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# Essay on intellectual property and patent backed financing

Doctoral Dissertation

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# Essay on IP and patent backed financing

## Executive Summary

### 1. The research project

This dissertation, which takes the form of three essays, starts from actual limitations and barriers to finance R&D and other innovation activities and presents investigations on the possibility to use intellectual property asset as source of funding and collateral security.

The intellectual property (IP) financing is a wide research topic and during the Ph.D work it has been analyzed through different perspectives and by means of both econometric and qualitative analysis. In particular the work focuses on the question of whether financial tools based on intellectual property rights and on patents might be valid alternatives to the problem of financing constraints for innovative firms. This issue appears to be fairly significant and of considerable interest for both policymakers and researchers.

The research idea starts from the consideration that, actually, it is widely accepted that intangible assets are the major drivers of growth in a large number of economic sectors (Hand and Lev, 2003) and represent a large share of a company's value. Their increasing importance is reflected in the upsurge of the share of investments in intangible asset on the overall amount of companies' business investments: intangible assets have become increasingly important as value drivers for companies operating in highly competitive environments (Levitas and McFadyen, 2009). The strategic relevance of intellectual property rights, and more specifically of patents and the fast development of the markets for technology (Arora, Fosfuri, Gambardella, 2001), lead companies to identify additional ways of extracting value from them.

Despite so, intangible assets contribution to the process of fund raising is still quite weak. Empirical evidence shows that an adequate level of fund leverage based on the value of intangibles, however important for the industry, is yet to be achieved. This is because several characteristics of the innovative processes undertaken by firms generate market failures when using traditional financial instruments (Hall, 2002 for a review). For this reason companies are likely to miss important capital resources that could be crucial for developing their business and for sustaining innovation investments. At the same time, financial institutions are missing valuable loan opportunities: recent studies (Ughetto, 2008) highlight that the banking system is still disregarding intangibles when assessing borrowers' creditworthiness and credit constraints are particularly harsh for innovative firms.

Like any other valuable assets, IP should play an important role in companies' fund raising process, but this is not fully happening. However, both firms and institutions are more and more aware of IP asset strategic and financial value: actually, given the widespread diffusion of the market for intellectual property and the ongoing innovation of financial tools, there is a growing need among companies to use IP portfolio, especially patents, as a source of funding and collateral security in order to finance new investments.

When one takes into consideration intellectual property as a cash flow generating asset, it is possible to set up tools and financial instruments that leverage on IPRs to obtain financing. According to several authors, the market for intellectual property finance is expected to develop significantly in the coming years, as a consequence of an increased awareness of the value of intellectual property (Edwards, 2001; Hillery, 2004) and of the growing need of companies to using IP portfolios to finance new purchases and investments. IP backed financial instruments can be defined as a wide set of tools and financial solutions leveraging on patents value to raise funds: they are usually characterized by unique features and by a high level of customization. Over the last years IP backed deals have been established through different financial vehicles

from commercial banks to specialized financial operators (Walsh and Cohen, 2007) and their actual diffusion is quite low and financial solutions are not standardized .

Research work, in particular, is focused on patents, even though they still represent the smallest area of IP-backed deals: against the background of constrained capital markets, especially for those companies with high ratios of intangible to tangible assets, and the parallel growth in the propensity to patent, it is clear that patent portfolios are increasingly becoming sources of competitive advantage and are a major determinant of market value when used as financial assets (Edwards, 2001).

Currently, even though firms and institutions are more and more aware of the strategic and financial value of IP assets, patent backed finance and monetization is far from a common practice. Patent backed deals are still relatively extraordinary events: the low level of standardization of these financial instruments and the lack of a widely recognized method for IP value appraisal emerge as the most critical barriers for the effective development of IP finance solutions. Despite their potential, patent backed financial instruments have grown less rapidly than expected. After the first celebrated deals, evidence shows that few deals have been established (Lovells, 2002) and their transparency level is, even now, quite low. Nevertheless, the significant economic value of patent is leading to a growing interest in this class of assets as a relevant source of funding and collateral security, due to their increasing market value: the problem patent use in financial solution appears to be quite important.

The research project starts from the evidence of limited diffusion of patent backed financial solutions and from empirical literature gap on this topic that is relatively unexplored by academic literature. Past investigations have been constrained by the lack of available data and consistent time series, since we can only enumerate a few examples of intellectual property underlying securitization deals; moreover, since the disclosure of sensitive information is an important issue, there have been so far very few tracks of IP-backed deals. Hence, current literature is mainly based on descriptive evidence and little empirical investigation has emerged.

This dissertation is focused on patent as underling for securitization solutions and auction process and gives a contribution in this direction offering one of the first empirical investigation in this research area.

The analysis of patent securitization and auction have been conducted with methods going further the traditional analysis that does not work well with lack of consistent data: simulation, fuzzy logic and case study approach were complemented by econometric tools.

The PhD work has been declined in the dissertation into three essays. Considering the new financial solutions with patent as the underlying asset, the first article (chapter 2) tries to assess the existence and the consistence of a market for patent securitization. More specifically, the work analyze the potential for securitization schemes depending on specific patent features and financial and economic context variables in order to assess the feasibility of patent securitization transactions.

The second essay (chapter 3) investigates the potential determinants leading to the success or failure of securitization deals having patents as underlying assets. A conceptual framework has been developed and tested on two well-known US patent securitization deals in the pharmaceutical industry, by using a fuzzy set approach.

Finally, starting from the importance of patent value appraisal for the development of the market of patent backed financial solutions, the third article (chapter 4) tries to shed light on patent auction mechanism for patent valuation. Specifically, the work investigates which are patent features increasing selling likelihood during the auction process and the impact of patent value determinant on patent selling price. The research considers also which are main factors affecting differences between the seller valuation of patents and the final selling price.

## 2. Intellectual property portfolio securitization: an evidence based analysis

It is clear from past literature that a wide range of restrictions undermine diffusion of patent securitization such as risk, valuation, demand side issues and socio-behavioral reasons. On

this basis, scientific valuation of key drivers affecting the suitability of different patents as underlying for financial solutions is an important issue.

Focusing on patent securitizations, the literature up to now has provided only descriptive evidence. So, starting from the limits and barriers to financing R&D and innovation and from the question of whether or not intellectual property could be used in order to raise funds, in this investigation an exploratory analysis of patent securitization is carried out by trying to quantify the main factors affecting its potential in a specific industry.

In this paper the existence and the consistency of a market for patent securitization is analyzed. The work investigates the reasons that limit its growth and the critical issues that should be overcome to secure the fast development of the market itself. In order to assess the feasibility of patent securitization transactions, this study analyzes what the potential for securitization schemes is depending on the specific patent features and the financial and economic context variables.

Following the contribution of Stone and Zissu (2006), we estimate a patent securitization space. The securitization space is a numerical index related to the potential of the deal measured with financial and rating variables. Along with the uniqueness of patents in comparison to other assets used in standard securitization, in order to estimate deal potential a broader range of factors must be considered: variables related to patent features, patent value, and the economic size of the deal have to be taken into account

The model is divided into three dimensions. The first dimension covers funding conditions and cost of capital features. It is the difference between two values: the improvement in the credit rating of the securitization in comparison to that of the patent owner, (expressed as the reduction in basis points above the Treasury rate) and the associated cost of the rating increase. The second dimension includes a synthesis of the main determinants affecting the patent's value. The third one considers the deal's economic feasibility, taking into consideration the expected value of cash flow associated with the patent along with the remaining drug's life.

The work is focused on the pharmaceutical industry in accordance with the importance of patent protection and the economic features of this industry. Through simulation, the model is tested on a sample of pharmaceutical drugs approved by the FDA during the 1990s. It highlights the potential for securitization for each drug by considering related patents as underlying the deal.

A broad issue emerges from the outcome of the work: large pharmaceutical companies usually have high corporate credit ratings and can leverage on a wide range of funding possibilities at a relatively low cost. Therefore, it is clear that while improving funding conditions is quite important, it probably is not the main driver for recourse to patent securitization, at least for this industry. These preliminary results are quite ambiguous. On the one hand, it seems that patent securitization should be more suitable for small and medium companies with a consistent patent portfolio but that do not have easy access to capital markets, or those that have a higher financial risk and little possibility of raising unsecured financing. On the other hand, the economic feasibility threshold and average deal size is not realistic targets for any firm. Large companies often own a wide patent portfolio and are more likely to exploit it and to generate a steady cash flow to cover the cost of issuance and debt service.

Market potential for patent securitization is also uncertain. Several authors have argued that patent securitization can be an effective alternative to traditional financing: the liquidity afforded by these kinds of deals and the opportunity they give to invest in technological niches and only on the patent portfolio rather than in the whole company are clearly significant benefits. But funding condition advantages are not as obvious: technology rich but cash poor firms may not be able to cover issuance cost and debt service, while high rated companies have access to numerous funding solutions and can not completely profit from opportunity to leverage on issuance rating. Furthermore, other barriers to overcome are the assessment of the patent portfolio value, the risk profile and disposal in case of default. Since a small number of deals have been established up to now, secondary market is highly illiquid.

### 3. Patent backed securities in pharmaceuticals: what determines success or failure?

The second paper analyzes the potential determinants leading to the success or failure of securitization deals having patents as underlying assets. The work investigate the success and failure factors of patent securitization deals. In past literature there is no prior evidence on this topic.

More precisely, the study aims to explore how and under which conditions a patent backed securitization transaction can create value for both the issuer and the investors. A successful transaction is defined as one in which the issuer has monetised its IP assets in an efficient, cost-effective manner, with the investors receiving a well-structured, highly-rated investment which provides a favourable risk/return trade-off (Walsh and Cohen, 2007).

Since PBSs are customized financial solutions and their number is too small to support statistical evidence, a traditional empirical analysis could not be implemented. Therefore, we developed a conceptual framework that we tested on a set of recent patent securitization deals in the pharmaceutical industry. In particular, we referred to two cases of securitization transactions based on patent drugs originating from the same company, Royalty Pharma AG, and which represent a failure and a success case respectively.

Our theoretical framework consists of a set of variables which we assumed could explain the potential outcomes that a PBS might have in the field of pharmaceutics. The identification of the most relevant determinants of failure and success of a PBS was based on the analysis of extant literature, on patent information derived from patent dataset and on direct interviews with experts on structured finance and pharmaceutical industry. The framework is defined by a three level dimension tree, in which each level corresponds to a macro category affecting a PBS outcome The first dimension (DRUG) refers to the characteristics of the asset(s) underlying a pharmaceutical patent royalty securitization for which it is important to consider all the relevant features of the market addressed by the drug, as well as its economic and regulatory attributes. The second dimension (PATENT) relates to patent characteristics, such as patent status and

value, which are crucial for a securitization to be attractive for both issuers and investors. The last dimension (DEAL STRUCTURE) concerns the deal architecture: the financial structure, the legal framework, the credit enhancement mechanisms, and the credit merit of the involved actors are key variables affecting the strength and rating of a securitization deal.

To implement the framework of the analysis, we adopted a fuzzy approach. Fuzzy logic has been widely exploited in engineering, management and business studies over the last 20 years to model systems which are hard to define precisely (Minola and Giorgino, 2008; Wang and Hwang, 2007; Chen, 2001; Chan et al., 2000). This method is in fact a useful tool to represent and analyze qualitative information and to deal with complex phenomena (Zadeh, 1965).

Results highlight that factors related to the market size, level of competition and expected market life of the assets underlying a PBS can reasonably increase the probability of success of a deal. Moreover, a higher quality of the underlying invention in terms of scope, technical novelty and technological importance and a longer patent residual life are likely to reduce the risk of technical obsolescence and sales losses. Finally, the strength of the credit enhancement mechanisms, the flexibility of the deal architecture and the adoption of a diversification strategy are other key factors determining the success of a securitization.

## 4. Patent value: seller and bidder perspectives

Actual background for IP monetization solutions include a wide and fragmented range of tools and initiatives: it is a complex and borderline area in ongoing development that involves both structured finance and IP management..

A part from the most common patent-backed financial instruments, IP loans, IP sale and lease back and IP securitizations, other options began to evolve even if their application is quite limited till now (Edwards, 2001; Hillery, 2004; Frank, 2005; Lipfert and Von Scheffer, 2006). Some examples are: the patent asset trust, the patent backed collateralized debt obligation, the patent funds and finally , there is the market for buying and selling patents. The diffusion of on

online listing services and IP auctions attempts to increase the awareness of IP available for sale and reducing transaction costs: the concept of a multi lot patent auction was born with the intent to introduce to the market place a forum to facilitate the exchange of IP with a critical mass of buyers (Malackowski, 2008).

One of the main issues affecting the diffusion of patent rights monetization solutions is the lack of a widely recognized method for value appraisal that can be deeply accepted and communicated among an extensive community of managers, analysts, financial institutions, IP professionals and investors. The auction mechanism overcomes this barrier: patent auction value data are not affected by estimation method and represent the real market value of the patent asset included its strategic component.

Starting from a complete set of data covering all patent auctions held until the end of 2008 by the major IP merchant bank, the objective of the paper is to investigate the impact of patent value determinant on patent value resulting from the auction process and to examine which are patent features increasing selling likelihood. In particular, main contribution on previous literature is based on the double perspective of the analysis. The research goes further the exploration of the final patent selling price and considers the value expectation of the seller too: the work analyzes which are main factors affecting differences between seller and market valuation of patents (patent valuation gap).

The sample of the analysis is composed by 8 auctions for a total of 593 lots including 1716 patents referring to a wide range of technological areas. Most of lots has a company or another organization as a seller while remaining ones are offered for sale by individual or groups of inventors. On average 44% of our sample lots have been sold during auction process.

According to the objective to investigate the factors affecting valuation from different perspective, three different dependent variables have been analyzed: the patent expected value expressed by the seller, the patent final price deriving from the auction process and the gap between these two values. An OLS regression model has been implemented for the analysis of

the impact of patent value determinants on sellers' expectation of value. However not all patent are sold during auctions since sample selection is clearly part of the auction process: coherently with past literature (Sneed and Johnson, 2008), in order to account for selection bias a two step Heckman selection model has been chosen to analyze the patent final price and the patent valuation gap. Two primary classes of independent variables have been considered: the first one measures invention characteristics, while the second one refers to technology features and accounts for seller characteristics.

In particular, among the findings it comes out that both seller and bidder positively evaluate the patent scope, the technological relevance of an invention (citations), and the time to expiration while the technology trend is, instead, positively considered only by the seller. The degree of the seller's technological knowledge and its commitment for the auction process have always a significant impact on value. The citations positively affect selling likelihood, while the residual patent life and the lot dimension have a negative impact on selection. The difference between seller's patent expected value and final transaction price is significantly correlated with the patent scope and with the the weight of patents on sale on seller's overall patent portfolio.

It is clear, however, that patent auctions represent for patent holders an alternative tool for monetizing their patent assets, particularly when aggressive licensing strategies are neither feasible nor desired. Furthermore, a fully functioning patent auction marketplace should help to establish more optimal and predictable prices: their price-establishing function could have impacts well beyond patent sale transactions, such as by facilitating the use of patents in lending, investing and insurance transactions.

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# Essay 1 – Intellectual property portfolio securitization: an evidence based analysis

## 1. Introduction

Even though intangible assets have been recognized as representing a large share of a company's value, they are usually not considered to be important drivers in companies' funding processes: many characteristics of innovative firms are expected to cause market failures in making use of traditional financial instruments (Hall, 2002 for a review).

However, in recent years, the ongoing innovation of financial tools and of asset-backed security practice has led to a growing interest in intellectual property (IP) as a relevant source of funding and collateral security.

Given the limits and barriers to financing R&D, innovation and other activities necessary to build up a wide IP portfolio, the question of whether or not intellectual property could be used to raise funds appears to be fairly significant.

Taking intellectual property into consideration as a cash flow-generating asset, it is possible to set up tools and financial instruments leveraging on IPRs to get financing.

However, despite their potential, these IP-backed financial instruments have grown less rapidly than expected due to different stakeholders' issues (Throckmorton, 2004), such as risk, valuation, demand side issues and socio-behavioral reasons.

Restricting our attention to patents, even though they still represent the smallest area of IP-backed deals, it is important to note that recent trends, as well as some specific events relating to the institutional nature of the patent system itself, have led companies from all over the world to reconsider and re-assess the potential value of securing transactions with their patent portfolio. Against the background of constrained capital markets, especially for those companies with high ratios of intangible to tangible assets, and the parallel growth in the propensity to patent, it is

clear that IP portfolios are increasingly becoming sources of competitive advantage and are a major determinant of market value when used as financial assets (Edwards, 2001).

Focusing on patent securitizations, the literature up to now has provided only descriptive evidence. In this paper, we try to assess the existence and the consistency of a market for patent securitization. On this basis, we move on to investigate the reasons that limit its growth and the critical issues that should be overcome in order to secure the fast development of the market itself. In order to assess the feasibility of patent securitization transactions, we want to analyze what the potential for securitization schemes is depending on the specific patent features and the financial and economic context variables.

Following the contribution of Stone and Zissu (2006), we estimate a patent securitization space. The securitization space is a numerical index related to the potential of deals. When we deal with patent securitization, variables related to patent features, patent value, and the economic size of the deal have to be considered in order to analyze the securitization space.

We focus our work on the pharmaceutical industry in accordance with the importance of patent protection and the economic features of this industry. The model is tested on a sample of pharmaceutical drugs approved by the FDA during the 1990s. It highlights the potential for securitization for each drug by considering related patents as underlying the deal.

The paper is structured as follows. Section 2 presents a review of the main literature results. In Section 3, we discuss the major requirements to establish a successful patent-backed deal and we describe the model for patent securitization potential assessment. In Section 4, model implementation is developed. Section 5 presents the primary results and Section 6 concludes.

## 2. Literature

A patent can be seen as a financial asset if we consider its main purpose as the production of revenue. Therefore, cash flows derived from patents, usually obtained through licensing or

contingent payment rights, can be used as underling flows for securitizations: it is possible, on the one hand, to design patent securitizations based on royalties defined by a licensing agreement and, on the other, to build it on future flows deriving from a share of future revenues[1].

The prior literature has been constrained by the lack of available data and consistent time series, since we can only enumerate a few examples of intellectual property underlying securitization deals; moreover, since the disclosure of sensitive information is an important issue, little empirical investigation has emerged. However, different issues about intellectual property as a financial asset are open research areas for both academics and practitioners alike. Their works are essentially focused on three main subjects.

The first one proves an assessment of existing patent backed financial instruments, implications and roles of different stakeholders. Frank (2005) investigates the use of IP and patents in financing contracts giving a comprehensive view of main types of financial instruments leveraging intellectual property and clarifies the role of intermediaries. Hillery (2004), Wantanabe (2003) and Kirsh (2005) instead direct their research efforts to securitization alone. Although patents are only one of many asset classes they consider, their works provide a good background reference to understand patent securitization market development. Common evidence is the initial life stage and geographical concentration that characterizes this market. According to Kirsch (2005), in the period between 1997 and 2004, only 38 IP securitization deals had been established. Hillery (2004) underlines the fact that securitizations based on IP royalty streams have grown considerably, at least in the US, starting from 417 million dollars in 1992 and exceeding 2.5 billion dollars in 2000. All known patent securitization transactions have involved pharmaceutical patents and, on the period between 1997 and 2004, they represent about 13% of all IP securitization deals.

Works by Edwards (2002) and Dorris (2003) limit their attention only to patents. Edwards proposes a classification for patent-backed security deals to promote patent

[1] Securitization is a structured finance tool typically applied to illiquid contracts where rights to receive certain future payments are sold in the form of securities.

securitization and to identify related profit opportunities. Dorris, instead, investigates the subject through an industry-based perspective. The work of Amable et al., (2005), the only theoretical modeling contribution in this field[2], stresses the use of patents as collateral leverages for R&D finance and magnifies the effect of innovative rentals on investments.

Especially because of disclosure problems that significantly affect data availability, case analysis literature converged on two well known patent securitization transactions.

Edwards (2001), Fischman (2003), and Kirsh (2005), among others, closely analyze the first case of a patent securitization deal. It was established in 2000 by Royalty Pharma AG, an investment company specialized in the pharmaceutical industry. This securitization was built on royalty payments for Yale University's patent on the HIV drug Zerit, licensed to Bristol Myers Squibb, and represented a milestone for patent securitization history. In 2003, after the Zerit securitization failure, Royalty Pharma succeeded in structuring a second patent securitization leveraging the royalty streams derived from a pool of thirteen drugs, raising 225 million dollars of variable funding notes with a triple A rating.

Another literature stream investigates the main legal issues related to the use of patents as security for debt finance. In one of the first papers on the topic, Bezant (2003), among others, builds a taxonomy of various legal concerns ranging from registration, to infringement, litigation and so on. In an uncommon example of country analysis, for the UK, Davies (2006) points out the structural uncertainty in the law relating to the use of patents as collateral for the purpose of raising debt finance.

The third research area is focused on different stakeholder benefits and on theoretical reasons attesting to the sustainability and efficacy of patent securitization (among others Fishman, 2003; Hillery, 2004).

[2] The authors, studied appliance of incomplete financial contracts to the collateral assignment of patents combined with random profitable R&D investment opportunities and they explored their effects on firms' R&D investment and savings at the microeconomic and at the aggregate level

Although we can count few examples where patents have been used as underlying a securitization deal, it has been argued by several researchers and practitioners that these financial solutions built on intellectual property rights, and especially on patents, can be, in some circumstances, an effective alternative to traditional financing.

A good assessment of the effectiveness of patent securitization is presented in Kirsh (2005).

From the asset owner's perspective, patent securitization represents a tool to allow companies or other rights owners access to better funding conditions than corporate ones. A lower total cost of capital, longer duration and more flexibility compared to a corporate bonds can be achieved thanks to a strong credit enhancement and through an external asset analysis assessing the patents' cash-flow potential. Thus, these financial instruments, enabling the separation between patents risk and company's one, answer well to the strong demand for a mechanism in which companies should be able to raise funds by leveraging their patent portfolio value, independent of the whole firm evaluation (Wantanabe, 2004). An important is the liquidity it provides: upfront payments can be more useful to a company's funding needs than future royalty streams or delayed sale revenues. In addition, patent securitization can be structured as non-dilutive and may embody a solution for technology rich but cash poor companies which, after the development stage, need funds to develop and commercialize their technology but do not want changes in their ownership structure and debt solutions to be too costly (Edwards, 2001)[3].

However, after the first celebrated deals, evidence shows that a small number of deals have been established (Lovells, 2002) and their transparency level is, even now, quite low considering the strategic role that such asset classes play in corporate business.

[3] For instance, in 2003 Guilford Pharmaceuticals decided to acquire the drug Aggrastat, developed by Merck, for a predicted acquisition cost of 84 million dollars. On the one hand, Guilford did not want to dilute equity capital or reduce its liquidity, but, on the other hand, there was no space for further debt capital. Therefore, it used securitization to finance the operation, selling royalty rights as a percentage of future sales from its products, the chemotherapeutic implant Gliadel, and Aggrastat itself (Lash, 2006).

Along with the particular nature of patents in comparison to other physical assets used in standard asset-backed transactions, various stakeholder issues reduce the widespread diffusion of the practice of patent securitization (Throckmorton, 2004; Hillery, 2004; Fishman, 2003; Watanabe, 2004).

