NBER WORKING PAPER SERIES

THE DYNAMICS OF THE TRANSFER AND RENEWAL OF PATENTS

Carlos J. Serrano

Working Paper 13938
http://www.nber.org/papers/w13938

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2008

I am very grateful to Thomas Holmes and Sam Kortum for their advice and patience. I would also like to thank Victor Aguirregabiria, Tom Astebro, Ian Cockburn, Nicolas Figueroa, Suqin Ge, Hugo Hopenhayn, Ig Horstmann, Chris Laincz, Matt Mitchell, Jennifer O'Reilly, Andy Skrzypacz, Rosemarie Ziedonis, and especially the editor and two referees for their very helpful comments and suggestions which significantly improved the paper. I acknowledge financial support from the Bank of Spain Graduate Fellowship, the Federal Reserve Bank of Minneapolis and the Connaught Start-Up award of the University of Toronto. Comments welcome to: carlos.serrano@utoronto.ca. First draft: April, 2004. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

The Dynamics of the Transfer and Renewal of Patents
Carlos J. Serrano
NBER Working Paper No. 13938
April 2008
JEL No. L1,O3

ABSTRACT

This paper explores the dynamics of the transfer of U.S. patents and the significance of the initial missallocation of patent property rights. Here we find that the initial missallocation of patent property rights is large and differs substantially across patentees and technology fields. We also find that the probability of a patent being traded depends on a number of factors - the age of the patent, the number of citations received by a given age, the patent generality and whether the patent has been previously traded or not. We will also analyze and interpret this new evidence using a theoretical model of patent transfers and renewal.

Carlos J. Serrano
Department of Economics
University of Toronto
150 St. George Street
Toronto, Ontario M5S 3G7
CANADA
and NBER
carlos.serrano@utoronto.ca

1 Introduction

An often discussed source of innovation for a national economy is the development of a market for technology. A well developed market permits the diffusion of existing innovations and allows firms to specialize in what they excel in. The benefits of diffusion and specialization could be substantial, potentially offsetting concerns about inefficiencies associated with the patent system such as the grant of monopoly rights. Previous work has recognized that an initial patent holder, a patentee, can find it advantageous to license a patent to another firm, maybe to a firm with a comparative advantage in the development and commercialization process (Arora [8]; Gans and Stern [17]; Arora, Fosfuri and Gambardella [9], etc.). A lesser known fact is that ownership of a patent can be transferred and that when there are potential gains from trade acquiring a patent rather than obtaining a license can pose some benefits.[1] Namely, to the extent that patent ownership offers a higher degree of residual control rights than a license does, transferring an initially missallocated patent to an alternative owner can reduce potential hold up problems especially when innovation is cumulative and the investments of the alternative owner are specific (Grossman and Hart [25]).[2]

The fact that a significant proportion of patents are being transferred illustrates that the benefits of this market are considerable. This evidence also suggests that patent property rights can be initially missallocated[3] and that residual control rights play an important role in the market for patents. Recognizing a role for residual control rights in this market is important because economic policy choices like patent enforceability and scope, which in effect determine the residual control rights of a patent owner, should have a direct impact on the functioning of this market. Furthermore, it is also likely that the impact of patent policy will be larger for those patentees and technology fields where the level of missallocation of property rights is significant, as well as for inventions where there are multiple cummulative uses and where the missallocation of property rights are likely

[1] The main difference between the licensing and the transfer of patents is that while the former constitutes a permission of use or a promise by the licensor not to sue the licensee, the latter involves the transfer by a party of its right, title, and interest in a patent.

[2] In a more general context, when innovation is cumulative it matters who owns the intellectual property rights because the incentives for subsequent inventors might be affected by the willingness to license or sell the patents when innovating around them is difficult (Merges and Nelson [40], Scotchmer [49], Gallini [19], Green and Scotchmer [22]).

[3] Property rights are missallocated when an alternative owner with higher patent value than the the current one and efficiency dictates that the patent should be reallocated to the alternative owner. For instance, property rights can be initially missallocated when there exist opportunities for specialization and innovators find it advantageous to sell their patent; or because innovators unexpectively obtain inventions that others have a higher value. The data, however, does not allow us to distinguish between these two sources of missallocation.

to be persistent over the life cycle of a patent. As a result, we expect that the design of patent policy not only faciliates the reallocation of existing patent property rights, but also potentially affects the direction of technological change towards some technology fields and patentees.

To assess these important economic implications, this paper analyzes how significant the missallocation of patent property rights are, whether there are any differences across patentees and technology fields, and what patent characteristics might be systematic determinants of the transfer and renewal of patents over their life cycle.

As we previously discussed, when a patent property right is missallocated, the patentee can find it beneficial to reallocate the patent to another firm. We have found that the United States Patent Trademark Office (USPTO) registers these transactions, so called assignments, in the Patent Assignments Database. We have obtained these records, converted them to the patent level, and merged them to existing data on the renewal status of patents as well as the number of patent citations received, technology field (i.e., the patent category), the generality of a patent, and the type of patentees (Hall, Jaffe, and Tratjenberg [26]).[4] The new data set contains all U.S. patents granted from 1983 to 2001 and describes the history of transfers and renewal decisions. The assignment data is particularly useful for empirical work because when a U.S. patent is sold the buyer might record the transaction at the USPTO. An assignment contains the patent numbers being transferred as well as information concerning the rational of the transfer allowing us to identify changes in the patents ownership.

By analyzing the changes in the patents ownership, we show that a large proportion of patents are traded at least once over their life cycle, and that the citations weighted fraction is even higher. If we look at reallocation patterns by patentees and technology fields, we find systematic evidence suggesting that the economic returns from patent trading and the gains from specialization differ across patentees and technology fields. In particular, we find that individual private inventors and small innovators are the most active sellers and that computer and communications as well as the drug and medical industries are the technology fields with the highest rates of transfer.[5] This evidence will also help us learn something about where patent trading and specialization in research is likely to be more important.

[4] There exist a very extensive empirical body of work in economics using patent data. Schmookler [47], Scherer [48], Griliches [24], Pakes and Schankerman [42] [46], Pakes [41], Tratjenberg [54], Harhoff, Narin, Scherer and Vopel [27], etc.

[5] Small innovator patents are those that are issued to firms that were granted no more than 5 patents in a given year. Similarly, large innovator patents are those issued to firms that were granted more than 100 patents in a given year.

The panel structure of the new data allows us to observe a number of patterns about the dynamics of the transfer and renewal of patents. First, we show that among patents of the same age, the probability of being traded and the probability of being renewed increases with the number of total citations received by a given age. Secondly, the probability of being traded and the probability of being renewed increases with patent generality. Third, previously traded patents, and especially the recently traded, are more likely to be retraded and less likely to be allowed to expire than the previously untraded ones. Finally, the probability of an active patent being traded decreases with age with one exception - in the year immediately following each renewal date the probability discontinuously increases. These patterns provide some information concerning whether the missallocation of property rights are likely to persist over the life cycle of a patent as well as some guidance in the assessment of models of intellectual property transfer.

In addition, our work on the assignment data opens up new avenues of research such as analyzing whether small firms specialize in the creation of innovations that are sold eventually to their larger counterparts. The patterns of the transfer and renewal of patents can be used to estimate the gains from trade in the market for patents (Serrano [50]). This new data can also be useful in examining to what extent the move towards higher protection of intellectual property rights that occurred in the mid 1980s facilitated specialization and consequently trade in patents. Furthermore, matching the transfer data with the characteristics of the buyers and sellers of patents permits both the estimation of returns to R&D through the market for patents and explores whether patent property rights tend to be transferred at the local geographical level as spillovers are. Finally, the data of individual owners allows scholars to assess the effects intellectual property taxation in promoting innovation and reallocation of patents. Heretofore these questions have not been previously addressed empirically due to a lack of data on how patents are traded.

To understand the empirical regularities in the data, we have used an extension of the patent renewal model of Pakes and Schankerman [42] [46] developed by Serrano [50]. The framework in Pakes and Schankerman relies on heterogeneity in the economic value of inventions and a fixed cost that owners must pay to keep a patent active. Our model allows for the transfer of patents and adds two key features. First, it considers that some firms garner greater benefits than others in the use of a given patent, which in effect implies that there may exist potential gains from reallocating patents to other firms. For instance, potential buyers might have complementary assets, prospective investments, better production facilities or managerial skills. Second, it assumes that adopting a technology developed by others involves a resource cost. This cost might represent a new organizational design by the acquiring firm, the hiring of new engineers, new R&D expenditures, etc. In summary, whereas Pakes and Schankerman's model has one margin, i.e., whether the patent owner should pay the fee for renewing the patent or not, our model has a second margin which illustrates whether the cost of technology adoption should be covered to reallocate the patent to an alternative owner.

