! In: VIVO – The business and Medicine Report. Informa Business information Inc. (2015)
36. Stevens, A.: Intellectual property valuation manual for academic institutions. WIPO – World Intellectual Property Organization (2016). https://www.wipo.int/meetings/en/doc_details.jsp?doc_id=332588
37. Pressman, L., Planting, M., Yuskavage, R., Okubo, S., Moylan, C., Bond, J.: The Economic Contribution of University/Nonprofit Inventions in the United States. Association of University Technology Managers and Biotechnology Innovation Organization (2017)
38. Heiden, V., Petit, N.: Patent Trespass and the Royalty Gap: Exploring the Nature and Impact of "Patent Holdout". Hoover Institution Working Group on Intellectual Property, Innovation, and Prosperity. Stanford University (2017)
39. Lagrost, C., Martin, D., Dubois, C., Quazzotti, S.: Intellectual property valuation: how to approach the selection of an appropriate valuation method. J. Intellect. Cap. **11**(4), 481–503 (2010)
40. Soares, I., Moreira, J., Pinho, C., Couto, J.: Decisões de Investimento. Análise Financeira de Projectos. Edições Sílabo. Lisboa (2007)
41. Lazzolino, G., Migliano, G.: The valuation of a patent through the real options approach: a tutorial. J. Bus. Valuation Econ. Loss Anal. **10**(1) (2015)
42. Jarosz, J., Heider, R., Bazelon, C., Bieri, C., Hess, P.: Patent auctions: how far have we come? Patent Auctions. Les Nouvelles, September 2010

43. EPO: Patents up for auctions. European Patent Office (2008)
44. Dakin, K.J., Lindsey, J.: Technology transfer - financing and commercializing the high-tech product or service from research to roll out. J. Technol. Transfer **16**(3), 62 (1991)

Webography

45. EPO IPScore. https://www.epo.org/searching-for-patents/business/ipscore.html. May 2022
46. IPR Valuation checklist, from the UK Intellectual property Office. https://www.gov.uk/guidance/valuing-your-intellectual-property. May 2022

View publication stats