From the sellers' side, i.e. firms, universities, and other patent rights owners, several issues related assets valuation, demand and socio-behavioral matters greatly affect securitization development. First of all, only a few companies thoroughly know the benefits of patent-backed financial instruments and are able to face a deal of such complexity: patent-backed securitization schemes are customized financial solutions and a considerable amount of cost is involved in the transaction. Consequently, in order to establish a profitable deal, the economic size of underlined asset increases. Moreover, methodological uncertainty about patent valuation strongly affects confidence in these financial tools.

On the other hand, from the buyer's perspective, assessing the value and risk profile of a patent portfolio is one of the most critical aspects of the development of these financial solutions, because of the uncertainty in cash flow forecasts and specific risk factors. Also, in order to establish a credit rating, a case by case assessment is required because the value of patents is characterized by high degree of internal variability in comparison to other physical assets and by lack of historical data on patent pool performance. Furthermore, patents may depend on access to co-specialized assets, and their value is strongly affected by the likelihood of being litigated or infringed. Finally, disposal in case of default is a relevant issue in defining collaterals because the secondary market for this kind of asset is highly illiquid.

Therefore, in a pro-patent era (Arundel et al., 2003), even though the number of patents is strongly increasing (Hall, 2004). and the potential basket of assets for securitization is becoming larger, the strategic use of patents may greatly affect patent value and, hence, the likelihood that they can be useful for raising funds.

## 3. Methodology

The fact that a patent could be theoretically securitizable, as a cash flow-generating asset, is not a sufficient condition to make securitization work effectively. Patents to be used as underlying for a financial deal should have distinctive attributes suitable to guarantee a successful transaction[4]. The main issues affecting the feasibility and transaction strength of patent securitization can be classified into three categories: assets-related, economic, and transaction structure-related.

**Table 1: Factors affecting patent securitization feasibility**

| | |
|---|---|
| **1) Assets issues** | Patent value determinants |
| | Industry features |
| **2) Economic issues** | Break even size of deal |
| | Cost of capital |
| **3) Transaction structure issues** | Legal framework |
| | Servicing |
| | Recourse |
| | Structural enhancement |

The first factor includes all the characteristics of the assets to be securitized. In order to establish attractiveness and potential for securitization, main patent value determinants, strategic use of patents and the issues of patent transferability, exploitation and independence must be considered.

The second factor concerns the economic feasibility and cost effectiveness of patent securitization. Patent securitization can be advantageous in comparison to alternative financial solutions[5] because it can achieve lower relative funding costs, obtaining a higher credit rating than that of the asset owner, just leveraging on the credit enhancement and on the underlying asset

[4] Walsh and Cohen (2007) defined a successful deal as a transaction where the originator achieves an efficient, cost-effective monetization of its IPRs and investors gain access to a well-structured and highly-rated investment.

[5] The funding conditions of IP securitizations are frequently undisclosed, due to the low level of market transparency and publicly placed deals, and for this reason are difficult to evaluate.

value separate from the whole originator entity. Furthermore, the cash flow generated by its exploitation must be stable and predictable in order to cover its issuance cost and debt service. Every transaction involves high structuring costs and, in order to achieve an economically efficient deal, the underlying asset size has to reach the break-even point.

The third factor is associated with the legal framework, servicing, recourse and structural enhancement associated to the transaction. These aspects influence the deal strength and rating assignment.

In order to assess the feasibility of patent securitization operations, in this paper our purpose is to investigate what the potential for securitization schemes is depending on specific patent features, and financial and economic variables.

Following the contribution of Stone and Zissu (2006), we estimate a patent securitization space. The securitization space is a numerical index related to the potential of a deal, measured with financial and rating variables[6]. Along with the uniqueness of patents in comparison to other assets used in standard securitization, estimating a deal's potential needs to consider a wider range of factors: variables related to patent features, patent value, and the deal's economic size have to be taken into account.

Our model considers only the first two factors affecting patent securitization potential: asset and economic issues (Table 1); the third one is primarily involved only after the decision to securitize leveraging on a specific patent has already been taken, and is strictly linked to the transaction architecture.

The model is divided into three dimensions. The first dimension covers funding conditions and cost of capital features. It is the difference between two values: the improvement in the credit rating of the securitization in comparison to that of the patent owner, (expressed as the reduction in basis points above the Treasury rate) and the associated cost of the rating

[6] In their work, Stone and Zissu studied the securitization of future export receivables as a funding solution for emerging countries; they built a model to calculate a tridimensional securitization space considering variables relating to the sovereign ceiling, the increase in securitization rating in comparison to the sovereign ceiling and the difference between the cost of securitization and the reduction in basis points above Treasury.

increase. The second dimension includes a synthesis of the main determinants affecting the patent's value. The third one considers the deal's economic feasibility, taking into consideration the expected value of cash flow associated with the patent along with the remaining drug's life.

Patent value is highly industry-dependent, which is why our work is focused on the pharmaceutical industry.

First, strategic use of patents is closely linked to specific industry features. The pharmaceutical industry is characterized by discrete product technologies (Hall, Oriani, Czarnitzki, 2005) and patents are effective in their protective function: after patent expiration, innovator firms experienced the entrance of imitators and an inevitable reduction of the market share.

Second, licensing activity is dynamic and consistent. According to Dorris (2003), worldwide pharmaceutical royalties generate approximately 300 billion dollars annually. Furthermore, the increased level of interdependence between large and small firms in the discovery phase led to an upsurge of technology transfer activities through licensing and other sharing arrangements.

Third, the pharmaceutical industry is a research-based field where companies invest a higher percentage of sales in R&D than most other industries do. R&D costs for a single new chemical entity have increased over time; competition after patent expiration has become more intense than before, reducing the time window of a drug's market life and associated profits, and turning out additional financing and capital needs. Finally, as Hillery (2004) underlined, on average, revenue streams for pharmaceutical patents present less performance variability when compared to other kinds of patents. These conditions make the pharmaceutical industry quite interesting for the future development of patent securitization and enlighten industry concentration for the past deals.

## 4. Data and model implementation

In order to assess patent securitization potential, we tested the model on a sample of 28 pharmaceutical drugs approved by the FDA between 1994 and 1999 (Table 2). We started from a larger sample of 81 drugs for which we collected US patents data, US sales data in the period between 2000 and 2007 and the corporate credit ratings of commercializing companies[7].

**Table 2 – Sample distribution on drugs approval year and companies' rating class**

| **Year** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | |
|---|---|---|---|---|---|---|---|
| **Drugs (%)** | 10,7% | 21,4% | 10,7% | 17,9% | 25,0% | 14,3% | |
| **Rating class** | **BBB+** | **B+** | **A-** | **A+** | **AA-** | **AA** | **AAA** |
| **Companies (%)** | 3,6% | 3,6% | 3,6% | 14,3% | 35,7% | 21,4% | 17,9% |

We considered only those drugs approved in the 1990s for which at least five years of sales were available and whose main patent had not yet expired in 2007. Therefore, the final sample is composed by a cohort of 28 drugs with a minimum of 5 to a maximum of 8 years of US market sales data.

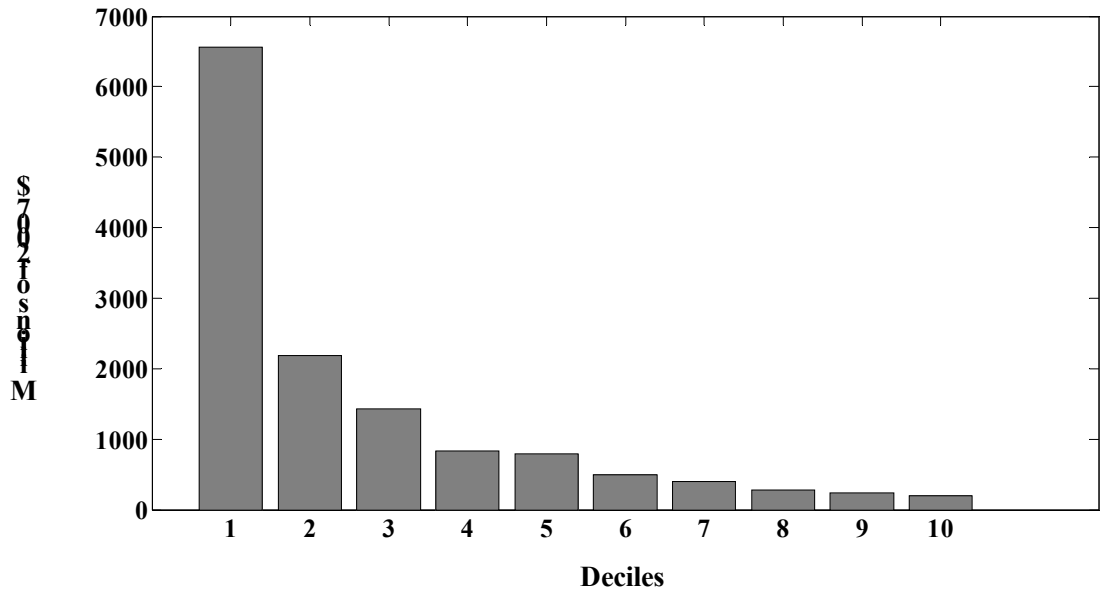
The expected market life for our drug sample has been set at 20 years, according to the shortening of the drug life cycle and the increased competitive pressure from generics (Grabowski and Vernon, 2000). The end of the sample drugs' life cycle is placed between 2015 and 2019. Considering 2007 as the reference year for the estimation of securitization potential, our 28 drugs are between year 8 and 13 of their hypothetical market life, while patent expiration is expected, on average, in year 10 through 16. Our sample also includes Bristol Myers Squibb's HIV drug Zerit. Even though the Zerit patent is almost expired, it represents a good threshold case to compare with other sample drugs.

The sales distribution across drug sample is highly skewed: if we consider the actual value for the eighth year of sales for each drug, the distribution by deciles (Figure 1) shows that most

[7] Patent portfolio information was drawn from the FDA Orange Book and USPTO, while we took drugs sales from the Drug Patent Watch database of ThinkBiotech LLC, a provider of pharmaceutical industry competitive intelligence; finally, rating levels are free data from S&P.

of sales revenues is generated by drugs in the first decile, which accounts for almost 49% of their value.

**Figure 1 - Sample distribution of sales by decile**




The next step in measuring the securitization potential for these drugs is to calculate and compare the relevant dimensions for each of them.

Funding conditions are measured in the first dimension: according to the possibility given by securitization to achieve an issuance rating higher than the corporate credit one, we want to examine the net benefits the originator can access through patent securitization, given its own credit rating.

On the profit side, for each rating level, we considered the benefit that an originator can gain by moving on to any higher rating. This benefit, expressed in basic points, is the reduction in spread over Treasury rate that can be achieved by increasing the actual rating of a certain number of notches through securitization[8]. For example, a patent owner with corporate credit rating of AA- can improve the patent securitization rating by one, two or three notches, reaching,

[8] We used data from Bondsonline on US Corporate Bond Spreads at the end of 2007 in order to build a kind of transition matrix (see Appendix 1); furthermore, we used corporate spreads data for a 10 year maturity since the historical average funding term for these solution has been 9.84 years.

respectively, the ratings of AA, AA+ and AAA, reducing the spread over Treasury since the higher the rating, the lower the compensation for the credit risk.

On the other hand, rating improvement is costly because it leverages credit enhancement tools. Following Stone and Zissu's study (2006), we have accepted the hypothesis that the cost of rating growth through securitization increases at an increasing rate the higher the improvement goal. Expensive mechanisms such as overcollateralization, subordination or excess spread are required by the rating agencies to allow rating improvement. The difference between these two values is the net funding benefit that the originator can achieve through patent securitization: clearly, it is positive only for some rating levels and for some improvement objectives. Stone and Zissu determined this positive area assuming a suitable securitization cost function; according to their estimation, we also obtained a positive net benefit region stuck between the B+ and BBB+ rating levels for a maximum of 5 notches of improvement (Appendix 1).

For each patent analyzed in the model, the first axis value will therefore be the net funding benefit expressed in basic points for a given owner corporate rating and for a given securitization rating increase objective. The distribution of sample drugs on corporate rating level of commercializing companies is highly asymmetric towards high values (see Table 2): most of those firms are large pharmaceutical companies with low financial and business risk levels. For this reason, the rating increase objective has been set equal to two notches in order to assure a realistic goal for most of the sample drugs.

The second dimension takes into account asset features. We collected data on the US patent portfolio for each drug, and we looked at the first patent, considering publication date, as the relevant one for protection (usually the drug substance patent)[9]. The underlying hypothesis is that, along with patent rights value skewness, a patent can be more or less suitable for

[9] Usually a group of patents is associated with each drug. All of the patents would protect some aspect of the drug product. A generic competitor will wait for expiration of the "strongest" patent, usually the drug substance patent that most truly prevents him from coming on the market.

securitization according to its economic value. Theoretically, the higher the patent value, the higher the probability it can originate consistent enough cash flows to be securitizable.

Therefore, we gathered data on a wide range of variables that past literature proved to be correlated with patent value (for a review, see Harhoff et al., 2003). On the one hand, we have classical patent value indicators covering citation measures and patent scope; on the other hand, we collected information about alternative uses of the drugs since the possibility a drug can be applied to a variety of underlying conditions may increase the its potential payment streams even after the patent expires (Table 3).

For each drug, the value on the second axis consists of the coordinates on the first factorial axis deriving from factor analysis realized on a sub-selection of patent variables[10] (see Appendix 2): the number of claims and four-digit IPCs, the number of backward citations per claim, the number of forward citation per claim occurred within five year from the application year and the number of possible alternative uses of the drug.

**Table 3 – Descriptive statistics on patent variables**

| Variable | N | Min | Max | Mean | Median | Std dev |
|---|---|---|---|---|---|---|
| Claims | 28,0 | 1,0 | 39,0 | 14,8 | 12,5 | 10,3 |
| IPC 4-digit | 28,0 | 1,0 | 5,0 | 2,1 | 2,0 | 1,2 |
| Bw citation per claim | 28,0 | 0,0 | 15,0 | 1,4 | 0,4 | 3,2 |
| Forward References (5 years) per claim | 28,0 | 0,0 | 5,0 | 0,7 | 0,1 | 1,2 |
| Exclusive Use | 28,0 | 0,0 | 7,0 | 2,3 | 2,0 | 2,1 |

For each drug, the value on the second axis consists of the coordinates on the first factorial axis deriving from factor analysis realized on a sub-selection of patent variables[11] (see Appendix 2): the number of claims and four-digit IPCs, the number of backward citations per

[10] The lower bound for the number of subjects providing usable data for the analysis should be the larger of 100 subjects or five times the number of variables being analyzed.

[11] The lower bound for the number of subjects providing usable data for the analysis should be the larger of 100 subjects or five times the number of variables being analyzed.

claim, the number of forward citation per claim occurred within five year from the application year and the number of possible alternative uses of the drug.

In the end, the third dimension expresses the economic feasibility of patent securitization. In order to be suitable for securitization, a patent must generate a steady cash flow to cover cost of issuance and debt service. According to Benz (2001), 25 million dollars is the smallest size for an IP securitization deal to be cost-effective and appealing for investors. Another interesting benchmark is the average size for past IP securitization, which is 254 million dollars; instead, the patent securitization value is smaller, at around 177 million dollars (Kirsh, 2005).

We estimate the actual value of potential cash flow for our sample patents along their residual life in order to assess whether or not the revenue streams are adequate to support a securitization deal.

Cash flow forecast have been proved to be one of most critical tasks for patent securitization success. The Zerit case is emblematic. Sales projections were systematically missed: Zerit revenues were always lower than expected and the transaction definitively failed in November 2002.

For the purpose of accounting for different possible scenarios of sales development in cash flow calculations, we made a simulation of sales proceeding for each of 28 sample drugs throughout their residual life. The reference year for the analysis is 2007.

The forecast window is clearly different for each drug: the variability derives both from the drugs' locations at different points of the life cycle, and from the different times to expiration for the associated patents. In general, the simulation horizon is divided into two parts: the first period starts from 2007 and lasts until the patent expiration; the second one covers year from patent expiry to residual life term.

According to the reference life cycle curve (Grabowski and Vernon 2000) and to the sales profile of the average new drug introduction in the 1990s (Grabowski, Vernon and DiMasi, 2002), sales reach the peak level, on average, during the ninth and the tenth year of market life,

and afterwards experienced a slow decline as a result of product obsolescence and competition in their therapeutic class. Our sample drugs' market life ranges between the eighth and the thirteenth year, just crossing over the period of maximum revenue development. For these reasons, during the first simulation stage, drug sales projections can be considered relatively stable. On the contrary, after patent expiration, sales usually decrease due to generic competition: we considered estimated reduction percentages among 43 and 42% for the first two years after expiration and 10% thereafter until the end of life (Grabowski and Vernon, 2000).

For the first time window, a random extraction from a uniform distribution, with domain between the lower and upper bounds of historical sales, has been established. However, because of the broad variability of past revenues for some drugs, future sales estimations result from two weighted components: the former is generated by a random extraction from the uniform distribution; the latter, instead, considers sales level of the previous year. The weight of this linear combination is a function of the of the historical sales composite's average growth rate. It reasonable to think that the sales level of the first simulation window should be influenced by a strong past sales trend, either positive or negative. The sample composite average growth rate is 0.108. We considered this value as a threshold to give more or less importance to the sales level of the previous year in comparison to the random component[12].

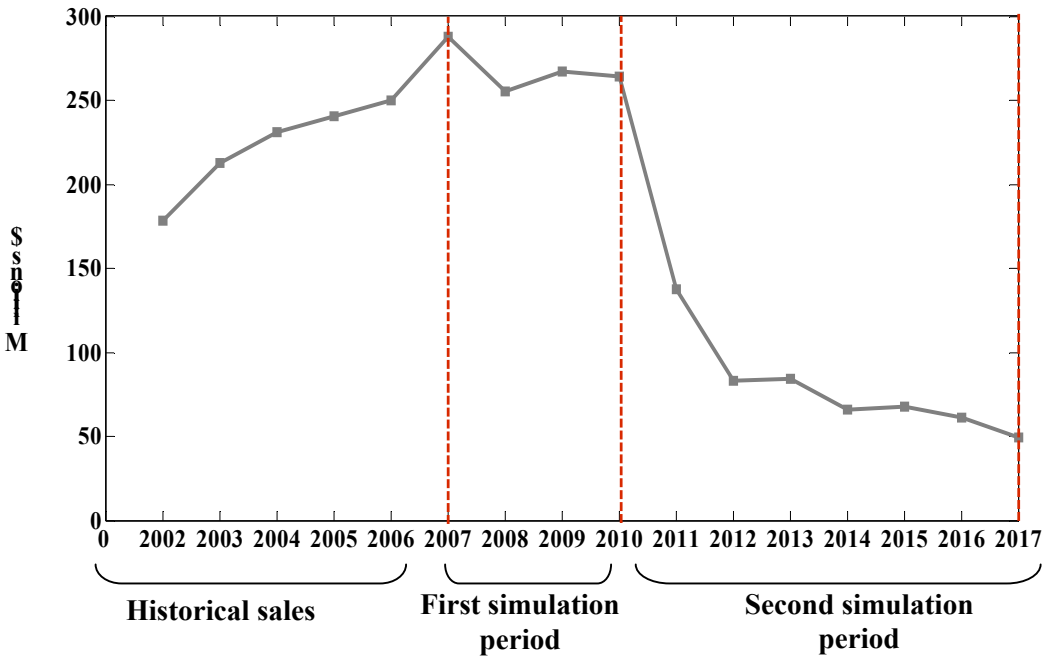
For the second time window, we applied to sales simulation a percentage of sales reduction, which accounts for the increase in competition after the exclusivity period (see Appendix 3). The revenue loss as a percentage of the normal sales level is different and increasing for each year after patent expiration; the simplifying assumption is that it is the same for all drugs, even though it should be correlated, at least, to the number of generic competitors and to the size of the market of the therapeutic class the drug addresses. However, assumptions on parameters setting common values for all drugs, while they do introduce a bias, allow for wider comparisons.

[12] If the absolute value of the composite average growth rate is lower than the threshold value the weight of the random component and of the previous year, sales is the same and equal to 0.5. If, instead, it is higher than the threshold, the latter component is considered more important and its coefficient is equal to 0.7.

Thus, we run a simulation of ten thousand forecasted scenarios: in this way we obtain not a single estimation, as in Zerit case, but a value distribution for every projection year.

Figure 2 considers one example drug, an antibiotic used to treat common respiratory infections, approved by the FDA in 1997, that has a residual life and a corresponding simulation window of 10 years: the first phase corresponds to 3 years since its patent will expire in 2010. In the second simulation window, generic competition reduces the sales level until 2017, the end of the drug's expected market life.

**Figure 2 – Sample drug sales progress**



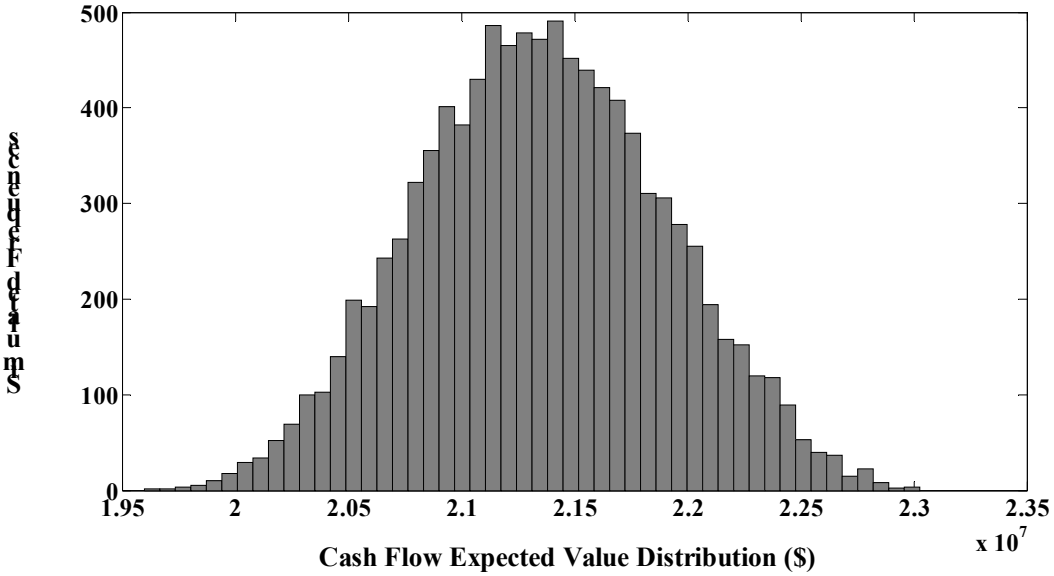

2007-2017: Expected residual life; 2010: Patent expiration

After estimating the sales level, it is necessary to consider the associated royalty stream as the revenue streams for patent securitization and, as a final point, to calculate the derived cash flow. A percentage of future sales for each drug have been considered as a royalty stream: in the baseline case we assumed a flat 10% royalty on simulated sales.

The final result is a distribution of net present values of cash flow on drug life for each patent, as shown for our example drug in Figure 3.

Thus, the third dimension of our model summarizes the potential value of patent cash flow. For each drug, the value on the third dimension is the mean value of cash flow simulated distribution corrected by subtracting its standard deviation: if the volatility of simulated cash flow is high compared to the mean and, thus, the risk of underperformance increases, this adjustment reduces the average level of cash flow without losing cash stream size information.