The previous empirical work on markets for technology has mainly investigated either strategic alliances or technology licensing by universities.[6] The main disadvantage of using data from strategic alliances is that the specific technology in the transactions cannot be linked systematically to specific technologies or patent data and that most licensing agreements are not publicly reported.[7] The latter approach uses more detailed data on the technology being transferred but the generality of the studies is limited to specific universities, geographical areas, etc. As a result, the previous literature has been hampered by a lack of systematic data on what type of technology is likely to be transferred, who are the most active sellers, what are the most transfer-intensive technology fields, and what characteristics are determinants of the transfer and licensing of patents.

Despite the rich information provided by patent assignments, there is very little work using these records. To the best of our knowledge, Lamoreaux and Sokoloff [34][35] and this paper are the only ones that explore this concept to study markets for technology. Lamoreaux and Sokoloff use a sample of patents sales of private inventors and provide a historical account of whether organized markets for technology existed in the late 19$^{\text{th}}$ and early 20$^{\text{th}}$ century.[8]

This paper is organized as follows. Section 2 presents the model and describes some of its predictions as it is useful to initially present an organizing framework for understanding some of the empirical regularities that we will develop later. Section 3 explains the characteristics of the new data, and section 4 documents the patterns. Section 5 concludes the paper. Finally, the appendix covers the details of the construction of the data.

---

[6] Studies using data on strategic alliances are Arora [8]; Lerner and Merges [36]; Anand and Khanna [4]; Arora, Fosfuri and Gambardella [9]; etc. Some studies using data on licensing by universities are: Agrawal and Henderson [3], Branstetter and Ogura [13], Jaffe [29], Jaffe, Tratjenberg and Henderson [30], Jaffe and Tratjenberg [31], Sampat and Ziedonis [45].

[7] One notable exception in which strategic alliances are linked to patent number is Gans, Hsu, and Stern [18]. They focus on a small sample of licensing agreements of biotechnology companies.

[8] Our paper also relates to the industrial organization literature on business transfers and exit, mergers, and reallocation. In particular, Evans [16]; Dunne, Roberts, and Samuelson [15]; Lichtenberg and Siegel [37]; Pakes and Ericson [44]; Holmes and Schmitz [28]; Mitchell and Mulherin [39]; Andrade and Stafford [5]; Graff, Rausser and Small [21]; Maksimovic and Phillips [38]; Jovanovic and Rousseau [32].

2 A Model of patent transfers and renewals

This section presents a model detailing the transfer and renewal of patents.[9] We will consider the decision problem faced by an agent who holds a patent and we will also obtain a number of predictions concerning both the probability of a patent being traded and its expiring.

The problem for the agent is to decide whether to keep, sell, or let the patent expire. Pakes and Schankerman [42] [46] examines the problem of a patent owner deciding in each period of whether or not to pay a renewal fee in a context with heterogeneity in the economic value of inventions. Building on their framework, we will consider that patents may be traded because some firms can generate higher revenue than others using a given patent, but transfering a patent and adopting the technology involves a fixed cost to be incurred by the buyer.[10]

Some potential buyers can generate higher patent revenue than a current patent owner because they might have better production facilities and managerial skills as well as complementary assets. We consider that the best potential buyer of a patent with current revenue x is characterized by an improvement factor $g^e \geq 0$ that generates revenue $y = g^e x$. We also assume that the sharing rule of the gains from trade is efficient and that the current owner obtains all the surplus. This seller-takes-all the surplus will be useful for our analysis, but allowing the buyer to capture some positive surplus as long as the sharing rule is efficient will not alter our qualitative results.

Let $V_a(x, g^e)$ be the expected discounted value of patent protection to the agent just prior to the a^{th} renewal of a patent with revenue x if kept by current owner, and with an improvement factor g^e when sold to the potential buyer. If the renewal fee is not paid, then the patent expires and $V_a(x, g^e) = 0$. If the renewal fee is paid the owner earns the current revenue x and keeps the patent until the next renewal date. If the cost of technology adoption and the renewal fee are paid, then the buyer earns patent revenue y and obtains

[9] The model in this paper is based on the theoretical model of the transfer and renewal of patents developed by Serrano [50].

[10] The model does not consider a number of important issues such as strategic considerations, asymmetry of information, the design and use of incentives in contracts of technology transfer, the demand for liquidity, etc.. Katz and Shapiro [33], Gallini and Winter [20], and Shepard [51] consider the transfer of technology as a strategic decision. Anton and Yao [6] [7] study markets where the inventors have an information advantage with respect to the value of the technology and sellers are reluctant to disclosure the idea because buyers may steal it without paying for it (Arrow [10]). Other scholars have analyzed the design of licensing contracts in terms of incentives (Aghion and Tirole [2] and Arora [8]; and recently Silveira and Wright [52] develop a model of the interplay between the demand for liquidity and the market for ideas.

the ownership of the patent.

$$V_a(x, g^e) = \max\{0, V_a^K(x, g^e), V_a^S(x, g^e)\} \qquad a = 1, ..., L$$

Where L is the maximum legal length of patent protection, and $V_a^K(x, g^e)$ and $V_a^S(x, g^e)$ are the values of keeping and selling the patent, respectively. The latter values are defined as the sum of the revenue of a patent of age a and the option value of the patent minus the renewal fee at age a, c_a:

$$\begin{aligned} V_a^K(x, g^e) &= x - c_a + \beta E_{g^e}[V_{a+1}(x', g^{e\prime}|x)] \\ V_a^S(x, g^e) &= y - c_a - \tau + \beta E_{g^e}[V_{a+1}(x', g^{e\prime}|y)] \end{aligned}$$

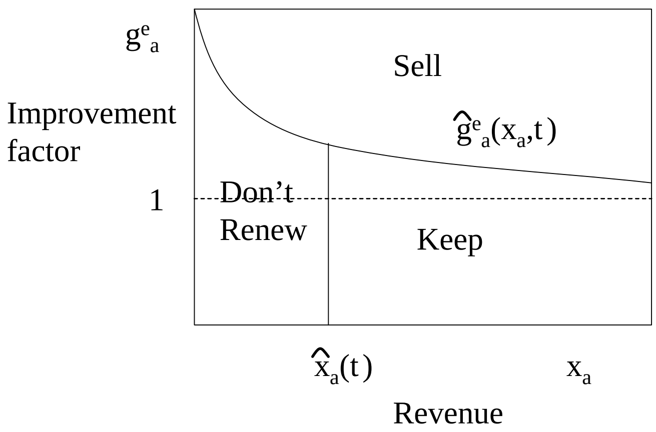
Where $\beta \in (0, 1)$ is the discount factor, τ is the cost of adopting a technology[11] and $E_{g^e}[.]$ is the expectation operator over the random variable g^e with cdf F_{g^e}. Finally, the initial patent revenue is distributed with cdf F_{x_1} and patent revenue depreciates deterministically between periods at a fixed rate $\delta \in (0, 1)$ as in Pakes and Schankerman. The deterministic rate implies that when the patent is kept, $x' = \delta x$, and when it is sold, $x' = \delta y$.

To illustrate the economic forces at play in the decision of a patent owner, consider a patent of age a with revenue x at the beginning of a period and with a potential buyer characterized by an improvement factor g^e. The patent will be sold when the improvement factor is large enough so that the fixed costs of adopting the technology can be amortized over time. If we look at an older patent with the same current revenue, it will be less likely to be sold because when the patent horizon is shorter, a higher improvement factor is needed to amortize the costs of adoption. Furthermore, if we fix the age of the patent, we find that the higher the patent revenue x is, the lower the improvement factor needed to amortize the cost of adoption. A lower improvement factor is needed because the difference between the value of keeping and selling the patent, i.e., $V_a^S(x, g^e) - V_a^K(x, g^e)$, increases with x as does the difference between the revenue of the potential buyer and the current owner, $y - x$. These are the main trade offs in the decision problem of a patent owner.

More formally, Serrano [50] shows that there exist functions $\widehat{g}_a^e(x, \tau)$ and $\widehat{x}_a(\tau)$ that divide the policy space into three areas (keep, sell or let the patent expire) as illustrated in Figure 1. The cutoff $\widehat{g}_a^e(x, \tau)$ is the improvement factor that makes a patent owner indifferent between selling or not selling a patent with revenue x and age a. If the improvement factor is above the cutoff, then the patent will be sold. For sufficiently low improvement

[11] There is little evidence on estimates of costs of technology transfer. Åstebro [11] studies the adoption of both CAD and CNC technologies and finds that there are large fixed noncapital and capital costs of adoption.

Figure 1: The Policy Space



factor, the revenue $\widehat{x}_a$ makes the owner indifferent between keeping the patent or letting it expire (as in Pakes and Schankerman). In this case, patents with lower revenues than $\widehat{x}_a$ are left to expire.

The model has two theoretical results, namely the selection and horizon effect, as well as a number of testable implications.[12] Serrano proves that for a fixed age, the function $\widehat{g}^e_a(x,\tau)$ is decreasing with x, implying that the probability of a patent being traded is increasing with x. That is, the higher the revenue x is, the lower the improvement g^e needed for the owner of the patent to be indifferent between selling it or not. We call this the *selection effect* because traded patents, and especially recently traded, have higher revenue on average prior to a potential trading date than the previously untraded ones. This selection effect will show why previously traded patents are more likely to be traded and less likely to be allowed to expire than the previously untraded ones as presented in Section 4. The second result illustrates that for a fixed patent revenue x, the function $\widehat{g}^e_a(x,\tau)$ is increasing with a which implies that the probability of an active patent being traded decreases with age for a fixed revenue x. That is, as a patent with a fixed revenue x gets older, the owners must meet better potential buyers in order to be indifferent between

[12]There are several key elements that allows Serrano to prove the results. One is that the cost of adopting a technology is fixed and does not fully internalize how the difference between the value of selling or not selling a patent changes as the revenue and age of the patent varies, i.e., the fixed cost of adoption of technology is not proportional to the difference between the value of not selling and selling the patent (net of the cost). Another important element of the structure of the model is that the improvement factor g^e is independent of the age and revenue of the patent. This simplifies the process g^e and implies that the buyer's per period patent revenue depends on the revenue of the current owner. If the revenue of the potential buyer was independent of the revenue of the current owner, then neither the selection nor the horizon effect would generally hold.

selling the patent or not. We call this the *horizon effect* because a shorter horizon implies less time to amortize the cost of adopting a technology. The horizon effect will show why the probability of an active patent being traded decreases with age with the exception of the renewal dates as presented in Section 4.

The fact that mandatory renewal fees in the US patent system are not due annually creates some interesting testable implications. Our model predicts that two opposing forces determine the probability of a patent being traded the year following immediately after a renewal date.[13] On the one hand, the probability of an active patent being traded may increase after a renewal date because the average revenue of the renewed patents is higher than the average revenue of the existing patents immediately prior to the renewal date. Consequently, the sample selection generated by the renewal decision and the result that patents with higher revenue are more likely to be traded (we will call this the renewal sample selection effect) implies a discrete jump of the probability of an active patent being traded following *immediately* after a renewal date.[14] On the other hand, this probability might decrease as the revenue of patents depreciate and their ages increase over the year following immediately after a renewal date. This is because when the revenue decreases with age the selection effect implies that the probability of a patent being traded decreases, and when a patent is older the horizon effect implies that the probability of a patent being traded decreases as well. Therefore, we should observe a discontinuous jump in the empirical probability of an active patent being traded the year following immediately a renewal date only when the renewal sample selection is the dominant effect.

We can summarize the prections of the model:

Prediction 1: *For a fixed revenue x, the probability of an active patent being traded decreases with age.*

Prediction 2: *For fixed age a, the probability of an active patent being traded increases with its revenue.*

Prediction 3: *Previously traded patents are more likely to be retraded than the previously untraded ones.*

Prediction 4: *Previously traded patents are less likely to be allowed to expire than the previously untraded ones.*

[13] In the U.S. patent system mandatory renewal patent fees are due at the end of the 4th, 8th and 12th year. If the fees are not paid, then the patent expires.

[14] This is because the distribution of per period revenue immediately after a renewal decision stochastically dominates the distribution of revenue prior to a renewal date.

Prediction 5: *Recently traded patents are more likely to be traded and less likely to be allowed to expire than the less recently traded ones.*

Prediction 6: *The probability of an active patent being traded increases immediately after a renewal date.*

Remark: This paper models the transfer of the ownership of patents but does not explicity consider the licensing of patents. However, the licensing of patents is certainly a real phenomenon and the model accommodates this possibility.[15] To account for this, we can think of patent revenue representing both the proceeds of adopting and using a technology as well as the ones that the buyer could additionally obtain by licensing the patent to others. Furthermore, the economic process we have considered here assumes that buyers of patents are adopters and users of the acquired technology rather than firms specializing on managing patents.[16] For instance, a firm could exclusively focus on managing a patent by licensing it to many others who can then adopt it, but firms exclusively managing patents is a rather new organizational form mainly associated with firms acquiring patents for prospective litigation purposes.

3 Measuring transfer of technology with the USPTO assignment data

There are several aspects that makes the assignment data particularly interesting for empirical work. In contrast to strategic alliance and licenses transactions, the transfer of the ownership of patents is recorded because of the legal requirement that all assignments have to be filled with the USPTO in order to be legally binding. Furthermore, assignments contain information concerning the rational of the transfer as well as the patent numbers being transferred which provide very detailed information on the technology that they represent. These aspects allow us to explore what type of patentees and in what industries patent trading is likely to be more important, the patent life cycle effects in the transfer of patents and the importance and the generality of the patent being transferred.

The rest of this section is divided into four parts. First, the contents of the assignment data we use to create the new data set of the transfer of patents. Second, the general

[15] There is no systematic data on patent licensing revenue, but there exist some anecdotal evidence. IBM's licensing revenue was \$1.6 billion in year 2000 (Berman [12]) as reported in Merrill, Levin and Myers [53]. In 1996 U.S. corporations received \$66 billion in income from royalties of unaffiliated entities (Degnan [14]). Texas instruments reported to have obtained \$1.6 billion in licensing royalties from 1996 to 2003 (Grindley and Teece [23]).

[16] We would like to thank a referee for pointing this issue to us.

principles that led to the decision made in the construction of the data. Third, the description of the data sample. Fourth, the contents of the new data set.

Original assignment data The main source of our data is the USPTO Patent Assignment Database. When a U.S. patent or a bundle of patents are transferred, an assignment may be recorded at the USPTO acknowledging the transfer by a party of the rights, title and interest in a patent or bundle of patents. The USPTO maintains all assignments recorded. A typical assignment is characterized by a unique identifier (i.e., reel frame), the name of the buyer (i.e., assignee) and the seller (i.e., assignor), the date that the assignment was recorded at the patent office (i.e., recorded date), the date the private agreement between the parties was signed (i.e., execute or signed date), the number of patents or patent applications included in the assignments, and the type of the assignment acknowledging the rational of the transfer (i.e., brief).[17] We have obtained these records in electronic format in a daily basis from August 1, 1980 to December 31, 2001.

The most recorded type of assignment in the data base represents the transfer of ownership from one entity to another (i.e., assignment of assignors). An assignment of assignors that is a first assignment tends to take place within the firm at which the original inventor of the patent works.[18] Instead, assignment of assignors that are subsequent assignments (i.e., reassignments) represent the transfer of the ownership of patents across firm boundaries. While assignment of assignors is the most common transaction, assignments can also be recorded to acknowledge the union of two or more commercial interests (i.e., mergers); when a patent is used as a collateral (i.e., security interest); a change of name of the firm that owns the patent or patent application (i.e., change of name); as a correction of a previous record (i.e., pro nunc tunc), etc.

Data construction. Here we will describe the three main principles that led to the decisions made in the construction of the data set. The details of the procedures we use to deal with the assignment data are explained in the appendix of this paper. First, our main interest in the new data ultimately lies in the reallocation of the ownership of patents for technological purposes. The assignment data allows us to identify and separate assignments recorded as administrative events such as a name change, a security interest, a correction, etc.

[17]Unfortunately, the names of the buyer and seller in the Patent Assignment Data Base were never standarized by the USPTO.

[18]The U.S. patent law mandates that patents rights first belong to their inventor unless assigned to others. For this reason, it is common in labor contracts to specify that employees must assign the rights of their inventions to the firm or organization in which they work.

Second, we focus on transaction of patents across firm boundaries. We identify whether the recording of a transaction is a first assignment or a reassignment using the name of the patent inventors and the assignee as of the grant date of the patent. When assignees as of the grant date of the patent are firms or government agencies, we exclude first assignments. On the other hand, if patents are individually owned as of the grant date, then we consider the assignment a patent transfer. For future reference, we define "trades" or "transfers" as reallocations of patents across firm boundaries.