**Figure 3 – Sample drug expected cash flow distribution**




## 5. Results

The final result of model implementation is a tridimensional space[13] (Figure 4). The first evidence is that most of drugs are concentrated near the origin of the axes, and a few elements are located far from the zeros. The comparative analysis indicates that the securitization potential is low for most of the sample patents.

[13] Values for all dimensions have been normalized.

**Figure 4 – Sample securitization potential**

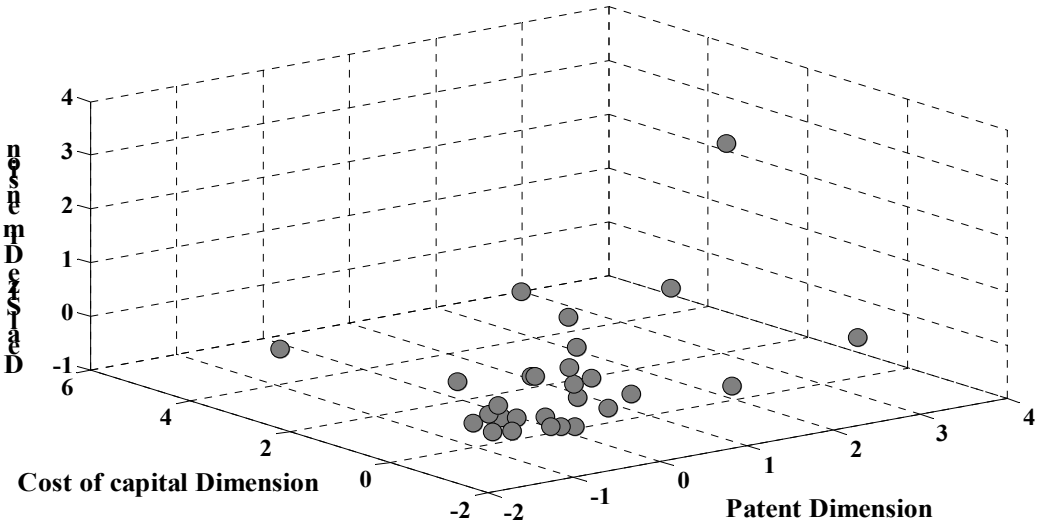
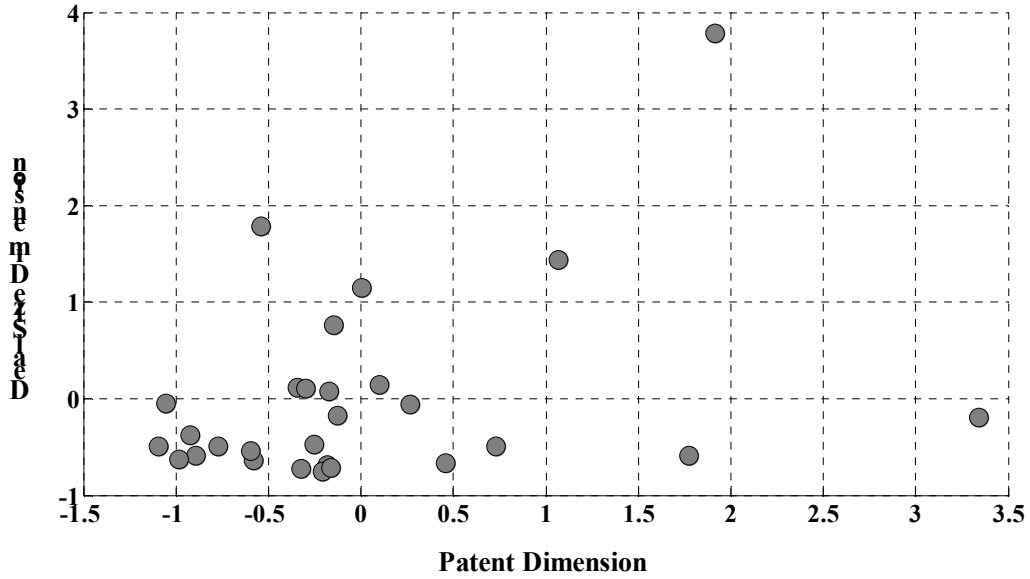



**Figure 5 – Sample securitization potential (axes 2 - 3)**

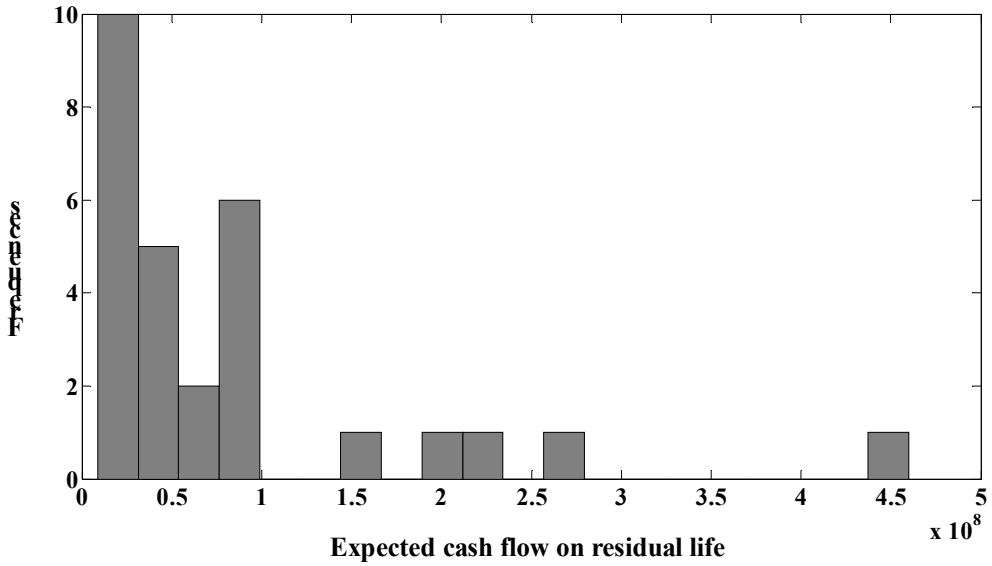



Considering the economic feasibility dimension (Figures 5 and 8), it is possible to separate a small group of drugs that accounts for most of the value; the expected value of profit streams is also affected by residual life, because life length and time to expiration positively influence securitization potential broadening revenues time window.

Patents, however, must generate sufficient cash flow in order to be suitable for securitization. Analyzing mean values of actual cash flow distribution for each drug, we can see

that it reaches a sufficient level in order to cover the securitization deal costs for most of the sample patent. For 21 drugs, the value of future profits derived from an hypothetical 10% royalty on sales is greater than 25 million dollars (see Figure 6) and so overcomes the threshold size indicated as the minimum amount required for a cost effective and appealing deal. However, this lower bound should be reduced to 10 million dollars if a minimum standardization level in structuring process could be reached; an increase in the number of transactions and cost saving securitization infrastructure can greatly cut down the break-even size (Benz 2001).

**Figure 6 – Sample securitization potential**

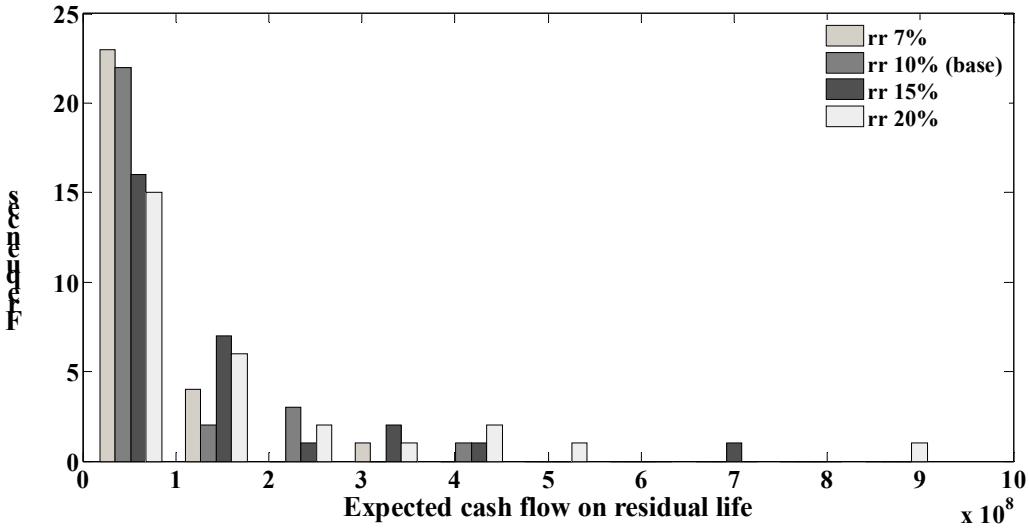



If we instead use the average size of past patent securitization deals (177 million dollars) as benchmark transaction size, only four drugs can generate sufficient cash flow. Two of them are characterized by a score higher than the average on patent dimension: as shown in Appendix 2, the first factorial axis, used in the securitization space, represents the citation variables well with positive sign. This suggests that the quality of those patents is significant, since their value on the second dimension reflects a good level of technical novelty and a fast recognition of its importance. Those drugs have already multiple uses and can potentially be applied to different

underlying conditions: this is an advantage over other single use medicines and positively influences their cash flow stability and therefore securitization potential.

Some interesting considerations emerge from a sensitivity analysis of royalty rates applied to sales forecast. Different values of royalty rates have been considered to derive revenue streams for the securitization: 7%[14], 15% and 20%[15].

**Figure 7 – Sample securitization potential sensitivity**

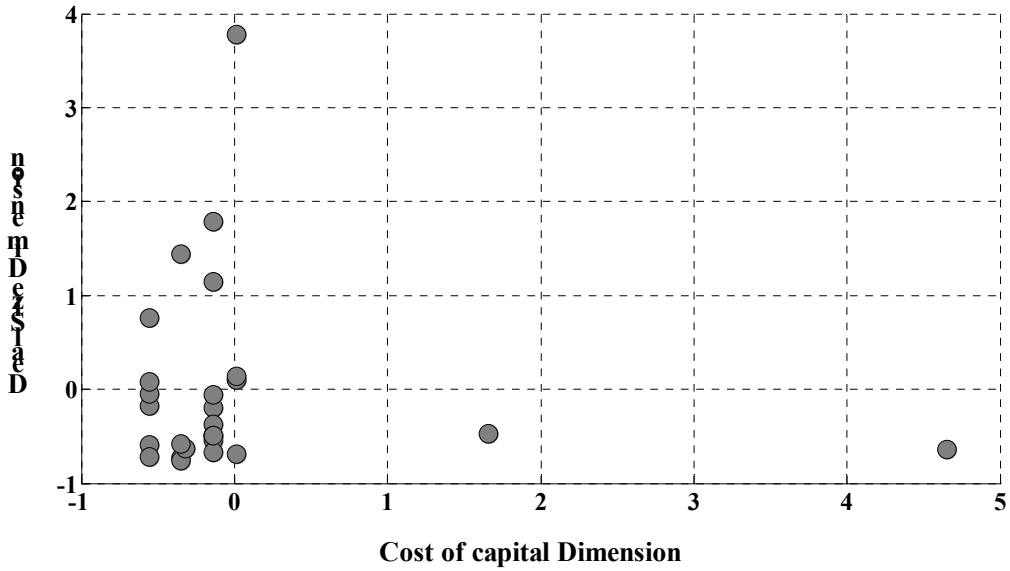



Increasing of the royalty rate we can see that nearly the entire sample, 24 and 26 drugs respectively, can reach the lower bound of 25 million dollars. The amount of drugs that can generate sufficient cash flow to achieve the 177 million dollars threshold reaches 9 units with a 20% royalty rate: it doubles from the baseline case but is at least a minority of the whole sample.

[14] According to the Licensing Economics Review, a review of 458 license agreements in the pharmaceutical and biotechnology industry over a 16-year period reveals an average royalty rate of 7.0 percent. (Licensing Economics Review: The Royalty Rate Journal of Intellectual Property, December 2002, p. 8.).

[15] A study conducted by Caroline Bodley and Trevor Cook indicates that royalty rates for proven pharmaceuticals range from 20 percent to 47 percent (Caroline Bodley and Trevor Cook, "Royalty Rates for Proven Pharmaceuticals," Licensing Economics Review, March 1991, pp. 7–10.).

**Figure 8 – Sample securitization potential (axes 1 - 3)**




Considering the funding condition dimension (Figure 8), it emerges that only two drugs gain a positive net benefit, allowing for a cost-effective procedure. In the majority, the difference between benefit and cost of a two notch rating improvement is negative. Companies that have been commercializing these two medicines have ratings, respectively, of B+ and BBB+: their actual credit merit is significantly lower than that of the other sample corporations, whose ratings range from A- to AAA[16], and it makes securitization tools more effective in order to reduce funding cost than it would be for firms with an higher corporate rating. However, the high score on the first dimension does not correspond to an elevated level in patent dimension or in economic size axis: only one of them has an actual profit value higher than 25 million dollars.

In this background, Zerit is one of the sample drugs with the smallest securitization potential: a negative net funding benefit, the lowest level of backward citations per claim, a single therapeutic use, the shortest residual life, and an actual cash flow under the lower breakeven bound.

## 6. Concluding remarks

Starting from the question of whether or not intellectual property could be used in order to raise funds, in this paper, we carried out an exploratory analysis of pharmaceutical patent securitization trying to quantify the main factors affecting its potential in the pharmaceutical industry.

From the outcome of the work, a wider issue emerges: large pharmaceutical companies usually have high corporate credit ratings and can leverage on a wide range of funding possibilities at relative low cost. Therefore, it is clear that improving funding conditions, even though quite important, is probably not the main driver for recourse to patent securitization, at least for this industry.

These preliminary results are quite ambiguous. On one hand, it seems that patent securitization should be more suitable for small and medium companies with a consistent IP portfolio but that do not have easy access to capital market or that have a higher financial risk and few possibilities to raise unsecured financing. On the other, instead, the economic feasibility threshold and average deals size are not realistic targets for any firm. Large companies often own a wide patent portfolio and have higher likelihood to exploit it and to generate a steady cash flow to cover cost of issuance and debt service.

The market potential for patent securitization is also uncertain. Several authors have argued that patent securitization can be an effective alternative to traditional financing: the liquidity afforded by this kind of deal and the possibility it gives to invest in technological niches and only in patent portfolios rather than in the whole company are clearly significant benefits. However, funding condition advantages are not equally evident: technology rich but cash-poor firms may not be able to cover issuance cost and debt service, while highly rated companies have access to numerous funding solutions and cannot wholly profit from opportunity to leverage on issuance rating. Furthermore, other barriers to overcome are the assessment of the patent

portfolio value and its risk profile, and its disposal in case of default: since a small number of deals have been established up to now, the secondary market is highly illiquid.

However, some market trends could support patent securitization developments. First of all, it is important to account for patent pooling: failure of some past deal underlined that a single patent is not securely securitizable, but a pool of patents can be a better solution in order to reduce underperformance risk.

Even though the analysis underlines how motivation for the recourse to patent securitization for large pharmaceutical companies is, on average, low, this financial solution could be more attractive for the biotech industry. There is also a greater need for funding since biopharmaceutical drugs require a more stringent regulatory production standard and have a more complex development and manufacturing process. Moreover, new biological entities, given their nature and the possibilities for wide application, are more likely to become a blockbuster in comparison to new chemical entities. It is not insignificant that the second patent securitization Royalty Pharma structured in 2003, after the Zerit crash, was based on a pool of thirteen drugs, most of which were biological-based drugs.

Finally, leveraging the fact that, in recent years, intellectual property exchanges have begun to evolve, a reduction in the uncertainty surrounding the use of patents as underlying assets for securitization deals could promote the development of a common language about IP-backed transactions and significantly help market development and stakeholders' confidence increase.

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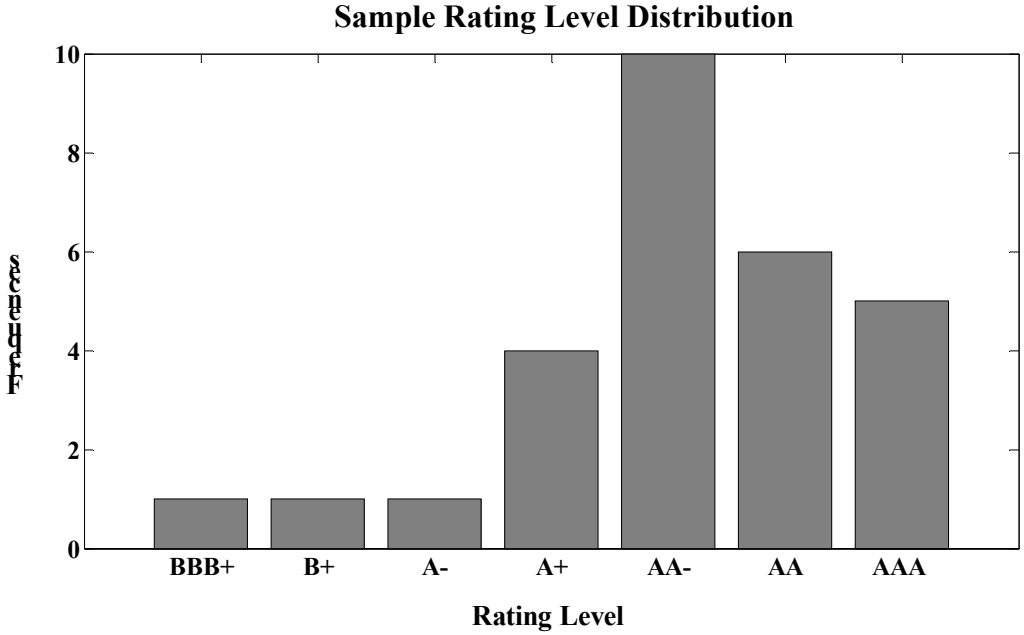
## 8. Appendix 1

Sample distribution of corporate rating levels of commercializing companies




Reuters Corporate Spreads for Industrials 12/31/2007):

| Reuters Corporate Spreads for Industrials 12/31/2006 | | | | | | | |
|---|---|---|---|---|---|---|---|
| | **1 yr** | **2 yr** | **3 yr** | **5 yr** | **7 yr** | **10 yr** | **30 yr** |
| **Aaa/AAA** | 77,0 | 92,0 | 112,0 | 118,0 | 111,0 | **99,0** | 100,0 |
| **Aa1/AA+** | 82,0 | 102,0 | 116,0 | 128,0 | 121,0 | **115,0** | 116,0 |
| **Aa2/AA** | 87,0 | 107,0 | 122,0 | 133,0 | 131,0 | **125,0** | 138,0 |
| **Aa3/AA-** | 92,0 | 112,0 | 127,0 | 138,0 | 136,0 | **130,0** | 143,0 |
| **A1/A+** | 97,0 | 119,0 | 137,0 | 148,0 | 146,0 | **135,0** | 154,0 |
| **A2/A** | 102,0 | 124,0 | 142,0 | 153,0 | 156,0 | **142,0** | 159,0 |
| **A3/A-** | 107,0 | 130,0 | 152,0 | 163,0 | 164,0 | **148,0** | 167,0 |
| **Baa1/BBB+** | 115,0 | 149,0 | 167,0 | 178,0 | 176,0 | **173,0** | 187,0 |
| **Baa2/BBB** | 120,0 | 154,0 | 187,0 | 198,0 | 203,0 | **202,0** | 232,0 |
| **Baa3/BBB-** | 137,0 | 210,0 | 225,0 | 265,0 | 245,0 | **260,0** | 280,0 |
| **Ba1/BB+** | 200,0 | 305,0 | 355,0 | 355,0 | 370,0 | **320,0** | 350,0 |
| **Ba2/BB** | 245,0 | 365,0 | 380,0 | 395,0 | 410,0 | **365,0** | 395,0 |
| **Ba3/BB-** | 275,0 | 410,0 | 445,0 | 450,0 | 445,0 | **400,0** | 410,0 |
| **B1/B+** | 305,0 | 435,0 | 470,0 | 485,0 | 495,0 | **455,0** | 445,0 |
| **B2/B** | 335,0 | 460,0 | 525,0 | 555,0 | 560,0 | **565,0** | 500,0 |
| **B3/B-** | 385,0 | 505,0 | 590,0 | 595,0 | 610,0 | **645,0** | 675,0 |
| **Caa/CCC+** | 525,0 | 590,0 | 650,0 | 670,0 | 685,0 | **715,0** | 755,0 |
| **US Treasury Yield** | 3,3 | 3,1 | 3,1 | 3,5 | 3,7 | **4,0** | 4,5 |

Source: Bondsonline

Net funding benefit that the originator can gain through patent securitization: the difference between the reduction in spread over Treasury that can be achieved by increasing the actual rating of a certain number of notches and associated cost according to Stone and Zissu's 2006) cost function.

| **10 yr** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Notches** | **CCC+** | **B-** | **B** | **B+** | **BB-** | **BB** | **BB+** | **BBB-** | **BBB** | **BBB+** | **A-** | **A** | **A+** | **AA-** | **AA** | **AA+** | **AAA** |
| **1** | -9,8 | -11,3 | -37,3 | **7,1** | **6,6** | **8,2** | **9,9** | **9,0** | **4,9** | **3,8** | 0,0 | -0,1 | -0,4 | 0,0 | 0,0 | 0,0 | |
| **2** | -24,6 | -31,5 | -61,7 | **9,9** | **12,9** | **15,8** | **69,6** | **12,3** | **6,7** | **3,5** | -0,7 | -0,8 | -0,8 | -0,3 | -1,2 | | |
| **3** | -55,3 | -54,8 | -88,3 | **8,8** | **16,4** | **17,0** | **14,2** | **9,4** | **4,2** | **1,9** | -2,3 | -2,7 | -3,6 | -3,8 | | | |
| **4** | -86,9 | -80,1 | -127,3 | **2,3** | **13,3** | **10,7** | **6,5** | **2,4** | 0,0 | -0,9 | -5,3 | -7,0 | -11,1 | | | | |
| **5** | -120,9 | -116,9 | -184,7 | -13,1 | **0,9** | -2,8 | -6,4 | -7,2 | -6,0 | -5,4 | -11,3 | -16,9 | | | | | |
| **6** | -165,9 | -170,1 | -258,2 | -33,3 | -15,8 | -18,9 | -20,4 | -18,3 | -13,7 | -12,6 | -23,5 | | | | | | |
| **7** | -228,3 | -233,4 | -320,5 | -59,2 | -36,1 | -38,8 | -38,4 | -32,3 | -24,8 | -25,0 | | | | | | | |
| **8** | -303,3 | -293,2 | -388,7 | -85,9 | -58,7 | -60,7 | -58,6 | -50,5 | -41,4 | | | | | | | | |
| **9** | -371,7 | -360,3 | -450,6 | -116,2 | -83,6 | -85,2 | -82,8 | -75,1 | | | | | | | | | |
| **10** | -447,0 | -419,6 | -517,5 | -149,5 | -112,8 | -116,6 | -116,6 | | | | | | | | | | |
| **11** | -517,0 | -487,0 | -588,7 | -187,7 | -148,0 | -155,3 | | | | | | | | | | | |
| **12** | -593,1 | -560,4 | -637,6 | -233,1 | -193,7 | | | | | | | | | | | | |
| **13** | -675,0 | -639,9 | -768,3 | -291,0 | | | | | | | | | | | | | |
| **14** | -766,4 | -736,2 | -1071,3 | | | | | | | | | | | | | | |
| **15** | -874,8 | -1185,7 | | | | | | | | | | | | | | | |
| **16** | -1005,2 | | | | | | | | | | | | | | | | |

## 9. Appendix 2

Principal Component Analysis on five patent variables: the number of claims and four-digit IPCs, the number of backward citations per claim, the number of forward citations per claim occurring within five years from the application year, and the number of possible alternative uses of the drug. Principal Component Analysis has been done on standardized variables and with a varimax rotation method.