Finally, we link the assignment records at the patent level to existing patent data on patent renewals, citations, generality, technology field, the name of the assignee as of the grant date of the patent, and other patent characteristics. The information on patent technology field, citations, generality and the name of the assignee as of the grant date of the patent can be obtained from the NBER Patent Database for patents granted from January 1, 1975 to December 31, 2002 . The renewal information is based on information from the USPTO Official Gazette as collected in the USPTO Patent BIB Data Base as of December 31, 2002. The data contains the renewal status of patents subject to renewal fees.[19]

Sample selection. The selection is based on a number of patents and patentee characteristics as of the grant date of the patent. First, we focus on patents that are subject to renewal fees and that were granted since January 1, 1983. U.S. patents subject to renewal fees are those applied for after December 12, 1980.[20] Furthermore, since on average the application period is about 2.5 years, we use patents granted since January 1, 1983 to create a comprehensive data set.

Second, we consider utility patents and exclude patent applications. Utility patents represent the most common type of patent. Patent applications are not included because we have no information about applications that were not granted.

Third, the time unit of analysis of the new data set is the age of a patent counted in years. In principle, an active patent can be traded at any date. In our empirical analysis,

[19] As of today, the Patent BIB Database is the best publicly available source in electronic format for information on patent expiration. However, we have found that there could be some inconsistencies dealing with patents that were initially expired and then reinstated due to late payment of mantenaince fees. This is certainly a very small number of patents and should not affect the results in the paper.

[20] In the U.S. patent system, the maximum possible term of an issued patent (assuming that any required renewal fees are paid) was 17 years until June 8, 1995. Since then, for patents applied prior to June 8, 1995, the term of a patent is either 20 years from the earliest claimed filing date or 17 years from the issue date, whichever is longer. For patents applied for after or on June 8, 1995, the maximum lenght is 20 years from the application date. In the U.S. patent system, patents applied for from December 12, 1980 are subject to renewal fees by the end of years 4, 8 and 12 since its grant date. If renewal fees are not paid, then the patents expire.

however, we consider that a patent is traded in a given year if it was traded at least once over that period.[21]

Finally, when studying patent transfers, one must recognize that patents that are traded in large blocks might not represent technology transfers, for example, a merger between two large companies.[22] Obviously, in a wholesale trade of thousands of patents, the decision making is not uniquely at the level of a single patent or necessarily driven by the reallocation of technology.[23] For this reason and to parallel our theoretical analysis at the patent level, it will be useful to look at patents from different patentees, and especially those from *small innovators* (i.e., patents granted to firms with no more than five patents granted in a given year) and *individually owned patents* (i.e., patents granted to individual inventors and unassigned patents as of their grant date).[24] In doing so, the economic forces that we highlight will be more salient than in the transactions involving two very large corporations or patents owned by large corporations.[25]

Contents of the transfer data. The new data set is a panel of patents whose history of trades and renewal decisions took place up to the end of the year 2001.[26] Patents are categorized by their quality or importance, generality, the patentees, and when the patentee is a corporation we can add a measure of the size of the firm as of the grant date of the patent. Summary statistics about granted and traded patents by type of patentee can be found in Table 5 in the appendix.

Every measure of patent quality or importance we can potentially use is going to be imperfect. We follow the previous literature and use citations received as such a measure. We consider that citations are correlated with the private value to patent protection, but they do not cause it. In practical terms, we use two terminologies that are associated to

[21]For instance, if a patent was traded during its second year of life (e.g. 17 or 22 months since being issued), we consider that the patent was traded at age 2.

[22]For instance, when Burroughs Corporation merged with Sperry Corporation to create Unisys Corporation in September 1986, this event appears in the data as transactions totaling 2261 patents (the largest single transaction includes 1702 patents).

[23]For instace, these transactions can be recorded as a result of large acquisitions pursued to increase the buyer's market share in a particular product or field, etc.

[24]Studying small innovators and individually owned patents is interesting in their own right, given the importance they play in the innovation process (Acs and Audretsch [1]; Arrow [10]).

[25]For instance, we find that the proportion of patents traded in bundles of more than 100 patents, which were mostly developed by large firms, disproportionately increase in the periods of merger such as the mid-1980s wave and late 1990s. In addition, according to Mitchell and Mulherin [39], a substantial number of acquisitions in the wave of mid 1980's could be explained by major shocks such as deregulation, increased foreign competition, financial innovations, etc. We see these forces inherently different than those that predict the transfer of knowledge due to specialization, which is what we mean by economic forces.

[26]There are 20 cohorts coexisting in the unbalanced panel. For the case of non-censored cohorts (i.e., granted from 1983 to 1985).

the number of patent citations received. We define *total citations received by a given age* as the sum of citations received from the grant year of the patent to the year it is up for trade or renewal. We define *total citations received by the maximum legal length of patent protection* as the sum of citations received from the grant date and until the maximum legal length of patent protection.[27]

The generality variable and patent category are defined as in Hall, Jaffe and Tratjenberg [26]. Generality measures whether the impact of a patent is broad. That is, conditional on the total number of citations ever received, if a patent is cited by others belonging to a wide range of fields, then the generality variable will be high, while if most citations are concentrated in a few fields, then it will be low. This measure is interesting because it reflects the range of opportunities of applications perhaps from potential buyers. The patent category variable assigns patents into six different technology fields: chemicals; computer and communications; drugs and medical; electrical and electricity; mechanical; and other.[28]

Finally, we consider six type of patentees or owners of patents as of their grant date. The type of patentees are individual private inventor patents, unassigned patents as of the grant date owned by the inventors; small, medium and large innovators; and government agencies.[29] When the owners are corporations or innovators, we can construct a measure of their size based on the total number of patents granted in a given year. This allows us to match all the patents to patentees. While we would like to use standard measures of firm size like employees or assets, it is difficult to find such measures for all the patentees.

The new data makes a contribution adding a dynamic component, namely the transfer of patents, to the existing data work on patents. The data, however, is not without drawbacks. First, after a patent has been granted, the names of the first buyer, and subsequent sellers and buyers of the transactions are not standardized by the USPTO. Second, we cannot distinguish the acquisition of a firm from the acquisition of a bundle of patents.[30] Third, we do not have information on the price paid for the patents transferred. Fourth, the data

[27] When the last year that a patent is observed in the panel is less than the maximum legal length, then we use the number of total citations received as of the last year the patent is observed. (i.e., a patent granted in 1990 will use the number of total citations received up to age 11).

[28] We thank a referee for suggesting us to consider the variable generality.

[29] Small innovators patents are defined as those owned by corporations that were granted no more than 5 patents in a given year. Large innovators patents are those issued to corporations with more than 100 patents granted in a given year. Medium innovators patents are the rest.

[30] In the hypothetical case that a small innovator was acquired rather than a bundle of its patents, we consider that it might be acquired mainly because of the value of its technological assets. In this scenario, the transfer will likely involve a cost of adopting and especially setting up the technology in the new firm. Thus, to some extent an acquisition of an innovative firm would be no necessarily different than the transfer of its patents.

does not allow us to distinguish between patent being acquired by firms who adopt the technology and firms who might specialize in managing patents by licensing them to many others who can then adopt it. Firms exclusively managing patents, however, is a rather new organizational form mainly associated with firms acquiring patents for prospective litigation purposes. For this reason we expect that the majority of the transfers in our data set represent the adoption of a technology. Fifth, we have assignment data in electronic format from August 1, 1980 to December 2001.

4 Patterns of the transfer and renewal of patents

In this section we present two sets of patterns underlying the transfer and renewal rates by type of patentees, technology field, patent characteristics and a patents life cycle. The first set of patterns show the level of missallocation of patent property rights across patentees and technology fields. These patterns present a introductory picture of the market for patents rather than a test of the theory previously developed in Section 2.

The second set of patterns identify a number of patent characteristics that are determinants of the trading and renewal decision such as the age and importance of a patent. These patterns are the empirical counterparts of the testable implications of the theory previously presented.

Furthermore, the robustness of the patterns is analyzed using a logit model.[31] The parametric analysis is useful because it allows us to control on a larger number of variables. There are two groups of regressions we present in the appendix. The first group considers all active patents and uses controls on age, patent category (i.e., technology field), patentee and citations. It is also useful to run a second group with each of the patentees in a separate regression.