**Total Variance Explained**

| Component | Initial Eigenvalues | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 1,891 | 37,830 | 37,830 |
| 2 | 1,277 | 25,531 | 63,361 |
| 3 | ,807 | 16,149 | 79,510 |
| 4 | ,519 | 10,387 | 89,897 |

| Component | Initial Eigenvalues | | |
|---|---|---|---|
| | Total | % of Variance | Cumulative % |
| 1 | 1,891 | 37,830 | 37,830 |
| 2 | 1,277 | 25,531 | 63,361 |
| 3 | ,807 | 16,149 | 79,510 |
| 4 | ,519 | 10,387 | 89,897 |
| 5 | ,505 | 10,103 | 100,000 |

**Component Matrix**[a]

| | Component | |
|---|---|---|
| | 1 | 2 |
| FW_CIT_T+5_per_claim | ,729 | ,010 |
| Bwcit_perClaim | ,715 | -,085 |
| Claims | -,652 | ,483 |
| ExclusiveUse | ,591 | ,635 |
| IPC4-digit | ,190 | -,819 |

## 10. Appendix 3

Percentage of sales reduction used for the second time window simulation: it considers the increase in generic competition after the exclusivity period.

| Year after patent expiration | Annual Post expiration loss (%) | Sales reduction percentage after expiration (%) | Sales percentage after expiration (%) |
|---|---|---|---|
| 1 | 43.00% | 43.00% | 57.00% |
| 2 | 42.00% | 66.94% | 33.06% |
| 3 | 10.00% | 70.25% | 29.75% |
| 4 | 10.00% | 73.22% | 26.78% |
| 5 | 10.00% | 75.90% | 24.10% |
| 6 | 10.00% | 78.31% | 21.69% |
| 7 | 10.00% | 80.48% | 19.52% |
| 8 | 10.00% | 82.43% | 17.57% |
| 9 | 10.00% | 84.19% | 15.81% |
| 10 | 10.00% | 85.77% | 14.23% |
| 11 | 10.00% | 87.19% | 12.81% |
| 12 | 10.00% | 88.47% | 11.53% |
| 13 | 10.00% | 89.63% | 10.37% |
| 14 | 10.00% | 90.66% | 9.34% |
| 15 | 10.00% | 91.60% | 8.40% |
| 16 | 10.00% | 92.44% | 7.56% |

Cash flow calculation for each drug is based on following assumptions:

- Contribution margin: 33% Grabowski and Vernon, 1990).
- Promotional expenditures: equal to sales in the first market life year, to 50% of sales in the second and to 25% in the third Grabowski and Vernon, 1990).
- Capital expenditures: equal to 50% of average sales level of the seventh, eighth and ninth sales years: two-thirds allocated in the two years preceding drug market launch, and residual one-third between the first and tenth sales years Grabowski and Vernon, 1990).
- Depreciation: hypothesis of straight-line depreciation in 10 years.
- Working Capital Change: 0.42% of annual sales based on industry data elaboration.
- Average debt ratio: 6.74%. represents the share of net capital expenditures and working capital change that are financed through the issuance of new debt: we assumed that the proportion of financing debt/equity is constant over time and equal to the average industry debt/equity ratio in the period of sample historical sales.
- Cost of capital: 10.35%. Average industry value in the period of sample historical sales.

| Drug life Year | CF/sales (%) |
|---|---|
| 1 | -73,71% |
| 2 | -23,71% |
| 3 | 0,84% |
| 4 | 24,78% |
| 5 | 24,49% |
| 6 | 24,24% |
| 7 | 24,12% |
| 8 | 24,13% |
| 9 | 24,22% |
| 10 | 22,80% |
| 11 | 22,81% |
| 12 | 22,58% |
| 13 | 22,51% |
| 14 | 22,51% |
| 15 | 22,51% |
| 16 | 22,51% |
| 17 | 22,51% |
| 18 | 22,51% |
| 19 | 22,51% |
| 20 | 22,51% |

# Essay 2 – Patent backed securities in pharmaceuticals: what determines success or failure?

## 1. Introduction.

It is widely accepted that intangible assets are the major drivers of growth in most economic sectors (Hand and Lev, 2003). The increasing role they are playing in terms of company value is confirmed by Standard & Poor's, which reports that since the mid-1980s, there has been a large increase in the ratio of market to book value (Standard & Poor's 500, 2008).

Although intangible assets might be actively managed and exploited much like tangible assets, they are not yet considered to be important drivers in company funding processes. This is confirmed by recent studies (Ughetto, 2008), which highlight that the banking system is still disregarding intangibles when assessing borrowers' creditworthiness. Moreover, the very little information provided by financial statements about these assets prevents banks from having a true estimate of the value of companies (Cañibano et al., 2000).

This often results in a limited capability of traditional financial intermediaries in sustaining investments in R&D and innovation. Being unable to appreciate the actual innovation potential of a company, banks observe only financial accounting ratios rather than future expected cash flows determined by the innovation activity. Credit constraints are particularly acute for innovative firms because their investment returns are uncertain, they have little collateral to secure debt, they are subject to higher informational frictions and their capital, which is mostly intangible, difficult to redeploy and characterized by relevant bankruptcy costs (Carpenter and Petersen, 2002; Hall, 2002). While the new rules on regulatory capital requirements recently introduced by the Basel II Accord do not seem to have a positive significant impact on lending conditions for innovative SMEs (Scellato and Ughetto, 2009), the current situation of credit markets is likely to exert its negative impact in the long run as well, due to the contraction of financial resources for innovative ventures. The lack of financial resources from the credit market

for these kinds of companies appears to be particularly critical given that only a small number of them are able to go public and to raise money on the stock market and that the venture capital industry still plays a limited role in many countries.

Recently, there has been growing interest in new financial tools that might significantly help ease financial constraints on innovation, at least in principle. These products are based on a particular category of intangible assets: intellectual property rights (IPRs). The value embedded in intellectual property rights often extends beyond directly profiting from them through their commercialization or licensing. IPRs are revenue-generating assets and as such, they can be exploited as a source of capital collaterized by the royalty streams they generate (Hillery, 2004; Agiato, 2002; Kirsh, 2005). The question of whether financial tools based on IPRs might be valid alternatives to the problem of financing constraints for firms engaged in relevant innovation activities appears to be fairly significant and of considerable interest for both policymakers and researchers.

One way to leverage IP assets is to securitize them. IP securitization is a device of structured financing where IP assets or rights to receive future payments originated by IP are converted into marketable securities.[17] Securitization is supposed to provide new opportunities for the corporate funding process and the leverage of IP portfolios. Despite their potential, the number of IP securitization deals established so far is limited, and mostly confined to copyrights and trademarks (Calderini and Odasso, 2008; Hillery, 2004), while patents represent the smallest area.

The literature on IP securitization is scarce and existing studies limit themselves to describing the distinctive features of these new types of instruments, implications and roles of different stakeholders (Frank, 2005; Hillery, 2004; Watanabe, 2004; Edwards, 2001; Dorris, 2003).

[17] The basic structure of a patent securitization is the following. The Originator, namely the party initiating the transaction, identifies a single patent or a pool of patents showing reasonably predictable cash flows to be securitized. Then, he sells the asset itself or the cash flow rights to a legally separate entity known as a Special Purpose Vehicle (SPV) in order to separate future receivables from its own corporate risks. The SPV, with the help of legal and financial advisors, designs the securities to be sold: a wide range of possible securitization structures exist and can involve some combination of equity and debt (either one class or multiple classes with senior and subordinate tranches). Finally, the SPV issues securities backed by the stream of patents' royalties on capital markets.

A few additional studies focus on legal issues affecting asset backed securities and on the use of patents as collateral to raise debt finance (Bezant, 1997; Davies, 2006). The literature in this field has been constrained by the limited number of IP securitization deals[18], by the lack of available data and by the high level of secrecy surrounding existing transactions.

A wide range of issues limits the applicability and diffusion of patent backed securitizations (PBSs) and reduces both borrowers and sellers' confidence in these kinds of tools (Throckmorton, 2004; Hillery, 2004; Fishman, 2003; Watanabe, 2004). First, PBSs are complex instruments of financial engineering, which involve high structuring costs. Second, assessing the value and risk profile of a patent portfolio is a key challenge for the development of these solutions. Lack of generally accepted methodologies for the valuation of intellectual property rights and the high degree of uncertainty to which patent value is subject strongly affect the confidence in PBSs.

While leaving this substantive examination to future work, in this paper we address a related topic, namely the study of the potential determinants leading to the success or the failure of securitization deals having patents as underlying assets. To our knowledge there is no prior evidence on this side either.

More precisely, we wanted to investigate how and under which conditions a patent backed securitization transaction can create value for both the issuer and the investors. A successful transaction is defined as one in which the issuer has monetised its IP assets in an efficient, cost-effective manner, with the investors receiving a well-structured, highly-rated investment which provides a favourable risk/return trade-off (Walsh and Cohen, 2007). Since PBSs are customized financial solutions and their number is too small to support statistical evidence, a traditional empirical analysis could not be implemented. Therefore, we developed a conceptual framework that we tested on a set of recent patent securitization deals in the pharmaceutical industry. In particular, we referred to two cases of securitization transactions

[18] Kirsch (2005) reports that between 1997 and 2004 only 38 IP securitization deals were established, and among them only 5 were PBSs.

based on patent drugs originating from the same company, Royalty Pharma AG, and which represent a failure and a success respectively.

Our theoretical framework consists of a set of variables which we assumed could explain the potential outcomes that a PBS might have in the field of pharmaceutics. The identification of the most relevant determinants of failure and success of a PBS was based on the thorough analysis of extant literature, on patent information derived from the Delphion dataset and on direct interviews with experts on structured finance and pharmaceutical industry. To build the framework of the analysis, we adopted a fuzzy approach. Fuzzy logic has been widely exploited in engineering, management and business studies over the last 20 years (Minola and Giorgino, 2008; Wang and Hwang, 2007; Chen, 2001; Chan et al., 2000) to model systems which are hard to define precisely. This method is in fact a useful tool to represent and analyze qualitative information and to deal with complex phenomena (Zadeh, 1965).

Results highlight that factors related to the market size, level of competition and expected market life of the assets underlying a PBS can reasonably increase the probability of success of a deal. Moreover, a higher quality of the underlying invention in terms of scope, technical novelty and technological importance and a longer patent residual life are likely to reduce the risk of technical obsolescence and sales losses. Finally, the strength of the credit enhancement mechanisms, the flexibility of the deal architecture and the adoption of a diversification strategy are other key factors determining the success of a securitization.

The paper is organized as follows. Section 2 provides a description of the methodology employed. Section 3 introduces the model. Section 4 discusses the results.

## 2. Methodology

In order to understand which factors might affect the likelihood of success of a PBS, we developed a conceptual framework that we tested on two recent patent securitization deals built on pharmaceutical patents. The unique nature of patents implies a case by case assessment of

their value and risk profile; as a consequence, the design of a PBS transaction does not usually involve a standard process as happens with asset-backed securitization (ABS) deals. Since PBSs are highly specific and customized financial solutions[19], we necessarily had to refer to a set of well- known examples of patent securitizations that would allow us to draw some relevant conclusions to be generalized to the whole category of PBSs.

The first step of our research was therefore the selection of two relevant cases of PBSs. An in-depth analysis of just one single case might not have been representative to delineate the relevant factors affecting a PBS deal outcome. Therefore, we decided to study two PBS transactions, which we feel are particularly important for assessing the factors that influence the applicability and diffusion of PBSs. The two deals, both originating from the same company (the Royalty Pharma AG) and based on pharmaceutical patents, represent the first two patent backed securitization deals historically established. Our interest in the two deals stems from the fact that they can be considered antithetic deals for both their transaction design and final results since they represent respectively a failure and a success.

The second step of the work was to define the several potential factors deemed to affect the outcome of a PBS deal. A well-formulated theory is actually missing and the literature on PBSs is sparse and lacks a comprehensive analysis of the phenomenon. Therefore, we had to define the conceptual framework of analysis leveraging not only on a throughout analysis of extant literature, but also on hand-collected data (on patents, drug history, licensing contacts, industry reports) and on direct interviews with experts on structured finance and the pharmaceutical industry.

Finally, the last step was to analyze the information collected with the help of a methodology that could capture the high level of complexity and uncertainty characterizing this research topic. For this reason, we decided to adopt the fuzzy logic approach. Fuzzy logic has

[19] Given the particular features of patents in comparison to other physical assets, designing a standard process is quite challenging. The cash flow generation streams are the only similarity between patents and other asset classes used for ABS deals (Hillery, 2004).

been widely used to represent uncertainty or to analyse qualitative information in a broad range of applications. Numerous scholars have underlined the benefits of using it for managing the heterogeneity and ambiguity of the natural language, enabling a formal structure that allows a quantitative representation (Chen, 2001; Wang and Hwang, 2007; Chan et al., 2000).[20] The specificity and complexity of the topic under investigation, as well as the lack of complete historical data or the qualitative nature of some variables makes the use of the fuzzy approach particularly suitable.

In the following paragraphs we will describe the above-mentioned steps in greater detail.

### *2.1 The selection of the cases: Zerit® and 13 Drugs Pool*

The first step was to select two relevant examples of PBSs, sufficiently similar to be compared but differentiating in their final outcome and transaction architecture. The two deals, both originating from the same company (the Royalty Pharma AG, an investment company specialized in the pharmaceutical industry) and based on pharmaceutical patents, can be considered antithetic deals both because of their transaction design and the final results, since they represent respectively a failure and a success. In addition, they are the first two patent historically established backed securitization deals.

The first PBS (Zerit®) goes back to 2000, when Royalty Pharma entered into an agreement with Yale University to purchase and securitize the royalty stream associated with Zerit®, a drug for the treatment of HIV infection developed by Bristol-Myers Squibb. In 1985, Yale University received a patent for its d4T discovery, a novel technology for the treatment of the HIV virus. A few years later, the University granted an exclusive license to Bristol Myers Squibb for the development of Zerit®, which was later approved by the US Food and Drug Administration (FDA) in 1994. Yale University maintained the ownership of the patent and

[20] Chen (2001) argued that the fuzzy theory provides a valuable tool to deal with the ambiguity involved in the data evaluation process. Wang and Hwang (2007) underlined that it is a useful alternative framework for dealing with uncertain project parameters in situations where there is lack of certainty in data or even lack of available historical data.

obtained 70% of the royalties, while the remaining 30% was paid to the two inventors (Fischer, 2002).

The royalty stream owned to the University was sold to Royalty Pharma and became the underlying asset for the first PBS transaction historically established. A bankruptcy-remote vehicle (the BioPharma Royalty Trust) was created primarily for the purpose of funding the purchase payment. The trust issued $115 million in debt and equity securities. Leveraging on the royalties deriving from the drug sales, BioPharma Royalty Trust obtained a six-year loan (from September 2000 to June 2006) for a portion of the purchase price ($100.3 million in senior, mezzanine and junior notes), while the remaining amount of $14.69 million was covered by three equity partners, Royalty Pharma, BancBoston Capital and Yale University. Yale University received a cash payment ($100 million) in addition to equity in the trust, which was then used to fund the construction of a research facility at its medical center. Besides the Originator and the licensing partners, several other stakeholders were involved in the deal: Bankers Trust Corp. was the transaction's trustee, West LB was the lead arranger, Clifford Chance was the legal advisor and Wilmington Trust Company was the servicer (Kirsh, 2005; Hillery, 2004).

Standard & Poor's gave the deal a single A rating, largely due to the good credit standing of Bristol-Myers Squibb and to the projections of sales of Zerit®. In 1999 worldwide sales of Zerit® reached $605 million with an average growth rate of 26% since 1997. The patent licensing agreement generated royalty payments for $41.6 million. In 2001 Standard & Poor's considered BioPharma Royalty Trust as a "model for future deals going forward".[21] However, in the subsequent years, Zerit® sales projections were systematically missed and revenue streams were lower than expected. In 2002 Zerit® sales declined to $443 million. In addition, during the second half of 2001 Bristol-Myers Squibb started selling its entire portfolio of Zerit® at a discount to wholesalers, in order to achieve corporate financial benchmarks. As a result, although royalties were high in that period, the excess cash flows (after covering debt service) were paid

[21] Standard & Poor's New Asset Hot Topic Seminar, 2001.

out to the marketers and were unavailable to investors when sales declined (Eisbruk, 2002). Bristol-Myers Squibb was downgraded to AA from AAA by S&P in June 2002. The transaction definitively failed in November 2002 when BioPharma Royalty Trust entered into early amortization, after breaching covenants for three consecutive reporting periods (Hillery, 2004).

In July 2003 Royalty Pharma issued a second PBS, leveraging on the royalty stream of a pool of thirteen drugs.[22] At the time of the deal, only nine drugs were generating royalty payments; the other four drugs were in the final phases of the FDA approval process, but not yet on the market. Through the SPV, the Royalty Pharma Finance Trust, the 13 Drugs Pool transaction raised $225 million of variable funding notes and was structured by Credit Suisse First Boston. The trustee for the transaction was Deutsche Bank Trust Co. Americas (Moody's Investor Service, 2003). The transaction included a three-year revolving borrowing period with an expected maturity of July 31, 2010 and a final maturity of July 31, 2012. During the revolving period, additional royalty assets could be included in the trust if they met the approval process. The deal was rated AAA by both Moody's and Standard & Poor's, largely because of the insurance provided by MBIA Insurance Group, which guaranteed timely payments of interest and ultimate repayment of principal on the notes. At the present time the deal is still on the market and its size has been increased several times reaching $2.2 billion and has a BBB- rating. The deal is considered a case of success because of the progressive increase in the capital raised after the first issuance and because of its longer life compared to the Zerit® deal.

Despite being well-known deals, most existing works simply provided a general description of them (their history, structure and the role played by different stakeholders), without highlighting the theoretical reasons at the basis of their sustainability. Edwards (2001) presented the Zerit® deal as an example of a patent securitization process, focusing on transaction details and main impediments to success. Eisbruck (2002) gave a detailed description

[22] The thirteen drugs included in the second patent securitization were: Genentech's and Biogen Idec's Rituxan®; Celegen's Thalomid®; Eli Lily's and J&J-Centocor ReoPro®; Centocor's Retavase; Chiron's TOBI®; Novartis' Simulect®; Roche's Zenapax®; Ligand's Targretin Capsules®; Memorial Sloan Kettering's Neupogen and Neulasta; Organon's Variza®; GSK and Adolor's Entereg®; Pfizer's lasofoxifene; Wyeth's bazedoxifene.

of the Zerit® case in terms of credit rating due diligence and deal architecture. Walsh and Cohen (2007) mentioned the two deals along with a broader discussion about the market potential for IP backed financial instruments. A much more thorough investigation and explanation can be found in Kirsch (2005) and Hillery (2004). While the first one presented the most relevant features characterising the Zerit® transaction, the second work, which represents the only relevant contribution for the 13 Drugs Pool deal, made an effort to identify the reasons supporting the rationales and the underlying patent features of the two deals.

### *2.2 The definition of the theoretical framework*

In order to compare the feasibility of the two different transactions, we complemented information taken from different sources by following three steps.

First of all, we analyzed the existing literature, drawing information from both academic and business journals. This overview gave us a widespread perspective on the main issues related to patent securitization and represented an important source of information. Through a backward intelligence process we collected data on each compound, identifying the original inventors, further developers, and the relevant licensing agreements on IPRs and core patents. The Zerit® transaction was based on two US patents and on several other non U.S. patents. The second PBS deal was established on royalties deriving from 13 drug patent licensing agreements or contingent payment rights. Using Delphion dataset, we collected information about the patents underlying each deal: the date of the first application; the date the patent was granted; the number of claims; backward references and forward citations; number of family members.

Secondly, we selected some independent experts in the field of structured finance and the biopharmaceutical industry to complete our background knowledge and to review and confirm the results on the identified patents. We then conducted a first run of face-to-face interviews. According to the results of the interviews and the revision process, and given the main issues raised from the literature, we built the framework of analysis on which the fuzzy model was

based. Finally, we asked experts to review the framework and express relative judgments on the two deals.

### *2.3 The analysis: a fuzzy approach*

The evaluation of patent backed securitization deals is extremely complex and relies heavily on subjective judgments. Due to the uniqueness of patents as underlying assets, of the transaction architecture, and of the main stakeholders, each case is different from the others and a high degree of uncertainty is involved. Moreover, a large number of exogenous factors are likely to influence the final outcome. Hence, it is difficult to assess the factors which are deemed to determine the success of a PBS deal, and appropriate methodologies that can cope with complex phenomena are needed.

Fuzzy set theory is a useful tool to represent and analyze qualitative information and to model systems which are hard to define precisely. While Boolean logic is based on the true-false paradigm, the fuzzy approach leverages on all possible values between these two extremes. Resembling human reasoning in its use of approximate information, it converts linguistic variables to fuzzy numbers under ambiguous assessments (Zadeh, 1965). This technique is suited to quantifying assessments made by experts, who tend to make evaluations based on their knowledge, past experience and subjectivity (Chan et al., 2000).

Since this original contribution by Zadeh (1965), fuzzy logic has been studied extensively. While first used to represent uncertainty in human cognitive processes, over the past 20 years it has also been applied extensively in engineering, management and business studies (Minola and Giorgino, 2008; Wang and Hwang, 2007; Chen, 2001; Chan et al., 2000; Kaufmann and Gupta, 1988[23]). In particular, fuzzy methods are commonly used to solve complex problems and to process undefined qualitative datasets in the field of artificial intelligence systems applied to financial markets.

[23] The study where Kaufmann and Gupta (1988) state that since 1965 more than 7,000 works on fuzzy set theory have been published, is just one example showing how extensively it has been applied in recent years.

Our analysis is not based on an advanced application of the fuzzy method. It is meant to be a first attempt to interpret the complex and emerging phenomenon of PBSs in a structured and comprehensive way, without the limits imposed by traditional methodologies. Therefore, we identified a set of variables for each dimension of analysis that we considered to be relevant determinants in explaining PBSs feasibility. Each variable was given a numeric value, based on expert judgments, closeness to the theoretical assumptions, and data evidence. The different values were aggregated to produce a synthetic index, which can be regarded as an indirect measure of the likelihood of success of a PBS.