4.1 The transfer and renewal of patents across patentees and technology fields

The first set of patterns present both the proportion of patents that are traded at least once over their life cycle and the proportion of patents that are allowed to expire by the last renewal fee across patentees and technology fields. These rates will allow us to learn something about where patent trading is likely to be more important and about the level

[31] Similar results should be obtained analyzing the data with alternative parametric model.

of missallocation of patent property rights.[32]

Pattern #1: *The proportion of patents traded varies across patentees, and this proportion is higher when weighted by the total number of citations received by the legal maximum length of patent protection.*

Table 1A provides the disaggregated cumulative transfer rates during the life cycle of patents across patentees. These rates vary from a low 4.1% to a high of 17.5%. The average rate of transfer is 13.5%. The columns in the table correspond to each of the patentees. Small innovators and private inventors are the patentees that are more likely to sell their patents; followed by medium innovators, individually owned unassigned patents as of the grant date, large innovators and governments agencies. Among corporations, the rates of transfer decrease with the size of the firms. Furthermore, when weighted by the total number of citations received by the legal maximum length of a patent, the cummulative rates of transfer are higher.[33] The weighted rates vary from 6% to 24.1%.

Pattern #2: *The proportion of patents that are let to expire varies across patentees. The proportion is lower when weighted by the total number of citations received by the legal maximum length of patent protection.*

Table 1B presents the cumulative expiration rates of patents by the last renewal fee at age 13. These rates vary substantially from 50% to 83.5%, with an average of 59.5%. When weighted by total number of citations received by the maximum legal length of patent protection, the rates are lower and the variation increases from a low 39.9% to a high 74.4%. The table also shows that corporations are less likely to let their patents expire than individual owners and government agencies. And within corporations, small innovators are the ones most likely to let their patents expire while large innovators are the least.

The robustness of the effects of pattern #1 and #2 are studied by the inclusion of dummy variables in a logit model. We consider dummies for the type of patentees, technology fields (i.e., patent categories) and patent age. With this parametric model we can also control on the total number of patent citations received by a given age. Table 6, in the appendix, presents both the predicted probabilities of a patent being traded and expired by

[32] I will be omitting the standard errors of the proportions because they are small as the number of observations is rather large.

[33] Similar results are obtained when the weighs are based on the total citations received by a given year, i.e., the year that a patent is up for trade or renewal.

Table 1: Proportion of Patents Traded and Expired by Type of Patentees

	Individual owners			Corporations (Innovators)				Govt. Agencies
	All	Unassigned	Priv. Inventors	All	Small	Medium	Large	
A. Proportion of patents traded over their life cycle by type of patentees								
Unweighed	12.4	12.2	16.2	14.0	17.5	14.6	10.5	4.1
Weighed by citations	19.0	18.7	24.1	17.2	24.0	17.4	11.4	6.0
B. Proportion of patents expired up to the last renewal fee by type of patentees								
Unweighed	77.5	77.7	73.1	55.1	60.3	55.5	50.0	83.5
Weighed by citations	68.4	68.9	62.0	43.2	48.8	42.8	39.1	74.4

Note: the proportions of this table are created using a pooling of all U.S. patents granted from 1983 to 2001.

type of patentees constructed with the estimates of the logit model. The probabilities are evaluated at the mean of the sample of the technology fields and citations. The predicted cummulative rates of transfer vary from a low 4.1% to a high of 18.6%.

Pattern #3: *The proportion of patents traded varies across technology fields (i.e., patent categories).*

Table 2A presents the cummulative transfer rates across technology fields. The six columns represent the aggregate technology fields in which patents are classified. The rates vary from a low 12% to a high of 16%. The patents most likely to be traded are those belonging to the categories of computer and communications, drugs and medical, and electricity and electronics.

Pattern #4: *The proportion of patents allowed to expire varies across technology fields (i.e., patent categories).*

Table 2B presents the rates of expiration across technology fields by the last renewal date at age 13. The columns of the table correspond to the technology fields. The proportion of patents allowed to expire differs across patent categories from a low 47.3% to a high of 67.9%.

While the differences in the rate of transfer and expiration across technology fields and patentees are significant, they could also depend on the patterns of patenting by patentees and the characteristics of their patents. To account for this possibility, we run logit models for both the trading and the expiring decision regressed on a number patent characteristics as controls. Like in the previous section, we use the total number of citations received and

Table 2: Proportion of Patents Traded and Expired by Patent Category

Chemical	Computer & Comm	Drugs & Medical	Elec. & Electro.	Mechanical	Other
A. Proportion of patents traded over their life cycle by patent categories					
14.9	12.9	16.0	13.8	12.0	13.1
B. Proportion of patents expired up to the last renewal fee by patent categories					
60.0	47.3	57.4	55.1	61.7	67.9

Note: the proportions of this table are created using a pooling of all U.S. patents granted from 1983 to 2001 and their trading and renewal decisions.

dummies for the type of patentees, technology fields, and patent age. Table 7 presents the predicted cummulative probabilities of transfer and expiration by technology fields and patentees evaluated at the sample mean of the controls. The differences are now somewhat smaller, but the rates are similar.

It is also useful to take a more detailed look at the rates of transfer and expiration. Table 3 reports these rates across patentees and disaggregated by technology fields. The top part of the table presents the cumulative transfer rates and the bottom part the cumulative rates of expiration by age 13. The columns of the table are the technology fields and the rows are the type of patentees. The magnitude of the differences in the transfer rates between patentees vary when we examine technology fields separately, maybe indicating a different degree of patentee specialization in research across technology fields. For instance, table 3A shows that in the computer and communication category, small innovators transfer 23.9% of their patents while large innovators only sell 7.9% of theirs. But in the chemical category the sale rates are 17.2% and 12.5% for small and large innovators respectively.

4.2 Patent characteristics and the transfer and renewal of patents

The second set of patterns we present identifies a set of patent characteristics that are systematically related to the trading and the renewal decision; namely the total number of patent citations received by a given age, the patent generality, whether the patent has been previously traded and the timing of the last trade. These patterns can help us understand what type of patents are more likely to be sold and how quickly the change in ownership occurs over the life cycle of a patent.[34] In addition, the following patterns are consistent

[34] I will be generally omitting the standard errors of the proportions in the Tables below because they are small as the number of observations is rather large. We will report them whenever we think they are useful such as in the discussion of pattern #10. The reader can find the estimates of all regressions and

Table 3: Proportion of Patents Traded and Expired by Patent Category and Patentee

	Chemical	Computer & Comm	Drugs & Medical	Elec. & Electro.	Mechanical	Other
A. Proportion of patents traded over their life cycle by patent categories						
Individual owned patents	16.1	15.8	17.0	14.7	11.6	10.1
Unassigned	16.1	15.6	16.8	14.4	11.3	9.9
Priv. Inventor	15.7	19.1	20.1	19.5	16.1	13.7
Corporations (Innovators)	15.0	13.0	16.0	14.0	12.3	14.9
Small	17.2	23.9	20.1	18.2	15.7	16.2
Medium	15.8	16.9	14.2	15.4	12.0	14.1
Large	12.5	7.9	13.3	11.2	8.5	12.3
Govt. Agencies	4.0	2.6	4.4	4.6	4.7	3.2
All	14.9	12.9	16.0	13.8	12.0	13.1
B. Proportion of patents expired up to the last renewal fee by patent categories						
Individual owned patents	77.5	73.0	69.3	68.4	74.1	81.1
Unassigned	72.8	69.8	69.0	74.6	79.3	81.3
Priv. Inventor	75.6	62.3	60.1	66.3	77.0	77.1
Corporations (Innovators)	58.3	44.6	54.5	51.9	56.7	60.1
Small	59.0	54.2	53.2	58.7	62.4	63.9
Medium	58.5	46.6	54.1	52.5	57.2	57.3
Large	57.6	40.6	59.1	48.1	49.0	53.6
Govt. Agencies	80.7	91.6	65.1	84.3	86.5	86.8
All	60.0	47.3	57.4	55.1	61.7	67.9

Note: the proportions of this table are created using a pooling of all U.S. patents granted from 1983 to 2001 and their trading and renewal decisions.

with the predictions of the model as presented in Section 2.[35]

Pattern #5: *Active patents with a higher number of total citations received by a given renewal date are less likely to be allowed to expire.*

Table 8B, in the appendix, presents the estimates of the decision of whether to allow a patent to expire at a renewal date regressed on the total number of citations received by the renewal date and a number of patent characteristics. The first column of this table presents estimates for the whole sample, while the rest of the columns contain the estimates that were obtained from running separate regressions for each patentee. The rows of the table present estimates on citations for different sets of patent characteristics which include age dummies, patent category dummies and patentee dummies. The estimates of the number of total citations received by a given age are negative and statistically significant. A negative number indicates that patents with a higher number of citations are less likely to be allowed to expire. For instance, using the estimates that control on age and technology field of the sample of small innovators and evaluating the predicted probabilities at the mean of the sample, an extra citation decreases the predicted probability of an active patent being allowed to expire at age 13 by about 1 percentage point, i.e., decresing from 36.9% to 35.9%. Since the distribution of total citations is highly skewed, it is also useful to calculate this predicted probability at a higher percentile of total citations. The predicted probability decreases to 27.1% when evaluated at the 95 percentile of total citations.