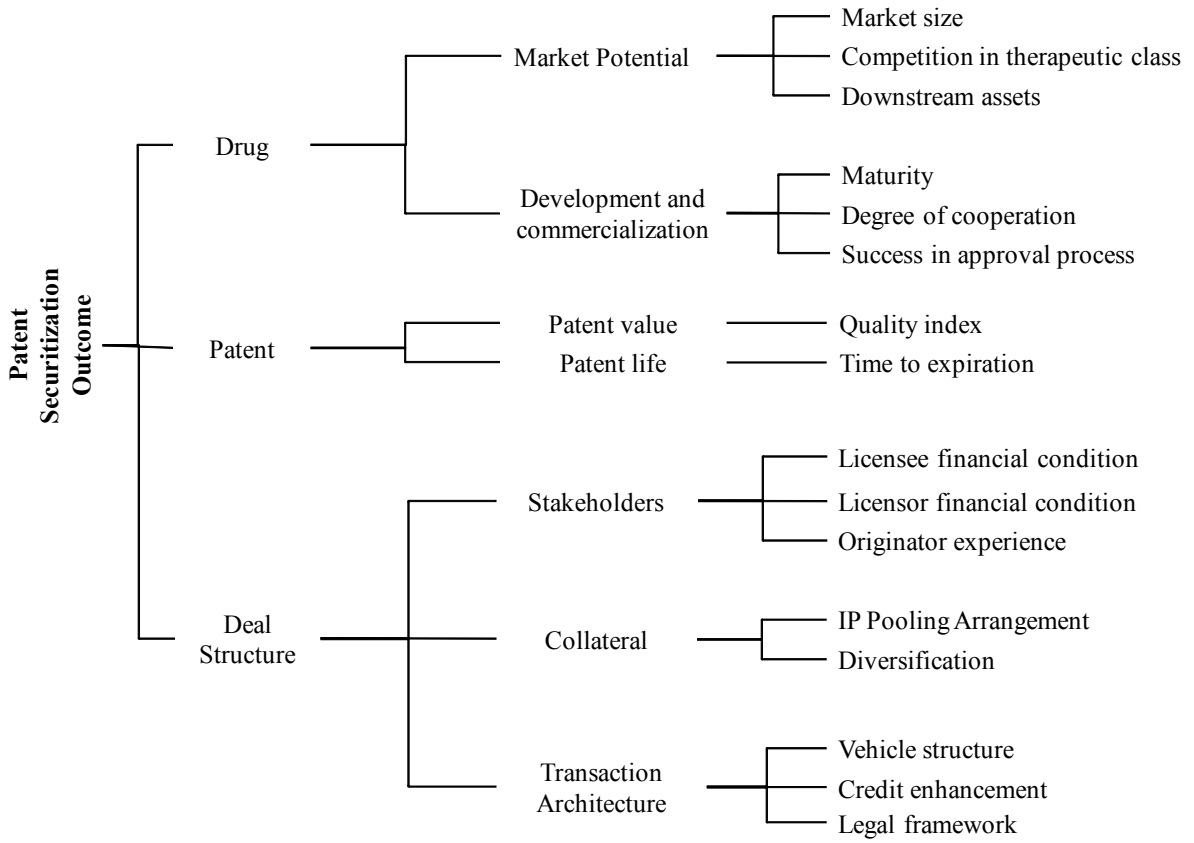
## 3. The model

### *3.1 The theoretical framework*

As mentioned, we tried to understand which factors might affect the likelihood of success of a PBS, by defining a theoretical framework that we tested on the two previously mentioned patent securitization deals by using a fuzzy inference process. This process consists in the elaboration of given inputs into a single numerical output using fuzzy logic. The main issues for which a PBS becomes an efficient solution for firms needing funding and a favourable investment for investors, were selected according to a thorough review of the literature and face-to-face interviews with experts in the fields of structured finance and biopharmaceuticals.

We defined a three level dimension tree (Figure 1), in which each level corresponds to a macro category affecting a PBS outcome. Each node of the tree was further divided into sub-dimensions, for which we identified the most relevant parameters. For each variable we collected information on both deals, considering the deal year as the reference year for the analysis. The model presents a synthetic index summarizing the suitability and strength of each deal in comparison to an optimal case. Indirectly, the index is a measure of the likelihood of success of a PBS transaction.

**Figure 1 – Framework of analysis**




The first dimension (DRUG) refers to the characteristics of the asset(s) underlying a pharmaceutical patent royalty securitization for which it is important to consider all the relevant features of the market addressed by the drug, as well as its economic and regulatory attributes. The second dimension (PATENT) relates to patent characteristics, such as patent status and value, which are crucial for a securitization to be attractive for both issuers and investors. The last dimension (DEAL STRUCTURE) concerns the deal architecture: the financial structure, the legal framework, the credit enhancement mechanisms, and the credit merit of the involved actors are key variables affecting the strength and rating of a deal. In the first two macro-areas, the analysis of existing information and data has been conducted at a drug level, considering one single drug for the Zerit® deal and thirteen drugs for the 13 Drugs Pool deal, while in the last dimension we referred to the whole transaction.

The hierarchical structure used to design the fuzzy model is detailed below.

**D1. DRUG**

Patent backed securitizations generally imply high structuring costs due to the low level of standardization and to the uniqueness of the IP assets involved. In order to achieve an economically efficient transaction, the underlying asset size has to reach a break-even point (Watanabe, 2004), where steady and consistent cash flows are generated to cover the costs of issuance and debt service.

According to Hillery (2004), New Biological Entities (NBEs) can be more suitable for securitization than New Chemical Entities (NCEs) because they are more effective in treating targeted diseases and more difficult to be developed and manufactured, thereby creating additional barriers to competitors entering the field. Biologic-based drugs also differ from chemical-based drugs in their approval process (DiMasi and Grabowski, 2007). However, the development, release and market success of new compounds is largely affected by exogenous scientific, regulatory and economic factors, which ultimately determine the feasibility that a drug can be securitized. Considering the differences that exist among drugs and the risks to which they are subject, in this macro-area we included all the relevant drug-related factors that can significantly influence the likelihood of success of a deal. They have been grouped into two categories: the first refers to the market potential of the drug, while the second is focused on the drug life and on its approval process.

***D1.1 Market Potential***

- *Market size*. All else being equal, drugs that address large and low competition markets are more likely to be successful and to generate sufficient cash flow to be securitized (Hillery 2004). As a proxy for market size we considered the average worldwide sales in the period 2000-2003 for the top Anatomical Therapeutic Classes (ATC). Data on sales were collected from IMS HEALTH (Top-Line industry data). We carefully checked whether

the drugs underlying the two securitizations belonged to these top selling classes, according to a three-digit level ATC classification. We assigned the scores based on the average size of the considered market segments.

- *Competition in the therapeutic class*. The stronger the market position of a drug, the higher the possibility of high and sustained revenues. Empirical evidence generally supports the first-mover advantage theory in pharmaceuticals (Berndt et al., 1997; Hurwitz and Caves, 1988; Grabowski and Vernon, 1992). As such, products that come to the market earlier have a competitive advantage over later entrants, which face the risk of being dropped out of the market. Being a first-in-class drug it is therefore a key element which ensures revenue gains and a sustained market share. NBEs have a significantly higher likelihood of being first-in-class drugs compared with NCEs (Grabowski, 2007). As a proxy for the level of competition, we considered whether the drugs underlying the two securitization deals were first-in-class or follower molecules. To assess this, we checked the number of compounds already marketed in the US in the same ATC class (4-digit level) of each of the 14 drugs before their approval.
- *Downstream assets*. A firm with downstream marketing capabilities may be able to extract greater value from a drug than a firm that lacks them. To ensure that its downstream assets are fully utilized, the firm will probably develop many compounds in the same therapeutic class (Arora et al., 2009). Therefore, the positive revenue-generating effect due to the success of a new compound might be offset by the decline in sales of equivalent products already on the market. For each of the 14 drugs underlying the considered PBS deals, we identified the portfolio of medicines in the same 3-digit ATC already marketed by the commercializing company before the FDA approval of the analyzed drugs. The number of portfolio ATC-equivalent drugs was considered as a proxy of the presence and exploitation of downstream assets.

***D1.2 Development and commercialization***

- *Maturity*. The expected market life of a drug positively influences its securitization potential. In fact, the longer the residual life of a compound, the broader the time window in which it generates revenues. For this reason, for each drug, we considered its expected residual market life at the time of the deal. We referred to an average expected market life of 20 years, given the shortening of drugs' life cycles and the increasing competitive pressure in pharmaceuticals (Grabowski and Vernon, 2000).
- *Degree of cooperation.* Many companies in the pharmaceutical sector have turned to development partnerships, joint-ventures and licensing to acquire technological know-how and to transfer resources for product commercialization. Several scholars have highlighted the benefits of collaborative arrangements in the research and development of drugs (Hamel et al. 1989; Ohmae, 1989; Kanter, 1989). However, these arrangements involve costs and risks associated with their definition, coordination of common activities and IPR management (see among others Williamson, 1975; Pisano, 1991). Frictions between involved parties could be caused by appropriability issues, when intellectual property is not adequately protected through patents, or by problems of coordination and asymmetric information about the project. According to Pisano (1997), a potential "lemons problem" can arise if projects with fewer market opportunities are licensed to collaborative partners, while those with better prospects are internally developed. We relied on two measures approximating the degree of cooperation among parties: whether a drug was internally developed or licensed out and the number of licensing steps established until its market launch.
- *Success in the approval process.* In pharmaceuticals, R&D is a multi-phase process, involving experimentation, modelling and testing. The full-scale development of a drug involves the transition from Phase I to Phase III before becoming a commercially viable product. Moreover, both generic and brand name drugs are subject to approval by the Food and Drug Administration. Drugs also need to be manufactured in accordance with FDA

regulations. Transition probabilities for each clinical phase and overall success rates vary significantly depending on the drug type (NCEs or NBEs), on the historical period (DiMasi and Grabowski, 2007) and on the therapeutic class (DiMasi, 2001). At the time of the 13 Drugs Pool deal, some of the involved drugs were still under investigation by the FDA. Therefore, assessing their likelihood of success in gaining approval was at that time a relevant matter. When available, we considered the probability of success in clinical development for the Anatomical Therapeutic class that our sample drugs belonged to. Alternatively, we assigned a probability of success to the drug category, relying on the fact that NBEs, on average, have higher overall rates of success than NCEs, but are characterized by a lower transition probability in the most expensive Phase III.[24]

## D2. PATENT

The quality and obsolescence of the assets underlying a securitization are key risk factors, which need to be taken into account when defining the credit merit of a deal (Hillery, 2004; Kirsh, 2005). In a PBS, it is important to assess the ability of a patent to generate sufficient cash-flow to pay interests and amortization. Consequently, the quality and residual life of patents deeply influence the sustainability of a PBS deal.

### *D2.1 Patent value*

- *Quality Index*. It has long been recognized that patents, and the innovations they protect, vary enormously in their economic value, and that the distribution of such value is extremely skewed (Hall et al., 2000). From a theoretical point of view, the higher the value of the patent, the greater the probability it can originate consistent cash flows to be securitized. As previously mentioned, we collected patent data underlying the two PBS deals. For each patent, we studied its breadth (Lerner, 1994), technical novelty (Lanjouw

[24] Biopharmaceuticals yield an overall clinical approval success rate of 30.25% (as opposed to 21.5% for NCEs), but their transaction probability from Phase III to approval is 64.2% against 68.5% of NCEs (DiMasi and Grabowski, 2007).

and Schankerman, 2001) and technological importance (Hall et al., 2000). For each patent, we estimated the Lanjouw-Schankerman quality index (Lanjouw and Schankerman, 2004), which is a composite index built on the number of claims, backward references, forward citations received in the first five years of patent life and family scope. The index is correlated with the economic value of a patent and can be considered an indirect measure of the probability that a patent can generate enough cash flows to be securitized.[25]

***D2.2 Patent life***

- *Time to expiration.* In the biopharmaceutical industry, a key time point in the sales life cycle of a drug is the year of patent expiration. Drugs with substantial market shares are expected to face strong generic competition and sales losses after a patent expires (Grabowski and Vernon, 2000).[26] The short life of a patent makes it difficult to securitize it (Hillery, 2004). Under the hypothesis that a patent owner could pay renewal fees until his patent expires, we estimated the relative residual life for each patent from the date of the application.

## D3. DEAL STRUCTURE

PBS architecture is another essential element for properly understanding and interpreting the outcome of a deal. Since PBSs are ad hoc transactions, the underlying financial and legal structure is customized and each deal is different from the others. IP deals require a proper legal framework, professional servicing, highly specialized financial, legal and tax advisers, the choice of appropriate credit enhancements. The deal strength and rating assessment is also influenced by

[25] In calculating the index we applied different weights for pharmaceutical and biotech drugs. The weights derive from the common factor analysis applied to the technological field in the paper by Lanjouw and Schankerman (2004). They are applied to each indicator on which the index is constructed, and show the expected value of quality associated with a unit increase in the considered indicator.

[26] The sales percentage decline in the first two years after patent expiration for drugs with $50 million sales or more at the time of patent expiration is estimated to be, on average, 43% and 42%, respectively (Grabowski and Vernon, 2000).

the Originator's degree of experience, by the financial situation of the licensees and licensors and by the strength of collateral guarantees.

***D3.1 Stakeholders***

- *Licensee/licensor financial condition.* Since patent securitizations are often based on licensing agreements, assessing the financial stability of both the licensee and the licensor is a key issue. In particular, the financial strength of a licensee is important because interest payments on securities depend on its performance. If the asset is not successful enough to generate the anticipated cash flows, the licensee can continue paying its license fees. For that reason, financially stable drug companies are more likely to exploit licensed drugs and to afford interest repayments (Hillery, 2004). We measured the degree of the financial strength of both licensees and licensors in the examined deals using a synthetic rating indicator built on the interest coverage ratio of each licensee/licensor in the deal year.[27]
- *Originator's degree of experience.* The Originator's degree of experience in handling a securitization process can determine the success of a transaction. The accumulated knowledge on how to structure the process might reduce the risk of failure. The more experience in the field, the higher the chance to properly structure an IP deal. Moreover, each new deal requires setting up trust among investors, which is costly. Long and consolidated knowledge in managing IP securitizations can make a new transaction more efficient and cost effective (Kirsh, 2005). In fact, an Originator's second deal is typically much easier and cheaper than the first one, as documentation and covenants are simply adjusted to the new pool. We approximated the Originator's degree of experience with the number of similar transactions in which he was involved in the years prior to the considered deal.

[27] The interest coverage ratio is expressed as the ratio between a company's EBIT and financial interests in the deal year. The ratio is an index of a company's ability to repay debt interests. According to the value of the interest coverage ratio, a "synthetic" rating and a default spread can be defined (for more details on rating ranges see Damodaran data on "Ratings, Interest Coverage Ratios and Default Spread").

***D3.2 Collateral***

- *IP Pooling Arrangement.* The major benefit in aggregating royalty streams coming from a pool of drugs (rather than just one) is that diversification lowers the risk that underperformance of any one income stream will cause the deal to default (Walsh, 2007). In order to assess the diversification potential of the studied PBSs, we considered the number of drugs involved in the deals.
- *Diversification.* The risk of underperformance of patent-backed securities is mitigated by the diversity of the overall pool of assets, the underlying patents and the license agreements. We accounted for the diversification of underlying drugs by analyzing the number of ATC classes for the 14 drugs, the difference in their residual market life and the different types of molecules.

***D3.3 Transaction Architecture***

- *Vehicle structure.* In a standard securitization process, the Originator sells the asset itself or cash flow rights to a bankruptcy-remote entity known as a Special Purpose Vehicle (SPV) in order to separate future receivables from its own corporate risks. SPV are not usually created for single transactions but usually are revolving and multi-purpose organisms. However, the unique nature of patents implies a case by case assessment of their value and risk profile and, as a consequence, the design of a PBS transaction cannot be a standardized process. Flexibility and customization of the vehicle can add solidity to the deal structure and increase the overall probability of success of the transaction. We assessed the vehicle structure by analyzing the degree of flexibility of the SPV and the possibility of further modifying the asset pool after the first issuance.
- *Credit enhancement.* Securitizations are structured with a number of credit enhancements that should further improve the attractiveness of asset-backed securities.[28] Due to the use of credit enhancements in securitization structures, it is possible to achieve a larger

[28] Credit enhancement mechanisms can be either internal (subordination, overcollateralization, excess spread mechanisms, reserve accounts, internal guarantees) or external (basket credit default swaps, third-party guarantees).

separation between the asset risk and the company risk (Moody's Investors Service, 2000). By virtue of these tools, a security's credit quality can be raised above the quality of the underlying asset pool or of the entity originating the assets. As a consequence, the use of tailor-made credit enhancement tools is assumed to significantly increase the likelihood that a deal will be successful. We assessed the presence of internal and external credit enhancement mechanisms and their efficacy to secure each deal.

- *Legal framework*. In examining the feasibility of a deal, attention must be paid to a variety of legal issues, such as the impact that country regulations have on the asset's underlying value, specific bankruptcy concerns and legitimacy over patent rights. Decoupling the assets from the bankruptcy risk of the Originator requires an appropriate legal structure. Moreover, legal due-diligence on patent ownership is essential to ensure effectiveness against the risk of patent infringement (Walsh, 2007). We compared the legal structure of the two deals and focused the analysis on the underlying asset ownership and on royalty contracts discipline.

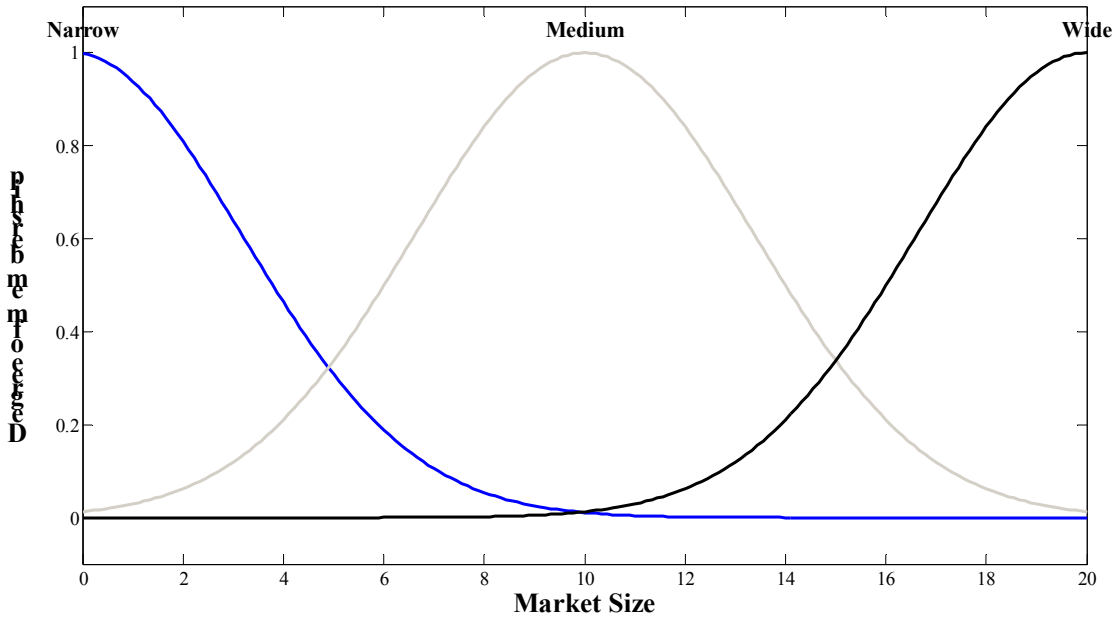
### *3.2 Model implementation*

Following the fuzzy approach, each of the identified variables is defined by five elements $(X, T(X), U, G, M)$. $X$ is the variable, $T(X)$ is the "term set", namely the set of values (single values are called "fuzzy variables") that the variable can take, $U$ is the universe of values upon which each set is defined, $G$ is a grammatical rule to generate the variables' names, $M$ is a semantic rule linking each linguistic variable to its meaning. A fuzzy set is defined by its elements and by their degree of membership: for example in the fuzzy set $T1 = \{(x, \mu(x))\}$, $x$ belongs to the universe and $\mu(x)$ is its degree of membership to $T1$. The function that represents the relationship between a value and its degree of membership in a specific set is called "membership

function". It often depends on the context, on the problem under investigation and on the researcher's subjectivity.[29]

For example, in our framework the variable "*Market size"* is a linguistic variable, defined as between $ 0-20 billion, the term set of which is "Narrow, Medium, Wide".[30] We used a set of fuzzy numbers from 0 to 20 to capture the fuzzy range of magnitude.[31] Within this term set, the fuzzy variable "Medium Market size" relates the potential market size of a drug to a degree of membership in the fuzzy set. For instance, the target market of the therapeutic area that the drug Rituxan (one of medicines used in the 13 Drugs Pool Deal) refers to was, on average, $7.3 billion between 2000 and 2003. This value determines its degree of membership to "Medium Market size". Figure 2 illustrates the example: the higher the expected size of the target market of the therapeutic area to which the drug belongs, the higher the degree of membership.

**Figure 2 – Membership Function "Market Size"**




[29] The shape of the membership function can be linear, nonlinear or discrete: the only requirement is that the degrees of membership should range from zero to one.

[30] The upper bound is equal to the average market size of the first therapeutic class in the period between 2000 and 2003.

[31] Each membership function is defined by some values according to its shape. For a trapezoidal shape, the membership function is defined by lower and upper base values. For a Gaussian shape, the membership function is defined by mean and standard deviation values. For instance, "*Market size"* shows 3 bell-shaped functions defined by (0, 3.4) for "Narrow", (10, 3.4) for "Medium" and (20, 3.4) for "Wide".

Appendix 1 reports the fuzzy system we used to compare the two patent securitization deals. The Table shows the membership function shape (Gaussian or Trapezoidal)[32], the universe of values upon which each term set was defined and the fuzzy numbers for each macro-area, sub-dimension and variable analyzed. The selection of the explanatory variables, of the term set and of the degree of membership relied both on data collection and on subjective judgment. In order to reduce arbitrariness in assigning degrees to the different dimensions and variables, we made a second run of interviews with industry and financial professionals. Experts' opinions helped us to interpret the evidence and to validate the model.[33]

The model is based on Mamdani's fuzzy inference method (see Mamdani and Assilian, 1975). We used simple trapezoidal or bell-shaped membership functions according to the discrete or continuous nature of linguistic variables. The model has been implemented on each hierarchical level for all the three macro dimensions. Starting from lower level variables, it generates a numerical value by aggregating the generated numbers into superior hierarchical stages. The final number is used to appraise the deals under investigation.

The model works in a simple way.[34] The first step is the fuzzification of the inputs, which consists in determining the degree to which each input belongs to each fuzzy set through the membership functions (see Figure 2). Second, a series of rules to connect inputs to the final output must be defined. For instance, the variable "*Market potential*" can be considered as the output deriving from the combination of three inputs: *"Market size", "Competition in the therapeutic class"* and *"Downstream assets"*. A set of rules which define the output level according to inputs' values is required. These rules are expressed in the form of If-Then constructs and are built on linguistic variables that can take the verbal values. Here is an example: "If *Market size is Narrow AND Competition in the therapeutic class is Low AND Downstream assets is Low, THEN Market Potential is Low"*. In general, we considered all possible scenarios deriving from the combination of

[32] We chose to use simple functional forms (bell-shaped and trapezoidal), depending on the continuous or discrete nature of the variables.
[33] Scores and judgments for "Drug" and "Patent" dimensions were formulated at single drug level and aggregated afterwards. Instead, we considered the whole transaction when dealing with the "Deal structure" dimension.
[34] The fuzzy system has been developed and implemented with MATLAB.

different inputs' levels and we aggregated them using the AND operator. In the upper hierarchical level we adopted a more conservative approach by reporting a *Low* state for the final output each time that a linguistic variable recorded *Low*. This was done so that DRUG, PATENT and DEAL STRUCTURE dimensions would all be considered necessary conditions for a successful transaction. All the input combinations and rules we set for the exemplificative variable "*Market potential"* are reported in Appendix 2.

Third, the If-Then rules are interpreted in classical logic by the implication operators, such as fuzzy union, intersection and complement and the output of each rule is aggregated into a fuzzy set.[35] Lastly, this aggregate output fuzzy set is defuzzified with a centroid method and the final result is a single number.

## 4. Discussion of results

Table 1 summarizes final scores at the different hierarchical levels and Figure 3 compares the suitability and strength of the analyzed PBSs. Considering the DRUG dimension, results highlight an overall little distance in *Market Potential* between Zerit® and the 13 drugs of the second deal (respectively, 4.76 and 5.27). However, if we look at the variables in which the sub-dimension is divided, some significant differences emerge.

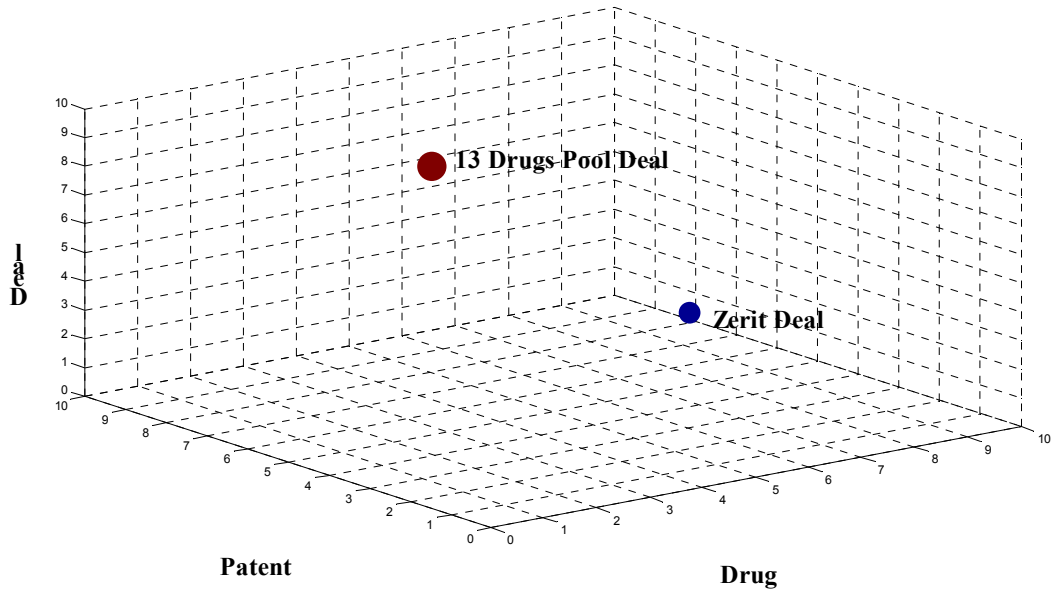
**Table 1 - Final scores**

| LINGUISTIC VARIABLES | Zerit® PBS | 13 Drugs Pool PBS |
|---|---|---|
| **DRUG** | **5.00** | **5.15** |
| Market Potential | 4.76 | 5.27 |
| Development and Commercialization | 5.14 | 6.56 |
| **PATENT** | **1.65** | **8.19** |
| **DEAL STRUCTURE** | **5** | **7.02** |
| Stakeholders | 5 | 8.68 |
| Collateral | 1.35 | 8.55 |
| Transaction Architecture | 5 | 7.23 |
| **PBS RESULT** | **2.94** | **5.37** |

[35] The implication method has been implemented through min. operator (minimum), which truncates the output fuzzy set. The output aggregation process has been implemented through max. \ operator (maximum).

Even though Zerit® was addressing a large market, its sales heavily declined after 2000 and dropped to $426 million in 2003. On the contrary, the nine drugs which were already on the market at the time of the second deal generated $ 4.4billion in sales and $49 million in royalties in 2002 (Hillery, 2004). The market size of the therapeutic classes of the other 13 drugs between 2000 and 2003 was higher on average. Given these premises, the *Market size* dimension shows final scores of 3 for the first deal and 4.54 for the second.

**Figure 3 – Output of the two PBS deals**




Most of the second deal drugs are NBEs, which have a greater likelihood of becoming first-in-class medicines. However, NBEs also require more stringent production standards and a more complex development and manufacturing process. Some of the 13 drugs were the only medicines available for certain indications, but the others were follower molecules. At deal time, three compounds in the same therapeutic class of Zerit® (4 digit level) had already been approved. Weighing all of these issues, we computed that the distance between the Zerit® score and 13 Drugs Pool deal for the *Competition in the therapeutic class* dimension was less than 1 point.

While there is not a significant difference in the results concerning the presence of downstream assets (scores are 0 for Zerit® and 0.43 for the 13 Drugs Pool) and the degree of cooperation in drugs development (scores are 2.5 for Zerit® and 4.11 for the 13 Drugs Pool), the expected life of a compound is a critical and differentiating factor. Zerit was approved for market launch in 1994. Considering an average expected market life of twenty years, its residual market life was 14 years at the start of the deal. At the time of the second deal, nine drugs were already on the market, while four compounds were under approval. In 2003, the average time from final approval of the nine drugs was 6 years[36] and the potential residual life for the other four compounds still under the approval process was 20 years. *Maturity* scores are respectively 14 (first deal) and 15.64 (second deal). Considering the typology and ATC of each drug, we estimated the probability of *Success in the development and approval process* at deal time to range between 30.25% and 33.3% for the four compounds awaiting approval (scores are 24.8 for Zerit® and 27.5 for the 13 Drugs Pool).

The aggregation of the three sub-dimensions resulting into the macro-area *Market Potential* leads to a final degree of 4.76 (deal 1) and 5.27 (deal 2), while the macro-area *Development and Commercialization* reached 5.14 (deal 1) and 6.56 (deal 2). The final scores of the DRUG dimension are respectively 5 for Zerit® and 5.15 for 13 Drugs Pool.

Results for the PATENT macro-area point to a more pronounced difference between the Zerit® deal and the 13 Drugs Pool deal ( 1.65 and 8.19 respectively). The Lanjouw-Schankerman quality index for the patents on which the Zerit® transaction was based, is lower (0.40) than the average value of the index for the other 13 drugs (0.78), indicating that, overall, the quality of the underlying invention is lower in terms of scope, technical novelty and technological importance. Concerning *Time to expiration*, patents of the second deal have a longer residual life on average

[36] The years of the approval of the nine marketed drugs were: 1991 for Neupogen; 1994 for ReoPro®; 1996 for Retavase; 1997 for Rituxan®, TOBI®, Zenapax®; 1998 for Thalomid® and Simulect®; 1999 for Targretin Capsules®; 2002 for Neulasta (FDA-CDER data).

than Zerit® patents. Given these considerations, the first deal scores 8, while the second scores 12.76.

In the DEAL STRUCTURE, the last macro-area, considerable differences between the two patent securitizations can be seen (Zerit® deal scores 5 and the 13 Drugs Pool deal scores 7.02). Clearly the financial situation of the licensor, and the licensee in particular, are important elements to ensure the generation of cash flow. At the time of the Zerit® deal, both Bristol-Myers Squibb (the licensee) and Yale University (the licensor) were AAA rated by S&P (Fisher, 2002). For the second deal, licensors and licensees were a diversified group of investment-degree companies (Hillery, 2004). According to our synthetic rating index (built upon companies' interest coverage ratios at deal year) scores for *Licensee/licensor financial condition* were respectively -0.45/51.58 for the Zerit® deal and 4.58/35.6 for the 13 Drugs Pool deal.

Another important factor which is likely to determine the success of a PBS is the Originator's degree of experience in handling a securitization process. Since 1996, Royalty Pharma AG has been working with research institutes and science-based companies to acquire revenue-producing intellectual property, principally royalty interests in marketed and late-stage biopharmaceutical products. At the time of the Zerit® deal, the company owned a diversified portfolio of assets and was quite expert in the acquisition of royalty interests in industry leading life-science products. However, the Zerit® deal was the first securitization transaction the company had engaged in that had ended up in failure. As Royalty Pharma management declared, the first patent securitization failure was considered a useful lesson to secure expertise for this kind of financial solutions (Hillery, 2004). Therefore, we assumed that the company's expertise would increase with the second deal and consequently we assigned scores 2 and 5 for deal 1 and deal 2 respectively. The aggregation into the macro-area *Stakeholders* leads to a final score of 5 (deal 1) and 8.68 (deal 2).

The first transaction was backed by the patent rights on a single drug (Zerit®), while the second deal was built on the patent rights of thirteen biopharmaceutical drugs, all very diversified

in terms of typology (NCEs vs. NBEs), ATC classes and residual market life. In both *Asset Pool* and *Diversification*, the second deal displayed superior scores (13 vs. 1 and 8.5 vs. 1, respectively); therefore the scores of the *Collateral* macro-area are 1.35 for Zerit® deal and 8.55 for the 13 Drugs Pool deal. The more difficult it is to predict how much exogenous factors are likely to affect patent value and drug performances, the more an Originator needs to diversify its asset portfolio to reduce the volatility of the expected cash-flows (Kirsh, 2005). Leveraging on multiple drugs with proven market acceptance has a good diversification potential and helps to reduce the risk of underperformance.

The two securitization deals also differed in their transaction architecture. Considering the *Legal framework* dimension, the characterization of the Special Purpose Vehicle in charge of the transaction was rather different. In deal 1, Yale University, which was the sole owner of the underlying asset, sold 70 percent of the royalties from the licensing agreement with Bristol-Myers Squibb for the Zerit® drug to SPV (BioPharma Royalty Trust). In deal 2, instead, even though the legal aspects related to the treatment of royalties under the bankruptcy code were the same, the SPV (Royalty Pharma Finance Trust) owned not only a percentage of royalty rights deriving from the licensing contracts, but also the underlying patent in some cases. For example, the antigen technology underlying the drug Rituxan was developed by Xoma Corporation, which licensed it to Genentech, Inc. Rituxan was further developed by Genentech and Idec and Royalty Pharma purchased the licensed patents from Xoma, assigning the ownership to Royalty Pharma Finance Trust. The legal framework of this second deal was judged superior by the experts we interviewed; consequently, we assigned the score 8 to the 13 Drugs Pool Deal and 7 to the Zerit® deal.

Another difference between the two deals consisted in the structure of the Special Purpose Entity. BioPharma Royalty Trust was an *ad hoc* vehicle, with a fixed structure that was established with the sole purpose of funding the acquisition of the Zerit® patent rights. On the contrary, Royalty Pharma Finance Trust was structured to be a warehouse facility, not only

thought to handle the 13 Pool Deal, but also allowing for the inclusion of other patent rights by Royalty Pharma. Even after the deal, the company could continue acquiring new royalty interests and issuing new securities to the investors (Hillery, 2004; Eisbruck, 2002),. In fact, in January 2004, Royalty Pharma acquired a portion of the Memorial Sloan Kettering Cancer Center's royalty interest in Neupogen/Neulasta drugs, adding it to the trust. Since this trust was adjustable, expandable, and scalable, and thus more flexible than the BioPharma Royalty Trust, we assigned a score of 7 to the 13 Drugs Pool Deal and 1 to the Zerit® deal.

In order to obtain a higher credit merit, the Zerit® deal relied on some internal credit enhancement mechanisms: overcollateralization and subordination through the issuance of three tranches of senior notes, mezzanine notes and equity.[37] The agreement also included a senior coverage ratio test covenant,[38] which could lead to early amortization and default unless requirements were fulfilled for three consecutive payment dates. This solution had the limitation of being too complex to be handled (Kirsh, 2005). The 13 Drugs Pool securitization was primarily backed by the MBIA Insurance Corporation, which provided protection against issuer default and downgrade risk. As one of the largest worldwide financial guarantors of structured financings, MBIA (AAA rated) provided credit enhancement for a wide variety of asset classes and was very active in the IP backed market. Royalty Pharma Finance Trust also benefited from a dynamic borrowing base calculation, and various reserve accounts. Finally, if some of the royalty streams underperformed, Royalty Pharma could request an indemnity from the companies selling their royalty interests. As the second deal was stronger in terms of credit enhancement mechanisms, we assigned it a score of 5 and gave a score of 8 to the Zerit® deal. The final score

[37] Kirsh (2005) reports the following amounts: $ 57.15 million senior tranches, $22 million mezzanine and $21.16 million junior tranches. The additional 14.69$ million were provided as equity investment. Moreover, BioPharma Royalty Trust secured cash flows to a collateral trustee, Bankers Trust Co., which created various operating accounts to collect and distribute the funds. Quarterly distributions first covered collateral trustee service expenses, then senior note holders' interest and principal, and finally mezzanine, junior and equity holders.

[38] The ratio is expressed as 70% of the amount of royalties payable by the licensee, assuming net sales were equal to four times net sales in a quarterly report, divided by the amounts required in the cash flow distribution through, and including, the principal on the senior notes (Fischer, 2002).

of *Transaction Architecture* is 5 for the Zerit® deal and 7.23 for the 13 Drugs Pool deal. Finally, these values resulted in a DEAL STRUCTURE degree of 5 (first deal) and 7.02 (second deal).

As previously described, the model generates a numerical value by aggregating the scores of lower level variables into superior hierarchical stages. The final number is used to appraise the suitability and strength of the two deals under investigation. The results pointed to a higher final score for the 13 Drugs Pool securitization (5.37 vs. 2.94 for the Zerit® deal), suggesting that this second financial solution was more likely to create value for both the issuer and the investors.

To sum up, several factors explain the relative success of deal 2 compared to deal 1. Royalty Pharma Finance Trust was able to mitigate all the risks related to the regulatory background and to the market performance of the underlying assets by leveraging on external credit guarantees, the high diversification of the drugs and the flexibility of the transaction architecture. On the other hand, BioPharma Royalty Trust underestimated the risk affecting the projected Zerit® revenues and failed to adopt an asset diversification strategy.

These results, which are tested on the two PBSs presented, point to some general conclusions. In a securitization transaction, advantages in terms of market potential, level of competition and expected market life of the underlying assets can reasonably increase the probability to generate stable and consistent cash flows to cover the debt service and principal payments. Moreover, a higher quality of the underlying invention in terms of scope, technical novelty and technological importance and a longer patent residual life are likely to reduce the risk of technical obsolescence and sales losses. Finally, the strength of the credit enhancement mechanisms, the flexibility of the deal architecture and the adoption of a diversification strategy can increase the overall probability of success of a transaction.

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## 6. Appendix 1 - Description of the Fuzzy model

| **LINGUISTIC VARIABLES** | | **MEMBERSHIP FUNCTION SHAPE *** | **UNIVERSE **** | **FUZZY NUMBERS ***** | | |
|---|---|---|---|---|---|---|
| **DRUG** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| **Market Potential** | | **Gauss** (μ,σ) | **[0-10]** | **Low (0, 1.7)** | **Medium (5, 1.7)** | **High (10, 1.7)** |
| Market size | Size of the considered market segments (billion $). | Gauss (μ,σ) | [0-20] | Low (0, 3.4) | Medium (10, 3.4) | High (20, 3.4) |
| Competition in the therapeutic class | Number of compounds already marketed in the US in the same ATC 4-digit. | Trap (a,b,c,d) | [0-14] | Low (-4.51, -1.09, 1.09, 4.51) | Medium (2.49, 5.91, 8.09, 11.51) | High (9.49, 12.91, 15.09, 18.51) |
| Downstream assets | Number of drugs in the same ATC 3-digit already marketed by the commercializing company before FDA approval. | Trap (a,b,c,d) | [0-2] | Low (-0.64, -0.156, 0.156, 0.64) | Medium (0.36, 0.84, 1.16, 1.64) | High (1.36, 1.84, 2.16, 2.64) |
| **Development and commercialization** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| Maturity | Years of residual market life at the time of the deal (with 20 years of expected market life). | Trap (a,b,c,d) | [0-20] | High (-6.44, -1.559, 1.559, 6.44) | Medium (3.56, 8.441, 11.56, 16.44) | Low (13.56, 18.44, 21.56, 26.44) |
| Degree of cooperation | Synthetic index of development process information (internal vs external) and of number of licensing steps established until market launch. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |
| Success in approval process | Probability of success in the overall clinical drug category. | Gauss (μ,σ) | [15.4 33.3] | Low (15.4, 3.041) | Medium (24.35, 3.041) | High (33.3, 3.041) |
| **PATENT** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| Quality index | Lanjouw-Schankerman quality index. | Gauss (μ,σ) | [0.4-1.27] | Low (0.4, 0.15) | Medium (0.83, 0.15) | High ( 1.27, 0.15) |
| Time to expiration | Years of residual patent life from the application date. | Gauss (μ,σ) | [2-13.14] | Low (2, 1.89) | Medium (7.57, 1.89) | High (13.14, 1.89) |
| **DEAL STRUCTURE** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| **Stakeholders** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| Licensee financial | Synthetic rating indicator: ratio between | Trap (a,b,c,d) | [-300-300] | Weak | Quite solid | Solid |

| | | | | | | |
|---|---|---|---|---|---|---|
| condition | a company's EBIT and financial interests in the deal year. | | | (-300, -300, 0.8, 1.25) | (0.8, 1.25, 2.5, 3) | (2.5, 3, 300, 300) |
| Licensor financial condition | Synthetic rating indicator: ratio between a company's EBIT and financial interests in the deal year. | Trap (a,b,c,d) | [-300-300] | Weak (-300, -300, 0.8, 1.25) | Quite solid (0.8, 1.25, 2.5, 3) | Solid (2.5, 3, 300, 300) |
| Originator experience | Similar transactions in which the Originator was involved in the years prior to the considered deal. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |
| **Collateral** | | **Gauss (μ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| IP Pooling Arrangement | Number of drugs involved in the deals. | Trap (a,b,c,d) | [1-20] | Narrow (-5.12, -0.48, 2.48, 7.12) | Medium (4.38, 9.02, 11.98, 16.62) | Wide (13.88, 18.52, 21.48, 26.12) |
| Diversification | Synthetic index of drugs diversification in terms of ATC classes, residual market life and types of molecules. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |
| **Transaction Architecture** | | **Gauss (μ ,σ)** | **[0-10]** | **Unsuitable (0, 1.7)** | **Quite suitable (5, 1.7)** | **Suitable (10, 1.7)** |
| Vehicle structure | Synthetic index of flexibility of the SPV. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |
| Credit enhancement | Synthetic index of efficacy of internal and external credit enhancement mechanisms. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |
| Legal framework | Synthetic index of the legal structure of the two deals. | Trap (a,b,c,d) | [0-10] | Low (-3.22, -0.78, 0.78, 3.22) | Medium (3.56, 8.44, 11.56, 16.44) | High (13.56, 18.44, 21.56, 26.44) |

* Gaussian membership functions are defined by mean and standard deviation values (μ, σ); trapezoidal membership functions are defined by the values of basis orthogonal projection on the abscissa (a,b,c,d).

** Universe represents upper and lower bound for each variable on the two PBSs. A [0-10] has been used when a variable is mainly based on qualitative judgments or is a synthetic indicator of different parameters.

*** Fuzzy numbers represent membership function parameters for each fuzzy variable.

## 7. Appendix 2 - Input combinations and rules for the variable "Market Potential"

| | IF | PROPOSITION 1 | AND | PROPOSITION 2 | AND | PROPOSITION 3 | THEN | OUTPUT |
|---|---|---|---|---|---|---|---|---|
| 1. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | (Market Potential **IS** *Low*) |
| 2. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | (Market Potential **IS** *Low*) |
| 3. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | (Market Potential **IS** *Low*) |
| 4. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | (Market Potential **IS** *Low*) |
| 5. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | (Market Potential **IS** *Low*) |
| 6. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | (Market Potential **IS** *Low*) |
| 7. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | (Market Potential **IS** *Low*) |
| 8. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | (Market Potential **IS** *Low*) |
| 9. | **IF** | (Market size **IS** *Narrow*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | (Market Potential **IS** *Low*) |
| 10. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | (Market Potential **IS** *Low*) |
| 11. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | (Market Potential **IS** *Low*) |
| 12. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | (Market Potential **IS** *Low*) |
| 13. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | **(**Downstream assets **IS** *Medium*) |
| 14. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | **(**Downstream assets **IS** *Medium*) |
| 15. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | **(**Downstream assets **IS** *Medium*) |
| 16. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | **(**Downstream assets **IS** *Medium*) |
| 17. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 18. | **IF** | (Market size **IS** *Medium*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 19. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | (Market Potential **IS** *Low*) |
| 20. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | (Market Potential **IS** *Low*) |
| 21. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Low*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | (Market Potential **IS** *Low*) |
| 22. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | **(**Downstream assets **IS** *Medium*) |
| 23. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 24. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *Medium*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 25. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Low*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 26. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *Medium*) | **THEN** | **(**Downstream assets **IS** *High*) |
| 27. | **IF** | (Market size **IS** *Wide*) | **AND** | (Competition in therapeutic class **IS** *High*) | **AND** | **(**Downstream assets **IS** *High*) | **THEN** | **(**Downstream assets **IS** *High*) |

# Essay 3 - Patent value: seller and bidder perspectives

## 1. Introduction

It is widely accepted that intangible assets are the major drivers of growth in a large number of economic sectors (Hand and Lev, 2003). Many national economies are now going through the transition from a manufacturing-based economy to an innovation driven one. Within this context, investments in IP and intangible assets are becoming crucial to economic growth and sustainable wealth creation.

Intangible assets have been recognized as representing a large share of a company's value. Their increasing importance is reflected in the upsurge of the share of investments in intangible assets on the overall amount of companies' business investments.

Furthermore, the number and importance of technology transactions are increasing as well: in the last twenty years, R&D joint ventures, partnerships, licensing and cross-licensing agreements, R&D contracts and other forms of technologies or technological services exchange had a growing diffusion among firms: data on technology transactions show that technology trade increased and high-tech industries have led this growth (Arora, 2001). Markets for technology have become more important since they have a strong effect both on buyers and sellers of technologies (Arora, Fosfuri, Gambardella, 2001).

Despite so, their contribution to the process of fund raising is still usually quite weak. Empirical evidence shows that an adequate level of fund leverage based on the value of intangibles, however important for the industry, is yet to be achieved. This is because several characteristics of the innovative processes undertaken by firms generate market failures when using traditional financial instruments (Hall, 2002 for a review). For this reason, companies are likely to miss important capital resources that could be crucial for developing their business and for sustaining innovation investments.

Financing constraints are particularly harsh for innovative firms. It is proved that companies with high ratios of intangible to tangible assets are those facing more difficulties in raising funds. Due to the uncertainty of their investment payoffs, they have insufficient credit-worthiness and are unable to get alternative liquidity leveraging on their capital, because of the intangible nature of their investments (Carpenter and Petersen, 2002; Hall, 2002).