Pattern #6: *Active patents with a higher number of total citations received by a given age are more likely to be traded.*

Table 8A, in the appendix, shows the estimates of regressing the decision to trade an active patent on a number of controls. The structure of this table is similar to table 8B. The sign of the estimates of citations is positive, implying that patents with more citations received by a given age are more likely to be traded.[36] The estimates are significant at

their corresponding standard errors in the appendix.

[35] Since we there is no systematic data on licensing, we are consequently neglecting the possiblity that some patents that are not traded could be licensed. To the extent that licensed patents are were likely to be cited than the not traded and the not licensed ones, it is likely that an average patent in our sample of not traded patents will have more citations received than a patent never traded and never licensed. Consequently, neglecting licensing would make the effect of citations received in the trading decision vs not trading decision, which is what we currently do, to be less strong than the effect of citations received in the trading decision vs a not trading and not licensing decision.

[36] Similar results are obtained when using the total number of citations received by the maximum legal length of patent protection.

standard levels and they are robust to a number of specifications.[37] Using the estimates that control on age and technolog field for the sample of small innovators, as presented in Table 8A, and evaluating the predicted probabilities at the mean of the sample of age, technology field and total citations, we can calculate that an extra citation increases the predicted probability of an active patent being traded at age 7 by about 0.02 percentage points, i.e., increasing the rate from 1.92% to 1.94%. This predicted probability increases to 2.13% when it is evaluated at the 95 percentile of total citations.

Pattern #7: *Active patents with higher generality measures are more likely to be traded and less likely to expire.*

Table 10A and 10B, in the appendix, present respectively the estimates of both the regression of the probability of a patent being traded and the probability of a patent being alllowed to expire regressed on the generality measure and a number of controls. The first column of the table presents the estimates of the whole data set while the rest of the columns show the estimates of separate regressions for each type of patentee. The rows consider different sets of patent characteristics. The estimates of generality are positive in the trading decision and negative in the expiring one. They are are statistically significant for every set of patent controls, i.e., age dummies, adding technology fields, adding citations, and the last one adding patentees.[38] When running a separate regression for each patentee, the result are consistent except for government agency patents. A positive coefficient in the trading decision implies that higher patent generality is associated with a higher probability of a patent being traded; a negative estimate in the expiring decision implies that patents with higher generality have a lower likelihood of being allowed to expire. For instance, using the estimates for small innovators that control on age and patent category, as presented in Table 10, the predicted probability of a patent being traded at age 9 evaluated at the sample mean of generality, patent age and category is 2.00%. This probability increases to 2.26% when evaluated at the 95 percentile of generality holding the values of the rest of the variables fixed. Similarly, the predicted probability of an active patent expiring at age

[37] There is one exception, the regression for the sample of patents of large innovators. The negative coefficient of patent citations is based on patent that belong to patent category 4 (Electrical and electronics). In the rest of the categories, the coefficient is positive and significant or not statistically significant. Moreover, when we estimate the probability of a *granted* patent being traded using the same explanatory variables, the effect of citations is significant across patentees and robust to patent categories.

[38] It is worthy to point out that when adding citations to the previous controls, the coefficient estimate of generality in the expiring decision drops by about three times, but the one in the trading decision does not change much. This result is consistent with generality capturing market oportunities to transfer a patent independently of how valuable the patent is, which is consistent with our definition of the improvement factor g^e.

Table 4: Patents Traded and Expired for Small Innovators

A. Patents Traded as a Percentage of All Active Patents

			Previously Traded (Years since last trade)				
Age of Patent (Years)	All	Not Previously Traded	Any Year	1	2	3	4
1	2.505	-	-	-	-	-	-
2	2.335	2.225	5.287	5.287	-	-	-
3	2.201	2.068	4.753	5.265	4.244	-	-
4	2.179	2.007	4.453	5.043	4.291	4.025	-
5	2.220	1.989	4.407	5.324	4.527	3.840	3.769
6	2.017	1.753	4.068	4.935	4.127	3.765	4.103
7	1.902	1.621	3.805	4.963	3.750	3.796	3.567
8	1.885	1.565	3.801	4.962	3.860	4.075	3.595
9	1.937	1.566	3.789	4.825	3.162	3.915	3.878
10	1.779	1.404	3.494	3.839	3.369	4.825	3.221
11	1.676	1.354	3.042	3.937	3.618	3.671	2.836
12	1.540	1.264	2.626	3.276	3.851	2.537	2.411
13	1.675	1.331	2.868	2.001	2.273	4.721	3.280
14	1.680	1.330	2.847	3.234	2.774	4.513	4.070
15	1.362	1.008	2.497	2.802	2.189	2.698	3.0
16	1.157	0.861	2.075	2.229	1.559	3.817	1.439
17	0.841	0.607	1.566	1.818	1.181	2.821	1.976

B. Patents Expired as a Percentage of All Active Patents

			Previously Traded (Years since last trade)				
Age of Patent (Years)	All	Not Previously Traded	Any Year	1	2	3	4
5	18.399	18.958	12.707	6.696	12.148	14.456	16.08
9	29.143	30.077	24.087	11.253	18.650	22.070	23.407
13	33.014	34.131	28.830	15.515	22.663	24.280	29.614

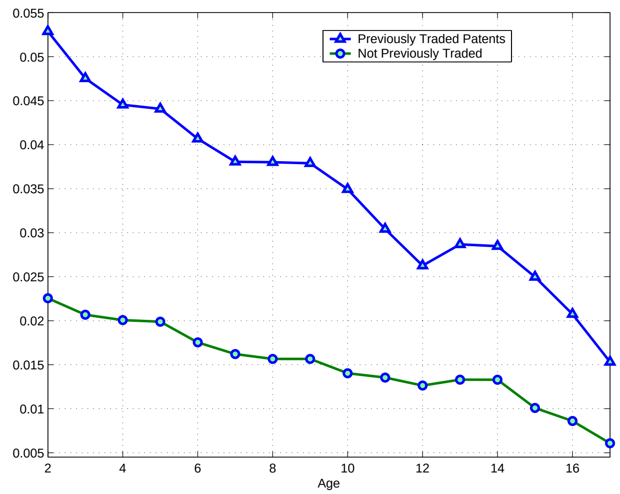
Note: the proportion of this table are created using a pooling of all U.S. patents granted from 1983 to 2001 and their trading and renewal decisions.

9 decreases from 27.8% to 26.0% when evaluated at the sample mean of generality and the 95 percentile respectively.

Pattern #8: *Active previously traded patents of the same age, and in particular the recently traded, are more likely to be traded and less likely to be allowed to expire than patents not previously traded.*

Table 4 shows the proportion of small innovators active patents traded and let to expire conditional on both being previously traded or not and the timing of the last trade. Figure 2 shows the proportion of an active small innovator patent being traded conditional on having been previously traded or not. It useful to examine the robustnes of these proportions in more detail and to assess the results across patentees and technology fields. Table 9, in the appendix, presents the estimates of both the probability of a patent being traded and the probability of a patent being allowed to expire regressed on whether a patent has

Figure 2: The Number of Patents Traded as a Proportion of Active Patents Conditional on Having Been Previously Traded or Not (Small Innovators)

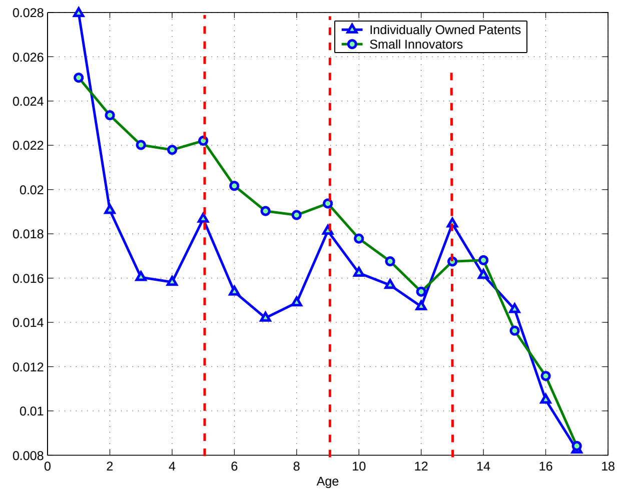


been previously traded and a number of controls. Table 11, in the appendix, shows the estimates of the same probabilities but now regressed on the number of years since the last trade and patent controls. The structure of these tables is similar to the previous ones. The estimates indicate that previously traded patents, and especially the recently traded, are more likely to be traded again and less likely to be allowed to expire. For instance, using estimates that control on age and patent category for the sample of small innovators, as presented in Table 9, and evaluating the predicted probabilities at the mean patent age and categories, we can calculate that the predicted probability at age 7 of a patent being traded increases from 1.68% to 3.81% if it has been previously traded. The probability of a patent being expired at age 9 decreases from 29.5% to 23.0% for previously traded patents. The results are significant at standard significance levels and robust to technology field and patentee dummies. When we run separate regressions for each patentee, the results are also statistically significant. There are few exceptions like patents of government agencies.