However, in recent years, the widespread diffusion of the market for intellectual property and the ongoing innovation of financial tools led to a growing interest among companies in Intellectual Property (IP) as a valuable asset to use for funding opportunities. Knowing the limitations and the barriers to finance R&D, innovation and other activities, the question of whether financial and exchange tools based on Intellectual Property Rights (IPRs) might be valid alternatives to the problem of financing constraints appears to be fairly significant and of considerable interest for both policymakers and researchers.

Actual background for IP monetization solution include a wide and fragmented range of tools and initiatives: it is a complex and borderline area in ongoing development that involves both structured finance and IP management.

IP-backed financial instruments can be defined as a wide set of tools and financial solutions leveraging on IPRs value to raise funds.

These financial solutions are usually characterized by unique features and by a high level of customization. In the latest years IP-backed deals have been established through different vehicles from commercial banks to specialized financial operators (Walsh and Cohen, 2007) and their actual background is quite fragmented. A part from the most common patent-backed financial instruments, IP loans, and IP sale and lease back, IP securitizations (for a review Calderini and Odasso, 2008), other options began to evolve even if their application is quite limited till now (Edwards, 2001; Hillery, 2004; Frank, 2005; Lipfert and Von Scheffer, 2006). Some examples are: the patent asset trust, that has a structure similar to securitization but based on equity issuance; the patent backed collateralized debt obligation that bundles a diversified pool

of patent loans and sells them to investors according to their risk profile; the patent funds, that are special investment funds investing only in patents. Finally, there is the market for buying and selling patents: the diffusion of online listing services and IP auctions attempts to increase the awareness of IP available for sale and reducing transaction costs: the concept of a multi lot patent auction was born with the intent to introduce to the market place a forum to facilitate the exchange of IP with a critical mass of buyers (Malackowski, 2008).

One of the main issues affecting the diffusion of patent rights monetization solutions is the lack of a widely recognized method for value appraisal that can be deeply accepted and communicated among an extensive community of managers, analysts, financial institutions, IP professionals and investors. The auction mechanism overcomes this barrier: patent auction value data are not affected by estimation methods and represent the real market value of the patent asset, included its strategic component.

Starting from a complete set of data covering all patent auctions held until the end of 2008 by the major IP merchant bank, our objective is to investigate the impact of patent value determinants on patent value resulting from an auction process and to examine which are the patent features increasing the selling likelihood. In particular, our contribution on previous literature is based on the double perspective of the analysis. The research goes further the exploration of the final patent selling price and considers the value expectation of the seller too: we analyze which are main factors affecting differences between seller and market valuation of patents.

## 2. Literature

The proliferation of filed patents both in Europe and in the US and the stunning growth of markets for technologies (Arora et al. 2000) confirm that patents, beside being conceived as legal protection mechanisms for inventions developed in-house, are increasingly appreciated as

technology transfer-enablers. In this context, however, the rigorous assessment of the economic value of patents and the identification of patent value drivers still represent key challenges.

The valuation of patents is especially difficult because of the intangible nature of these rights and the great uncertainty their expected returns are subject to (Sobrero, Oriani, 2002). This uncertainty is composed of technical and market uncertainty associated with the underlying invention protected by the patent but also by the legal uncertainty whether the patent stays in force or is invalidated or amended. Moreover, there is a lack of generally accepted methodologies for the valuation of innovation and intellectual property rights (Encoua et al. 2005). These problems make it hard to determine the value of specific patents and patent portfolios and the overall contribution of patents to a firm value in different stages of its lifecycle. These shortcomings are critical to several important decisions of managers and financial investors, such as patent licensing, patent litigation, venture capital financing, IP-backed financing, and access to public equity markets in order to finance innovation projects. Addressing these issues would therefore be important both for practical evaluation problems within patent-related transactions among firms and for policy analysis concerning the development of the markets for technology (Arora et al. 2009) and the support of financial markets for innovation processes.

Questions concerning the economic value of patents have attracted economists' interest for years, both from theoretical and empirical standpoints. However, the task of assessing the value of patent rights is a difficult one, since the distribution of these values is highly skewed (Scherer (1965), Pakes and Schankerman (1984), Pakes (1986), and Griliches, 1990) and is rarely observable.

The initial approaches to measuring the value of patents have relied on data on patent renewals. The obligation to pay renewal fees to keep patents 'alive' implies that it is expensive to patent holders to renew patent protection for an additional year. Most of the research in this field looks at the aggregate value of patents, such for example by technology category and nationality of patentees (Schankerman, 1998 and Lanjouw, 1998). The pioneering papers in this field are

Pakes (1986), and Schankerman and Pakes (1986). In these papers the observed renewal decisions are used to estimate the distribution of patent values. Bessen (2008) further develops this early approaches by combining information about patent renewals with information about the owner and patent characteristics. More recent approaches have tried to infer patent value from estimating patent rents (Bessen, 2009).

A more indirect approach to approximating patent value has been to use a set of variables correlated with patent value and look at the relationship between patent value and a variety of patent characteristics. Scholars identified several proxies of patent values: weather a patent is litigated or opposed (Harhoff et al. 2003, Allison et al. 2004, Lanjouw and Schankerman, 2004), the number of jurisdictions in which a patent is protected (Putnam, 1996), the observed decision to sell (re-assign) patents (Serrano, 2005), whether the patent is renewed (Lanjouw and Schankerman, 2004; Harhoff et al., 2003), survey measures of subjective patent value (Harhoff et al., 1999) and firm market value (Hall at al. 1995).

Concerning patent value inferred by whether the patent had been litigated, Lanjouw et al. (1996), and Lanjouw and Schankerman, (1999) demonstrated that litigated patents were more valuable than non-litigated patents. They also found that a patent's quality was a strong function of its number of claims and number of forward citations, with some role for backward citations, family size, technology group and nationality of the patentee. Haroff et al. (2003) confirmed previous evidence that patents which are upheld in opposition and annulment procedures are more valuable than non-opposed patents. Putnam (1996) points out that the number of countries in which the patentee files is correlated with the value of an invention.

Patent value may also be inferred from econometric models that link firms' market value to patents (Griliches, 1981; Pakes, 1985). A large number of researchers have run regressions that use firm market value (or Tobin's Q) as the dependent variable and some patent measures as independent variables. Hall et al. (2005) use data on Compustat firms during 1979–1988 and

show that the firms' market value is correlated with the ratio between R&D and firm assets, the ratio between patents and R&D, and the ratio between citations and patents.

It has also been a recurring idea in the literature to view patents as real options and value them accordingly. In this perspective, a patent is analogous to an option on the future revenues generated by its potential commercial application. Starting out with Pakes (1986) the idea of valuing patents as (real) options has developed further until today (Pitkethly, 1999; Reitzig, 2002; Wu and Tseng, 2006; and Amram,2005).

Estimates of the patent rights value from surveys of patent holders have been conducted in a few studies. Haroff et al. (2003), relying on a survey directed to German patent holders, found that the number of references to the patent literature as well as the forward citations are positively related to patent value. Reitzig (2003) relied on a survey to assess patent value and found the most important indicators of the present value of a patent are primarily firm-specific: the level of importance the IP has to a specific firm, the inter-related importance of current IP as related to other IP held, the usefulness of the IP to other firms, and the difficulty in legally creating a similar invention.

Using a different approach Sneed and Johnson (2009) used a dataset on patent auctions to determine whether known objective patent characteristics lend value to a patent offered for sale, or add to the probability of a successful sale. They found that that publicly owned and frequently referenced patents are more valuable, and that other things being equal, there is an optimal time to offer a patent up for auction.

### 3. Data and summary statistics

A patent auction process is quite similar to the well known antique art of auctions. A number of patent auction formats and intermediaries exist, from bankruptcy proceedings designed to raise funds for paying off creditors, to live patent auctions of IPAuctions.com and IPB GmbH, to on-line auctions on Free Patent.com. The most recognized patent auctions are

those organized by Ocean Tomo, an intellectual capital merchant bank that held its first IP auction in April 2006, attracting over 400 professionals and transferring over $8 million including auction results and further transactions (Landers, 2006).

As a patent auction house, Ocean Tomo organizes multi-lot live auctions for intellectual property assets: the auction is conducted according to an ascending bid model (English Auction) and a contract for the sale of the patent is formed by the highest bid made above the seller's reserve and before the fall of the auctioneer's hammer (Landers, 2006). Such auctions enable sellers to offer one or more patents according to a predetermined set of terms and conditions and allowsthe auction house to charge listing fees, attendance fees, buyers' premiums and/or sellers' commissions (Millien, 2007).

Auction preparation is a formal and structured process. Each seller is requested to pre-qualify his patents releasing all relevant information about the IP that will be on sale, such as ownership status, validity, licensing activity, infringement, potential value and so on. Each bidder must meet registration requirements in order to access the auction information; bidders have also the option to leverage on private due diligence meetings with sellers prior and during the event. Ocean Tomo, actually, does not undertake any independent investigation of the information provided by the sellers, and the bidder must carry out any due diligence necessary to verify actual status and quality of patents offered for sale.

Our sample is composed by data on eight IP auctions organized and conducted by Ocean Tomo between April 2006 and October 2008. We restricted our attention only to patents, not considering other intellectual property transactions. However, the weight of copyrights, trademarks, domain names and other forms of IP is marginal on the whole asset stock on sale.

We considered 593 lots including 1716 patents. For each of them we gathered information from both the Ocean Tomo auction catalogue and from Delphion patent database.

The auction catalogue is a rich source of data on the seller, the invention, the main area of technology, the potential licensees and the lot expected price. All information on the lots

within the auction catalogue are released by the sellers: all expectations of values have been provided exclusively by the seller of each patent according to an Ocean Tomo's quality and valuation system, and can be considered the estimation of suitable future selling price made by the asset owner, according to his private information. We can find also data on whether and which lots were finally sold and on their final transaction price.

Our sample is composed of 8 auctions with on average 74 lots and 215 patents each. 64% of lots has a company or another organization as a seller, while a remaining 36% is offered for sale by individual or groups of inventors.

**Table 1 – Sample features**

| Auctions | Spring 2006 | Fall 2006 | Spring 2007 | Summer 2007 | Fall 2007 | Spring 2008 | Summer 2008 | Fall 2008 | Total |
|---|---|---|---|---|---|---|---|---|---|
| **Lots n°** | 77 | 72 | 67 | 47 | 77 | 86 | 63 | 104 | 593 |
| **Patents n°** | 423 | 258 | 174 | 223 | 146 | 208 | 105 | 179 | 1,716 |
| **Average Lot dimension** | 5.5 | 3.6 | 2.6 | 4.7 | 1.9 | 2.4 | 1.7 | 1.7 | 2.9 |
| **Sold Lots (%)** | 33.8% | 30.6% | 50.7% | 27.7% | 49.4% | 61.6% | 44.4% | 46.2% | 44.2% |
| **Company Seller (%)** | 59.7% | 69.4% | 70.1% | 76.6% | 57.1% | 54.7% | 60.3% | 69.2% | 64.1% |

The average dimension of the lots is 2.9 but this value has great variability. From 2006 the number of lots in auctions increased, while the lot dimension has dropped: the average lot dimension changed from 5.5 of the first edition to 1.7 of the last one.

Listed patents refer to a wide range of technological areas. We clustered together technology classes in homogenous groups: roughly 70% of lots are related to communications and computers-electronics technologies; another 20% is related to monitoring technologies, life science, chemicals and industrials-machinery; residual lots are fragmented in heterogeneous technological classes ranging from business methods and financial services applications to entertainment & gaming, from energy saving applications to printing technologies.

The distribution of patents among patent offices shows that most of sample's patents are US patents (97,4%) and only a small fraction are from WIPO, EPO or other national patent offices.

About 44% of our sample lots have been sold during auction processes: the maximum percentage of assets sold has been reached in the Spring 2008 edition where more than 60% of lots were sold, while in the Summer 2007 edition only 27% of lots succeeded in being acquired. Total auctions sales amount shows an increasing trend until the Spring 2008 edition from $3 million to $19 million. Revenues, however felt down to $12-13 million in the last two editions.

**Table 2 – Sold and Unsold Lots: dimension and seller type**

| | **Unsold** | **%** | **Sold** | **%** | **Total** | **%** |
|---|---|---|---|---|---|---|
| **Company lots n°** | 219 | *66.0%* | 161 | *61.4%* | **380** | ***64.0%*** |
| **%** | *57.6%* | | *42.4%* | | ***100.0%*** | |
| **Inventor lots n°** | 112 | *33.8%* | 101 | *38.5%* | **213** | ***35.9%*** |
| **%** | *52.6%* | | *47.4%* | | ***100.0%*** | |
| **Total lots n°** | **332** | ***100.0%*** | **262** | ***100.0%*** | **594** | ***100.0%*** |
| **%** | *55.8%* | | *44.2%* | | ***100.0%*** | |
| **Average Company lot dimension** | 4.11 | | 2.90 | | 3.60 | |
| **Average Inventor lot dimension** | 1.79 | | 1.46 | | 1.63 | |
| **Average lot dimension** | 3.3 | | 2.3 | | 2.9 | |

The number of lots sold increased as well, from 22 (33.8%) of the first edition to 48 (46.2%) of the last auction. On average 38.5% of sold assets have a private seller, while 61.5% are company owned lots: lots sold placed by single inventors are more concentrated among sold ones with respect to the overall distribution on seller type. Another interesting evidence is that the average lot dimension is smaller for sold lots: a lot with a higher number of patents appears to be more difficult to be sold.

Detailed patent data were drawn from Delphion patent database. Complete information was only available for 1708 patents. We gathered data on a wide range of variables that literature proved to be correlated with patent value (for a review: Harhoff et al., 2003): table 3 shows some descriptive statistics on patent variables.

**Table 3 - Descriptive statistics on patent variables**

| | Mean | Median | Standard deviation | Min | Max |
|---|---|---|---|---|---|
| **Claims** | 19.67 | 16.00 | 16.84 | 0.00 | 267.00 |
| **Ipc class (4-digit)** | 1.88 | 2.00 | 1.05 | 0.00 | 8.00 |
| **Family** | 5.41 | 4.00 | 3.96 | 0.00 | 32.00 |
| **Backward citation** | 20.76 | 11.00 | 34.72 | 0.00 | 256.00 |
| **Forward citation** | 14.85 | 6.00 | 27.98 | 0.00 | 406.00 |
| **Inventors** | 2.16 | 2.00 | 1.67 | 1.00 | 17.00 |
| **Assignee** | 1.052 | 1.00 | 0.27 | 1.00 | 4.00 |
| **Lot dimension** | 12.92 | 5.00 | 19.32 | 1.00 | 82.00 |

The focus of our study is patent value: for each lot we know the expected value (i.e. the expectations of values provided by the seller) and for sold lots we know the final transaction price too (i.e. the real value). The expected patent value distribution of the final sample has a mean value of $186.7 thousands and a median of $89.3 thousands (see Table 4). On the other hand, the distribution of patent price shows a mean value of $131.9 thousands and the median is about $77.4 thousands (both in 2006 prices). The right tail of both distributions includes high extreme values: the maximum patent value is respectively $3.07 million and $4.80 million.

**Table 4 – Patent expected vs real value**

| | Patent Expected Value (2006 US$) | Patent Price (2006 US$) |
|---|---|---|
| **Mean** | 186,680 | 131,920 |
| **Median** | 89,286 | 77,362 |
| **Standard Deviation** | 293,534 | 292,529 |
| **Max** | 3,075,740 | 4,799,559 |

This evidence is quite consistent whit the results provided by the literature on patent value. For example Schankerman and Pakes (1986) found that the distribution of patent value for patents issued in Germany, France and the UK in 1970 had mean values respectively of $19,124, $6,656 and $6,963 and median values respectively of $17,329, $847 and $1,861 (all in 1980 prices). Analyzing data on commercial transfer of US patent rights Serrano (2005) obtained the median value to be equal to $27,895 and the mean equal to $86,782 (2003 prices). Bessen (2007) estimates an average patent value of $376,000 for a sample of US firms for the period between

1969 and 2001 (1992 prices). Gambardella et al. (2008), based on a survey, estimated a mean of the patent value distribution higher than €3 million and the median as being almost €400 thousand.

Results on patent value based on patent auction data have the great advantage not to be influenced by estimation methods, but to represent the real market value of the patent asset, including its strategic component, systematically underestimated by renewal data.

Difference in the two distribution mean is quite significant (see table 5): in most of the cases (84,5%) seller expected value is larger than final transaction price: so usually patent owner valuation is overestimated in comparison to real value.

**Table 5 – T test on patent expected vs real value means**

| **T-test for difference between the means of PAT_EXP_VAL and PAT_FIN_PRICE** | | |
|---|---|---|
| Diff=Mean(PAT_EXP_VAL) - mean(PAT_FIN_PRICE)<br>Ho: Diff= 0 | | t = 3.9690 |
| **Ha: diff != 0** | Pr(\|T\| > \|t\|) = 0.0001 | |
| **Ha: diff > 0** | Pr(\|T\| > \|t\|) = 0.0000 | |
| **T-test for mean of PAT_VAL_GAP different from 0** | | |
| Mean=Mean(PAT_VAL_GAP)<br>Ho: Mean(PAT_VAL_GAP) = 0 | | t = 12.4255 |
| **Ha: Mean!= 0** | Pr(\|T\| > \|t\|) = 0.0000 | |
| **Ha: mean> 0** | Pr(\|T\| > \|t\|) = 0.0000 | |

In this perspective our intent is to compare seller and market valuation analyzing the gap between the expected and realized value of a patent.

## 4. The model

According to our objective to investigate the factors affecting valuation, we analyzed three different dependent variables: the patent expected value (PAT_EXP_VAL), the patent final

price (PAT_FIN_PRICE) and the gap between these two valuations (PAT_VAL_GAP); all of these variables are expressed in 2006 US$.

All patent on sale are listed in the official Ocean Tomo auction catalogues: for each of them the seller expected value is reported (apart from few missing values due to the catalogue publication timing). As data shows, not all patents are sold during the auction process: information on the transaction price is, therefore, available only for the sold fraction of the whole sample. We observe the value of the two dependent variables patent final price and patent valuation gap only for a restricted, nonrandom group. Sample selection is clearly part of the auction process, since not all patents are sold and sale is a systematically not casual event.

For this reason, we decided to analyze the impact of patent value determinants on sellers' expectation of value (PAT_EXP_VAL) for their own patents through an OLS regression model. On the other hand, and coherently with past literature (Sneed and Johnson, 2008), we applied a two step Heckman selection model to analyze patent final price (PAT_FIN_PRICE) and patent valuation gap (PAT_VAL_GAP).

The Heckman model is based on two latent variables $y_i^*$ and $d_i^*$. They depend on independent variables $x_i^*$ and $z_i^*$:

$$d_i^* = z_i\gamma + \nu_i \qquad (1)$$

$$y_i^* = x_i\beta + \varepsilon_i \qquad (2)$$

$$\text{with } (\nu_i, \varepsilon_i) \approx N.$$

$$d_i = 1 \quad \text{if} \quad d_i^* > 0; \quad d_i = 0 \text{ otherwise}$$

$$y_i^* = y_i \quad \text{if} \quad d_i = 1; \quad y_i^* = \text{n.a. otherwise}$$

The two latent variables cannot be observed. In a patent auction environment $d_i$ is a dummy variable (SOLD) that indicates if the patent has been sold or not (1=sold, 0=unsold): only in case of successful sale ($d_i$=1) we can see the final price of the patent itself ($y_i^* = y_i$). The first equation (1) explains the bidder decision to acquire or not and whether an observation is

included in the sample. The second equation (2) determines the patent final price (PAT_FIN_PRICE) or patent valuation gap (PAT_VAL_GAP).

The two step procedure draws on the conditional mean $E(y_i \mid x_i, z_i) = x_i\beta + \varrho\sigma_\varepsilon\lambda(z_i\ \gamma)$. In the first step, it uses an ordinary probit model to obtain consistent estimates of the parameters. In the second step, the value equation is estimated by OLS for the observations sold during the auction.

$\lambda$ provides the estimated coefficient on the inverse Mills ratio, so testing the null hypothesis that the coefficient on $\lambda$ is zero is equivalent to testing for sample selectivity.

In the models two primary classes of independent variables have been included: the first one measures invention characteristics, while the second one refers to technology features and accounts for seller characteristics.

The first class of variables is related to invention and takes account of several patent value indicators: table 6 provides a detailed description of each.

**Table 6 – Variables related to invention**

| ***Patent value indicators*** | |
|---|---|
| ***CLAIMS*** | N° of claims shown in patent document |
| **IPC_CLASS** | N° of IPC 4-digit technological class reported on patent document |
| **FAMILY** | N° of countries in which the patent protection is active |
| **BW_CIT** | N° of backward patent citation reported on patent document |
| **FW_CIT** | Average n° of forward citation per year received by the patent |
| **TTE** | N° of years of residual life for the patent |
| **INTERNAT** | Binary variable equal to 1 if the country of residence of the applicant is different from the one of the inventor, 0 otherwise |
| **MULTIPLE_INVENTOR** | Binary variable equal to 1 if the patent has more than one inventor, 0 otherwise |
| **MULTIPLE_ASSIGNEE** | Binary variable equal to 1 if the patent has more than one assignee, 0 otherwise |

Even though, till now, the literature cannot quantify the patent's latent value determinants and little empirical evidence on the interaction between indicators and determinants exists (Reitzig, 2004), a consistent work has been done on the assessment of patents by value indicators.

Past literature investigated a lot of variables as indicators of patent value (Reitzig, 2003): from the first and second value indicators (derived by patent first page data) to more recent third generation indicators (i.e. any indicators compiled from the patent full-text itself). Past empirical

evidence underlined that the number of claims, the number of family members and the number of IPCs classes are correlated with the private value of patents as a measure of patent breadth (see Lerner, 1994; Putnam, 1996; Tong and Frame, 1992; Lanjouw and Schankerman, 2004); literature has shown as well that the number of backward references, considered as an empirical measure of the patent technical novelty, appears a significant indicator of patent value itself (Carpenter et al.,1980; Lanjouw and Schankerman, 2004); furthermore, many authors pointed out that forward citations are a significant measure of patent quality and are related to its value: in particular those citations received in the first years of patent life imply a significant recognition of its technological importance (Hall, Jaffe and Trajtenberg, 2000); finally patent age, number of applicants, number of key inventors and number of trans-boarder research co-operations have a strong theoretical foundation too as patent value determinants (for a review Reitzig, 2004).

The second class includes several independent variables related to patent technology and to the seller, representing important factors for the potential buyer. TECH_TREND accounts for the development of technology field the patent is referred to and it is a measure of attractiveness of the technological class. It is measured by the composite average growth rate of US patent application filled in the IPC technological class (4 digit) of the considered patent in the last five years preceding the auction period (2000-2005). TECH_LOW is a split dummy for low level of technology growth (it has a value of 0 when TECH_TREND is lower than its percentile at 95%). Ocean Tomo itself, in order to standardize catalogues information, makes a classification of lots according to technology domains: we clustered together technology domains in six macro-homogenous areas and insert a dummy for each of them (TECH_AREA 1-6)[39]. A dummy variable to consider the auction year has been included as well (YEAR 06-08). Since sellers can be individuals or firms, we introduced a dummy variable, SELLER_TYPE, equal to 1 when the seller is a company, a university, or another research organization; it is 0 when the seller is a private inventor. Sometimes the seller includes some copyrights, trademarks, domain names

[39] TECH_AREA dummy variables are related to following technology domains: 1 - Life science-chemicals; 2 - Industrials-machinery; 3 - Computers and electronics; 4 – Communications; 5 - Monitoring technology; 6 – Others.

or pending patent application to its main patents listed on the auction catalogue: RELATED_IP is a dummy variable accounting for the simultaneous presence in the lot of other forms of IP in addition to core patents on sale. LOT_DIMENSION indicates, instead, the number of patent included in each lot.