Pattern #9: *The number of expired patents as a proportion of all active patents (i.e., the expiration rate) increases with the renewal dates.*

Table 4B shows that the expiration rate is increasing with the renewal dates for small innovator patents. The pattern is similar across type of patentees and it is significant and robust to technology field dummies as seen in the logit regressions. Table 6, in the appendix, presents the estimates.

Figure 3: The Number of Patents Traded as a Proportion of Active Patents (Small Innovators and Individual Owned Patents)



Pattern #10: *The number of patents traded as a proportion of all active patents decreases with age except in the year immediately after a renewal date. The year immediately after a renewal date, this rate discontinuously increases.*

Figure 3 shows the probability of an active patent being traded as a function of its age for both small innovator patents and individually owned patents. The decreasing pattern is consistent across type of patentees and patent categories with the exception of large innovators. Table 12, 13, 14 and 15, in the appendix, show the estimates of the age dummies in regressions run with a number of controls. Using the estimates from the logit regressions with age dummies, we find that the jumps in the transfer rate are significant at standard significant levels for the sample of all patents and for individually owned patents (private inventors and unassigned patents), but for small innovators the jumps are significant but at somewhat higher significance levels.[39] The results are similar when technology field controls are used.[40]

[39]We test the following three null hypothesis for all the samples: *i*) age_year4≥age_year5; *ii*) age_year8≥age_year9; and *iii*) age_year12≥age_year13. If the p values are sufficiently low then, we can reject the hypothesis and conclude that the jumps are significant at a certain statistical significance level. We obtain the following p values. The first to last number in the parenthesis represent null hypothesis *i* to *iii*. All innovators (0.2819; 0.00; 0.00); Individually owned patents (0.00; 0.00; 0.00), unassigned (0.00; 0.00; 0.00), private inventors (0.0529; 0.0755; 0.03776), small innovators (0.140; 0.1468; 0.0308); medium innovators (0.9697; 0.0125; 0.00); large innovators (0.00; 0.00; 0.6461) and government agencies (0.777; 0.00; 0.4490). Similar results are obtained when the sample proportions are used instead of the age dummies.

[40]When we estimate the probability of a patent being traded on age dummies and total citations received by a given age, the jumps of the age dummies after a renewal date are smaller than when the variable total

In addition, we have four remarks concerning the above patterns. First, renewal dates do not act as a signalling device in a context of asymmetry of information with respect to the value of patent protection. When we use the sample of patents that never expired, and look at the probability of a patent being traded, this probability does not discretely jumps the year after a renewal date. Second, when we condition on granted patents, the probability of a patent being traded decreases with age with no jumps in the year after a renewal date. Third, there are elements other than age and total citations received by a given age that affect the trading decision. We find that despite controlling for total citations received by a given age and generality, previously traded patents are still more likely to be traded than the ones that were not previously traded. Fourth, total citations received are not a perfect measure of the value of patent protection. For instance, patents keep getting citations after their expiration date. Two reasons might be that citations are not contemporaneous with patent protection and that citations also represent spillovers.

5 Conclusion

This paper has used a newly constructed data set showing the transfer of ownership of patents to study how significant the initial missallocation of patent property rights is and to provide a summary of basic patterns of the transfer and renewal of patents.

We have explored a number of issues in this paper. The first aspect we have looked at is whether the missallocation of patent property rights and the intensity of patent trading differs by the type of patentees and technology fields. We have found that small innovators and private inventors are the most active sellers of patents, while government agencies and large innovators are the least. The number of patents traded as a proportion of all granted patents is a significant number, and it is higher when weighted by the importance of the patents as measured by their total number of citations received. Furthermore, there are differences in the rates of transfer and renewal across patent categories, having computer and communications, drugs and medical, and electricity and electronics as the most actively traded.

The second aspect we have analyzed are the patent characteristics and the life cycle properties of the transfer and renewal of patents. We have found a number of patterns. First, among patents of the same age, we showed that those with a higher number of total citations received by a given age are more likely to be traded and less likely to be allowed

citations received by a given age is not included. To the extent that the number of total citations received by a given year is correlated with the revenue of a patent, the result is consistent with the implications of the theoretical model considered in the paper.

to expire. Second, among patents of the same age, those with higher generality are more likely to be traded and less likely to expire. Third, among traded patents of the same age and especially the recently traded, they are more likely to be retraded and less likely to be allowed to expire than the previously untraded ones. Fourth, the probability of an active patent being traded decreases with age, but with one exception - the year following immediately after a renewal date this probability discontinuously increases. Finally, the probability of an active patent being allowed to expire increases with age.

These empirical results have implications concerning the way markets for technology are structured and operate. First, the significant proportion of patents sold and the timing of the sale suggests that the patent system permits the transfer of intellectual property assets towards a more profitable use. The transfer of patents might happen because of a comparative advantage by potential buyers due to a better use of the existing technology, complementary assets, or perhaps an improvement of the existing technology that in order to be legally implemented requires the acquisition of prior intellectual property rights. The former issue is particularly relevant for economic policy because the efficiency of the patent system has been especially criticized in the context in which innovations are sequential and the discovery and adoption of technological improvements might be blocked by incumbents. Second, the fact that a significant proportion of patents is transferred also suggests that residual control rights are important in the functioning of the market for patents. One implication of this is that innovators prefer to acquire patents rather than license them to minimize potential hold up problems. Third, the fact that small innovators are more likely to sell their patents than their larger counterparts indicates that small innovators might be specializing in research which is then sold in the form of patents to others, maybe to large firms with a comparative advantage in the production or commercialization process. In this context, understanding the degree of specialization and the size of the gains from trade in the market matters because of innovation, mergers and the design of patent policy. For instance, the benefits of the market for patents could offset concerns about the inefficiencies associated with the patent system such as the granting of monopoly rights. Finally, the model of patent transfer we have used to understand the dynamics of patent trading suggests that the interplay betweeen costs of technology adoption, the gains from trade and the value and age of patents are important determinants of the transfer of technology.

Furthermore, the new data will allow scholars to empirically address questions that previously were not attainable. For instance, Serrano [50], estimates the gains from trade in the market for patents. Other interesting empirical questions in which the data can be useful might be: Do small firms specialize in the creation of knowledge and then sell their patents to their larger counterparts? To estimate the returns to R&D through the market for patents? To what extent did the move towards higher protection of intellectual property rights that occurred in the 1980s facilitate specialization and the transfer of knowledge in the form of patents? Do patent property rights tend to be transferred at the local level like spillovers do? Researchers can also examine policies to promote innovation in the context of markets for technology such as the use of taxation on the transfer of intellectual property. We leave these topics for future research.

References

[1] Acs, Z. and Audretsch, D. (1988), "Innovation in Large and Small Firms: An Empirical Analysis." *The American Economic Review*, Vol. 78, No. 4, 678-690.

[2] Aghion, P. and Tirole, J., (1994), "The Management of Innovation." *Quarterly Journal of Economics* 109 (4), 1185-1209.

[3] Agrawal, A. and Henderson, R. (2002), "Putting Patents in Context: Exploring Knowledge Transfer from MIT." *Management Science*, Vol. 48, No. 1, pp. 44-60.

[4] Anand, B.N. and Khanna, T., (2000) "The Structure of Licensing Contracts." *Journal of Industrial Economics*, Vol. 48, No. 1, pp. 103-135.