Finally, for the sub-sample of patents put on sale by companies and other organizations we collected information on seller patent portfolio. First we considered the importance of patents put on sale for the seller; the variable SELLER_STRATEGY represents the weight of patents on sale on the overall seller's portfolio: it is expressed as the ratio between firms' patents listed in the auction catalogue put on sale and the whole US patent portfolio collected by the seller within twenty years at the time of the first auction. The higher is this ratio, the more the seller's commitment for the auction results will increase. The distribution of SELLER_STRATEGY is bimodal and indicates that most of the companies are concentrated on the two opposite sides of distribution in the classes with SELLER_STRATEGY below 10% (31% of sellers) and over 90% (33,9% of sellers). This evidence points out the existence of two large categories of sellers: the first one accounts for those sellers putting on sale a marginal portion of their own portfolio, (probably minor patents over a larger patent stock); the second one instead includes sellers putting on sale most of their portfolio or in extreme cases all the patents they owns and these sellers are usually small firms trying to monetize their technological knowledge.

Finally, we considered how the seller is involved in related technological knowledge of each patent on sale (Ziedonis, 2002) and the role of the specific technology in his overall portfolio. The variable SELLER_EXPERTISE is used to measure the degree of the seller's technological knowledge and it is defined as the ratio between the sum of firms' US patents applied for within twenty years at the time of the first auction that are in the same IPC (4-digit) class of the patent on sale and the whole US patent portfolio collected by the seller in the same period. Sometimes it is possible that the seller of a patent is different from the legal assignee of the patents rights: according to Ocean Tomo this inconsistency can occur for several reasons.

Sometimes a security interest is at stake or there is some type of encumbrance placed on the assets by a third party: In these cases the merchant bank usually tries to resolve the issues in the pre-auction period; often, however, it happens that a transfer has not been yet recorded by the patent offices or reported in the patent databases. So, if the seller and the assignee were different in our data, we considered all patent listed in the auction catalogue as already owned by the seller and summed them to his portfolio. The distribution of this variable shows similar features for the SELLER_STRATEGY's one. In the same way most of the sellers have SELLER_EXPERTISE below 10% (18,5% of sellers) or over 90% (33,3% of sellers). This indicates the existence of two types of assignee according to their technological knowledge: the first one has a diversified portfolio while the second one has a patenting activity strongly concentrated on few specific technological domains.

## 5. Results

First of all we analyzed sellers' expectation of value (PAT_EXP_VAL) for their own patents through an OLS regression model and then, for the patent final price (PAT_FIN_PRICE) and the patent valuation gap (PAT_VAL_GAP), a two step Heckman selection model has been applied.

Each model has been implemented on the whole sample and on the sub-sample in which the sellers are companies or universities or other juridical institutions.

**Table 7 – OLS regression on PAT_EXP_VAL**

| **Dep Variable Log(PAT_EXP_VAL)** | **Overall sample** | **Sub sample SELLER_TYPE=1** | |
|---|---|---|---|
| ***CONST*** | 9.799 *** | 9.371 *** | 9.493 *** |
| | (0.000) | (0.000) | (0.000) |
| ***Log CLAIMS*** | .006 | -.072 | -.083 * |
| | (0.888) | (0.107) | (0.065) |
| **Log IPC_CLASS** | .0544 | .170 | .108 |
| | (0.575) | (0.107) | (0.300) |
| **Log FAMILY** | .181 *** | .124 ** | .135 ** |
| | (0.000) | (0.020) | (0.011) |
| **Log BW_CIT** | .191*** | .166 *** | .165 *** |
| | (0.000) | (0.000) | (0.000) |

| | | | |
|---|---|---|---|
| **Log FW_CIT** | .271 *** | .245 *** | .252 *** |
| | (0.000) | (0.000) | (0.000) |
| **Log TTE** | .129 * | .179 ** | .174 ** |
| | (0.073) | (0.014) | (0.017) |
| **INTERNAT** | .140 | -.062 | -.085 |
| | (0.103) | (0.548) | (0.406) |
| **MULTIPLE_INVENTOR** | .017 | .108 | .124 * |
| | (0.788) | (0.103) | (0.063) |
| **MULTIPLE_ASSIGNEE** | .608 *** | .922 *** | .883 *** |
| | (0.000) | (0.000) | (0.000) |
| **RELATED_IP** | .034 | -.047 | -.042 |
| | (0.671) | (0.605) | (0.643) |
| **Log LOT_DIMENSION** | -.344 *** | -.335 *** | -.342 *** |
| | (0.000) | (0.000) | (0.000) |
| **SELLER_EXPERTISE** | | .398 *** | |
| | | (0.000) | |
| **SELLER_STRATEGY** | | | .377 *** |
| | | | (0.000) |
| **TECH_TREND** | .321 | .728 ** | .719 ** |
| | (0.238) | (0.016) | (0.017) |
| **TECH_AREA_1** | .436 ** | .570 ** | .599 *** |
| | (0.002) | (0.002) | (0.001) |
| **TECH_AREA_2** | 1.052 *** | 1.262 *** | 1.250 *** |
| | (0.000) | (0.000) | (0.000) |
| **TECH_AREA_3** | .411*** | .636 *** | .682 *** |
| | (0.001) | (0.000) | (0.000) |
| **TECH_AREA_4** | .978*** | 1.215 *** | 1.225 *** |
| | (0.000) | (0.000) | (0.000) |
| **TECH_AREA_6** | .346 ** | .481 | .496 ** |
| | (0.030) | (0.017) | (0.014) |
| **YEAR_07** | -. 057 | -.129 | -.143 |
| | (0.515) | (0.172) | (0.130) |
| **YEAR_08** | .103 | -.016 | -.023 |
| | (0.301) | (0.885) | (0.835) |
| **R-squared** | 0.2439 | 0.2914 | 0.2914 |

P-values based on robust standard errors in parentheses.* p < 10%; ** p < 5%; *** p< 1%.

Table 7 shows the results of the OLS model where the dependent variable (PAT_EXP_VAL) is expressed in logarithms.

Considering the variables related to invention, results outline that, coherently with the past literature, citations have a positive and significant impact on the perceived value: seller increases his valuation with the number of backward citations (BW_CIT) included in the patent because it implies less uncertainty on the underlying technology (Ziedonis, 2002) and with the number of forward citations (FW_CIT), because it means higher patent quality and a significant recognition of the technological importance of the invention. Patent scope expressed by the

FAMILY indicator has a positive and significant impact too: geographical extension is expensive and clearly seller discounts this factor in his value expectation; the other scope measures, CLAIMS and IPC_CLASS, are instead not significant. Time to expiration (TTE) also positively affects PAT_EXP_VAL since the longer is the residual patent life , the more the invention can be useful for commercial exploitation. The presence of R&D agreements with multiple assignees (MULTIPLE_ASSIGNEE) and the fact of the presence of an international background for the invention (INTERNAT) is also positively evaluated by the seller.

Considering, instead, technology and seller related variables we can see that the seller does not increase his expected value if some RELATED_IP is sold with the core patents, while the LOT_DIMENSION has a significant and negative impact on the seller's expected value: this result is quite outstanding and it can be explained by the fact that if the number of patents included in the same lot increases, the upper bound of the single patent value decreases even if the whole value of the lot grows. Reasonably, each seller has the propensity to positively evaluate his technological expertise and so the SELLER_EXPERTISE variable positively affects patent valuation. The variable SELLER_STRATEGY has a positive impact too: if its value grows, it means that the seller is putting on sale a substantial portion of his portfolio and his concern for the auction results increases, so the value expectation increases as well. Technology dummies are always significant and considering the sub-sample of companies, results point out that the seller positively appraises the TECH_TREND since the more the technology underlying the patent is growing fast, the more value expectation can be realistically high. The statistical significance of the TECH_AREA dummies underlines that the seller's expected values change according to the technology field.

**Table 8 – Two Step Heckman model PAT_FIN_PRICE**

| **Dep Variable *Log(PAT_FIN_PRICE)*** | **Overall sample** | | **Sub sample SELLER_TYPE=1** | | | |
|---|---|---|---|---|---|---|
| | **Selection Eq** | **Value Eq** | **Selection Eq** | **Value Eq** | **Selection Eq** | **Value Eq** |
| ***CONST*** | -.605 * | 9.13 *** | -.634 * | 8.809 *** | -.634 * | 9.001 *** |
| | (0.074) | (0.000) | (0.102) | (0.000) | (0.102) | (0.000) |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Log LOT_ DIMENSION*** | -.070 ** | -.560 *** | -.048 | -.563 *** | -.048 | -.610 *** |
| | (0.030) | (0.000) | (0.177) | (0.000) | (0.177) | (0.000) |
| ***Log CLAIMS*** | -.028 | .096 | .006 | -.025 | .006 | -.023 |
| | (0.541) | (0.215) | (0.915) | (0.764) | (0.915) | (0.783) |
| **Log IPC_CLASS** | .004 | .130 | -.012 | .425 ** | -.012 | .362 * |
| | (0.970) | (0.479) | (0.925) | (0.023) | (0.925) | (0.053) |
| **Log FAMILY** | .009 | .076 | -.029 | -.027 | -.029 | .000 |
| | (0.882) | (0.468) | (0.653) | (0.778) | (0.653) | (0.997) |
| **Log BW_CIT** | .140 *** | .094 | .178 *** | .148 ** | .178 *** | .157 ** |
| | (0.000) | (0.127) | (0.000) | (0.022) | (0.000) | (0.016) |
| **Log FW_CIT** | .096 * | .571 *** | -.008 | .584 *** | -.008 | .586 *** |
| | (0.099) | (0.000) | (0.912) | (0.000) | (0.912) | (0.000) |
| **Log TTE** | -.326 *** | .888 *** | -.302 *** | .849 *** | -.302 *** | .830 *** |
| | (0.000) | (0.000) | (0.001) | (0.000) | (0.001) | (0.000) |
| **INTERNAT** | | 1.150 *** | | 1.39 *** | | 1.384 *** |
| | | (0.000) | | (0.000) | | (0.000) |
| **MULTIPLE_ INVENTOR** | | .257 ** | | .230 * | | .271 ** |
| | | (0.017) | | (0.056) | | (0.027) |
| **MULTIPLE_ ASSIGNEE** | | .660 *** | | .636 * | | .595 * |
| | | (0.007) | | (0.056) | | (0.075) |
| **TECH_TREND** | | -1.120 ** | | -1.493 *** | | -1.492 |
| | | (0.021) | | (0.007) | | (0.007) |
| **RELATED_IP** | | .814 *** | | 1.106 *** | | 1.101 *** |
| | | (0.000) | | (0.000) | | (0.000) |
| **SELLER_ EXPERTISE** | | | | .562 *** | | |
| | | | | (0.004) | | |
| **SELLER_ STRATEGY** | | | | | | .320 * |
| | | | | | | (0.057) |
| **ASSIGNEE_TYPE** | -.089 | | - | | - | |
| | (0.316) | | | | | |
| **TECH_LOW** | -.334 * | | -.468 ** | | -.468 ** | |
| | (0.071) | | (0.031) | | (0.031) | |
| **TECH_AREA_1** | -.065 | | -.307 | | -.307 | |
| | (0.729) | | (0.193) | | (0.193) | |
| **TECH_AREA_2** | .984 *** | | .890 *** | | .890 *** | |
| | (0.000) | | (0.000) | | (0.000) | |
| **TECH_AREA_3** | .530 *** | | .347 * | | .347 * | |
| | (0.001) | | (0.086) | | (0.086) | |
| **TECH_AREA_4** | .946 *** | | .888 *** | | .888 *** | |
| | (0.001) | | (0.000) | | (0.000) | |
| **TECH_AREA_6** | .087 | | -.246 | | -.246 | |
| | (0.650) | | (0.337) | | (0.337) | |
| **YEAR_07** | .904 *** | | .954 *** | | .954 *** | |
| | (0.000) | | (0.000) | | (0.000) | |
| **YEAR_08** | .537*** | | .503 *** | | .503 *** | |
| | (0.000) | | (0.000) | | (0.000) | |
| **Wald chi2** | 462.56 *** | | 534.43 *** | | 521.68 *** | |
| | (0.000) | | (0.000) | | (0.000 | |
| **Mills-lambda** | -1.38 *** | | -.870 *** | | -.897 *** | |
| | (0.000) | | (0.000) | | (0.000) | |

P-values based on robust standard errors in parentheses.* p < 10%; ** p < 5%; *** p< 1%.

Table 8 shows the results of the Heckman model where PAT_FIN_PRICE is the dependent variable. The model includes all relevant variables in the value equation, while only the main variables related to invention and technology features and some dummies were considered in the selection equation: we considered the most relevant seller's characteristics as value determinant. As for PAT_EXP_VAL, citations, scope and time to expiration (BW_CIT; FW_CIT, IPC_CLASS; TTE), have a positive impact on patent price, confirming again the results of previous literature: quality and residual patent life can drive the value of a patent up once the patent is sold. The variables BW_CIT, FW_CIT and TTE have also a significant impact on selection: citations favor the probability to be sold, while residual patent life decreases the likelihood of selection, reasonably because if a patent is too young it has a higher potential value but also a higher risk and uncertainty.

Results show that, considering the whole sample, the presence of R&D agreements with multiple assignee/inventors and the fact that the invention has an international background (MULTIPLE_ASSIGNEE, MULTIPLE_INVENTOR, INTERNAT) is also positively evaluated by bidders and increases the final patent price.

Considering the other group of variables, it emerges that LOT_DIMENSION has a negative and significant impact on the final patent price and, considering the whole sample, it has an effect also on the probability that the patent will be sold: this outcome is consistent also with the previous literature (Sneed and Johnson 2008). Unlike the case of PAT_EXP_VAL, the bidders positively evaluate the presence of other IPR's (RELATED IP) bundled with the patents on sale: purchasing also correlated applications, domain names, and other IPR's can favor a deeper exploitation of the core invention. Considering only the subsample in which the sellers are companies or other organizations, we can see that both SELLER_EXPERTISE and SELLER_STRATEGY show a positive and significant impact on PAT_FIN_PRICE. The more the patent seller is involved in the technology field the patent refers to, the more he is credible and his invention valuable and the more the market positively evaluates his expertise in the

technology. In the same way, if the variable SELLER_STRATEGY increases, it means that the seller is putting on sale a consistent part of his patent portfolio, his commitment for the auction increases and the bidder positively evaluates his concern. The variable TECH_TREND has a negative impact on the selling price: if the technology is instable, uncertainty increases and this could reduce patent value in a fast changing technology background. However, the significance of the TECH_LOW dummy indicates that if the technology has a small growth rate, its selling likelihood decreases. Finally, results underline that also the technology domains and time dummies ($TECH\_AREA_i$ and $YEAR_i$) are significant for the selection process.

**Table 9 – Two Step Heckman model PAT_VAL_GAP**

| **Dep Variable** ***Log (PAT_VAL_GAP)*** | **Overall sample** | | **Sub sample SELLER_TYPE=1** | | | |
|---|---|---|---|---|---|---|
| | **Selection Eq** | **Value Eq** | **Selection Eq** | **Value Eq** | **Selection Eq** | **Value Eq** |
| ***CONST*** | .041<br>(0.907) | 10.168 ***<br>(0.000) | .162<br>(0.693) | 10.370 ***<br>(0.000) | .162<br>(0.693) | 10.671 ***<br>(0.000) |
| ***Log LOT_*** **DIMENSION** | -.292 ***<br>(0.000) | .103<br>(0.321) | -.277 ***<br>(0.000) | -.066<br>(0.534) | -.277 ***<br>(0.000) | -.096<br>(0.341) |
| ***Log CLAIMS*** | .002<br>(0.968) | -.101<br>(0.324) | .048<br>(0.405) | -.278 **<br>(0.012) | .048<br>(0.405) | -.339 ***<br>(0.002) |
| **Log IPC_CLASS** | .011<br>(0.920) | .109<br>(0.659) | -.022<br>(0.868) | .245<br>(0.331) | -.022<br>(0.868) | .173<br>(0.479) |
| **Log FAMILY** | -.122 **<br>(0.043) | .491 ***<br>(0.000) | -.163 **<br>(0.017) | .419 ***<br>(0.002) | -.163 **<br>(0.017) | .455 ***<br>(0.001) |
| **Log BW_CIT** | .036<br>(0.356) | .323 ***<br>(0.000) | .067<br>(0.137) | .269 ***<br>(0.005) | .067<br>(0.137) | .286 ***<br>(0.002) |
| **Log FW_CIT** | 0.100 *<br>(0.096) | .363 ***<br>(0.003) | -.0141<br>(0.851) | .201<br>(0.132) | -.0141<br>(0.851) | .154<br>(0.237) |
| **Log TTE** | -.313 ***<br>(0.000) | .252<br>(0.195) | -.287 ***<br>(0.002) | .087<br>(0.647) | -.287 ***<br>(0.002) | -.004<br>(0.979) |
| **INTERNAT** | | .525 ***<br>(0.007) | | .138<br>(0.546) | | .116<br>(0.603) |
| **MULTIPLE_** **INVENTOR** | | .375 **<br>(0.012) | | .381 **<br>(0.018) | | .482 ***<br>(0.002) |
| **MULTIPLE_** **ASSIGNEE** | | .571 *<br>(0.0842) | | .879 **<br>(0.034) | | .783 *<br>(0.055) |
| **TECH_TREND** | | -.504<br>(0.445) | | .363<br>(0.605) | | .219<br>(0.6752) |
| **RELATED_IP** | | -.438 **<br>(0.014) | | -.343 *<br>(0.080) | | -.429 **<br>(0.024) |
| **SELLER_** **EXPERTISE** | - | - | | .358<br>(0.134) | | |
| **SELLER_** **STRATEGY** | - | - | | - | | .799 ***<br>(0.000) |
| **ASSIGNEE_TYPE** | .008<br>(0.925) | | - | - | - | - |

| | | | |
|---|---|---|---|
| **TECH_LOW** | -.367 *<br>(0.053) | -.554 **<br>(0.013) | -.554 **<br>(0.013) |
| **TECH_AREA_1** | .123<br>(0.525) | -.057<br>(0.813) | -.057<br>(0.813) |
| **TECH_AREA_2** | 1.14 ***<br>(0.000) | 1.062 ***<br>(0.000) | 1.062 ***<br>(0.000) |
| **TECH_AREA_3** | .571 ***<br>(0.000) | .430 ***<br>(0.000) | .430 ***<br>(0.000) |
| **TECH_AREA_4** | .813 ***<br>(0.000) | .763 ***<br>(0.000) | .763 ***<br>(0.000) |
| **TECH_AREA_6** | .046<br>(0.817) | -.240<br>(0.364) | -.240<br>(0.364) |
| **YEAR_07** | .533 ***<br>(0.000) | .540 ***<br>(0.000) | .540 ***<br>(0.000) |
| **YEAR_08** | .439 ***<br>(0.000) | .399 ***<br>(0.000) | .399 ***<br>(0.000) |
| **Wald chi2** | 137.66 ***<br>(0.000) | 107.25 ***<br>(0.000) | ***<br>(0.000 |
| **Mills-lambda** | -1.29 ***<br>(0.000) | -.877 ***<br>(0.008) | ***<br>(0.000) |

P-values based on robust standard errors in parentheses.* p < 10%; ** p < 5%; *** p< 1%.

Finally, table 9 presents the Heckman model on log (PAT_VAL_GAP) and following results. It is confirmed the role of LOT_DIMENSION and time to expiration (TTE) in the selection process and the significance of the technology domain and the time dummies for the likelihood of a patent to be sold. LOT_DIMENSION has no impact on the gap between the seller's expected value and the final auction price: sellers and bidders consider the lot dimension in the same way. Backward citations (BW_CIT) have always a positive and significant impact on the PAT_VAL_GAP: backward citations can be considered a measures of scope (Reitzg, 2004) and if the scope increases, valuation is more complex and the valuation gap increases as well. FAMILY, instead has a negative impact on the selection since a large geographical scope means higher maintenance costs, but it positively affects PAT_VAL_GAP since a larger scope indicates also an higher difficulty in the valuation process and can be considered in a different way by the seller and the bidder. The same reasoning applies to the variable CLAIMS. Also the presence of multiple assignees (MULTIPLE_ASSIGNEE) and inventors (MULTIPLE_INVENTOR) and the presence of an international invention (INTERNAT) increases the gap between the two valuations. As a final point, while SELLER EXPERTISE seems not to affect valuations

divergence since it is considered in the same way by sellers and bidders, SELLER_STRATEGY amplifies the gap. If strategy raises, the seller is putting on sale a higher part of his portfolio up to the extreme case in which his whole patent portfolio is listed in the auction catalogue: in this case the seller is highly involved in the auction process and his valuation discounts this factor.

## 6. Concluding remarks

In this paper we have used an original dataset based on patent auctions held until the end of 2008 by a major IP merchant bank to investigate the impact of patent determinants on patent value. Previous studies have inferred the value of patents through proxy variables, ranging from weather a patent is litigated or opposed (Harhoff et al. 2003, Allison et al. 2004, Lanjouw and Schankerman, 2004), the number of jurisdictions in which a patent is protected (Putnam, 1996), the observed decision to sell (re-assign) patents (Serrano, 2005), whether the patent is renewed (Lanjouw and Schankerman, 2004; Harhoff et al., 2003), survey measures of subjective patent value (Harhoff et al., 1999) and firm market value (Hall at al. 1995). In this paper we depart from this literature and from the literature on patent auctions (Sneed and Johnson, 2009) by combining two new measures of patent value: the value expectation of the seller, as well as the final selling price of the patent. We then assess what are the main factors affecting differences between seller and market valuation of patents.

In particular, among the findings it comes out that both sellers and bidders positively evaluate patent scope, technological relevance of an invention and time to expiration. The attractiveness of the technological class, in terms of dynamicity of filed patents, is instead positively considered by the seller but not by the bidder. Seller's technological knowledge and commitment have always a significant impact on both sellers' expected value and on the final auction price.

Considering the probability of a successful sale, patent quality always positively affects the selling likelihood, while residual patent life and lot dimension have a negative impact on selection.

Finally, results pointed out that the difference between seller's patent expected value and the final transaction price is significantly correlated with patent scope and with the weight of patents on sale on his overall patent portfolio.

The fast diffusion of the market for IP occurred and the current development of financial solutions created in recent years a wider awareness of intellectual property value and of the possibility to get finance leveraging on IPRs.

IP and patent auctions are one of the IP-backed financial solutions available: for patent holders they represent an alternative mean for monetizing their patent assets, particularly when aggressive licensing strategies are neither feasible nor desired.

Furthermore, give the fact that the lack of a standard practice for patent value appraisal is a critical issue for the development of market for intellectual property financing, a fully functioning patent auction marketplace should help to establish more optimal and predictable prices. Its price-establishing function could have impacts well beyond patent sale transactions, such as by facilitating the use of patents in lending, investing and insurance transactions.

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