[5] Andrade, G. and Stafford, E. (2004). "Investigating the Economic Role of Mergers." *Journal of Corporate Finance* 10, No. 1 (2004): 1-36.

[6] Anton, J. and Yao, D. (1994), "Expropriation and Inventions: Appropriable Rents in the Absence of Property Rights." *American Economic Review* 84 (1), 190-209.

[7] Anton, J. and Yao, D. (2002), "The Sale of Ideas: Strategic Disclosure, Property Rights and Contracting." *Review of Economic Studies* 69, 513-531.

[8] Arora, A. (1995), "Licensing Tacit Knowledge: Intellectual Property Rights and the Market for Know-how." *Economics of New Technology and Innovation* 4, 41-59.

[9] Arora A., Fosfuri A. and Gambardella A. (2002), "Market for Technology: The Economics of Innovation and Corporate Strategy." The MIT Press. Cambridge, MA.

[10] Arrow, K. (1983). "Innovation in Large and Small Firms." In *Entrepreneurship*, edited by Joshua Ronen. Lexington Books. Lexington, MA.

[11] Ǎstebro, T. (2002). "Non-Capital Investment Costs and the Adoption of CAD and CNC in the U.S. metalworking Industries." *RAND Journal of Economics*, 33(4), pp. 672-688.

[12] Berman, B. (2002). "From Tech Transfer to Joint Ventures - Part 1." Cafezine. Available at http://www.cafezine.com/index_article.asp?deptId=5&id=555&page=1

[13] Branstetter, L. and Ogura, Y. (2003). "Is Academic Science Driving a Surge in Industrial Innovation? Evidence from Patent Citations." Working paper Carnegie Mellon University.

[14] Degnan, S.A. "The Licensing Payoff from U.S. R&D." *Journal of the Licensing Executives Society International* 33(4)

[15] Dunne, T., Roberts, M.J. and Samuelson, L. (1989). "The Growth and Failure of U.S. Manufacturing Plants." *Quarterly Journal of Economics* 104 (November): 671-98

[16] Evans, D.S. (1987). "Tests of Alternative Theories of Firm Growth." *Journal of Political Economy* 95 (August 1987): 657-74

[17] Gans, J., and Stern, S. (2003). "The Product Market and the Market for "Ideas": Commercialization Strategies for Entrepreneurs." *Research Policy*, vol.32, pp.333-350.

[18] Gans, J, Hsu, D., and Stern, S. (2004). "The Impact of Uncertain IP Rights on the Market for Ideas: Evidence from Patent Grant Delays." Working paper, Northwestern University.

[19] Gallini, N. (1992). "Patent Policy and Costly Imitation," *The RAND Journal of Economics*, Vol. 23, No. 1, 52-63.

[20] Gallini, N. and Winter, R. (1985). "Licensing in the Theory of Innovation." *Rand Journal of Economics* 16 (2), 237-252.

[21] Graff, G., Rausser, G., and Small, A. (2003)"Agricultural Biotechnology's Complementary Intellectual Assets", *Review of Economics and Statistics*, May 2003, vol. 85, No. 2, 349-363.

[22] Green, J. and Scotchmer, S. (1990). "Novelty and Disclosure in Patent Law," *Rand Journal of Economics*, 21: 131-46.

[23] Grindley P.C. and Teece D.J. (1997). "Licensing and Cross-licensing in Semiconductors and Electronics," *California Management Review.*

[24] Griliches, Z. (1984). (ed.) *R&D, Patents, and Productivity*, NBER Conference Proceedings. University of Chicago Press, 1984

[25] Grossman, S. J., and Hart, O. D. (1986). "The Costs and Benefits of Ownership: A Theory of Vertical and Lateral Integration." *Journal of Political Economy*, Vol. 94, No. 4, 691-719.

[26] Hall, B., Jaffe, A., and Tratjenberg M. (2001). "The NBER Patent Citation Data File: Lessons, Insights and Methodological Tools." NBER Working Paper 8498.

[27] Harhoff, D., Narin, F., Scherer, F.M., and Vopel, K. (1999), "Citation Frequency and the Value of Patented Inventions." *The Review of Economics and Statistics*, August, 81(3): 511-515.

[28] Holmes, T. and Schmitz, J. (1996). "Managerial Tenure, Business Age, and Small Business Turnover." *Journal of Labor Economics*, 1996, Vol. 14, No. 1

[29] Jaffe, A. (1989). "The Real Effects of Academic Research." *American Economic Review*, Vol. 75, No. 5, pp. 957-970.

[30] Jaffe, A., Tratjenberg, M. and Henderson, R. (1993), "Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations." *Quarterly Journal of Economics*. Vol. CVIII, Issue 3, p. 577.

[31] Jaffe, A. and Tratjenberg, M. (1996). "Flows of Knowledge from Universities and Federal Labs: Modeling the Flow of Patent Citations over Time and across Institutional and Geographic Boundaries." NBER working paper no. 5712.

[32] Jovanovic, B. and Rousseau, P.L. (2004). "Mergers as Reallocation." Working Paper, New York University.

[33] Katz, M. and Shapiro, C. (1986). "How to License Intangible Property." *Quarterly Journal of Economics* 91 (1), 240-259.

[34] Lamoreaux, N. and Sokoloff, K. (1997). "Inventors, Firms, and the Market for Technology: U.S. Manufacturing in the Late Nineteenth and Early Twentieth Centuries." NBER Working Paper H0098.

[35] Lamoreaux, N. and Sokoloff, K. (1999). "Inventive Activity and the Market for Technology in the United States, 1840-1920." NBER Working Paper 7107.

[36] Lerner, J. and Merges, R.P. (1998). "The Control of Technology Alliances: An Empirical Analysis of the Biotechnology Industry." *Journal of Industrial Economics*, Vol. 46, pp. 125-156.

[37] Lichtenberg, F.R., and Siegel, D. (1987). "Productivity and Changes in Ownership of Manufacturing Plants." Brookings Papers on Economic Activity 3: 643-73

[38] Maksimovic, V. and Phillips, G. (2001). "The Market for Corporate Assets: Who Engages in Mergers and Asset Sales and Are There Efficiency Gains?" *The Journal of Finance*, Vol. 56. No. 6 (Dec), 2019-2065.

[39] Mitchell, M.L. and Mulherin, J.H. (1996). "The Impact of Industry Shocks on Takeover and Restructuring Activity," *Journal of Financial Economics* 41(2): 193-229.

[40] Merges, R. P. and Nelson R.R. (1990) "On the Complex Economics of Patent Scope," *Columbia Law Review*, 4: 839-916.

[41] Pakes, A. (1986). "Patents as Options: Some Estimates of the Value of Holding European Patent Stocks." *Econometrica*, Vol. 54, No. 4

[42] Pakes, A. and Schankerman, M. "The Rate of Obsolescence of Patents, Research Gestation Lags, and the Private Return to Research Resources.' in Griliches (1984), pp. 73-88.

[43] Pakes, A. and Griliches, Z. (1984). "Patents and R&D at the Firm Level: A First Look." In *R&D, Patents and Productivity*, ed. by Z. Griliches. Chicago: University of Chicago Press.

[44] Pakes, A. and Ericson R. (1998). "Empirical Implications of Alternative Theories of Firm Dynamics." *Journal of Economic Theory*, Vol. 79, No. 1, pp. 1-45

[45] Sampat, B.N. and Ziedonis, A.A. (2002). "Cite Seeing: Patent Citations and the Economic Value of Patents." Working Paper.

[46] Schankerman, M. and Pakes, A. (1986). "Estimates of the Value of Patent Rights in European Countries During the Post-1950 Period." *The Economic Journal,* Vol. 96: No. 384, pp. 1052-1076

[47] Schmookler, J. (1966). *Invention and Economic Growth.* Cambridge: Harvard University Press, 1966.

[48] Scherer, F.M. (1982). "Inter-industry Technology Flows and Productivity Growth,", *Review of Economics and Statistics*, 64, November 1982.

[49] Scotchmer (1991). "Standing on the Shoulders of Giants: Cummulative Research and the Patent Law", *Journal of Economic Perspectives*, Vol. 5, No. 1, pp 29-41.

[50] Serrano, C. (2006). "The Market for Intellectual Property: Evidence from the Transfer of Patents", Working Paper, University of Toronto.

[51] Shepard, A. (1994) "Licensing to Enhance the Demand for New Technologies." *Rand Journal of Economics* 18 (3), 360-368.

[52] Silveira, R. and Wright, R. (2006). "Liquidity and the Market for Ideas." Working paper University of Pennsylvania.

[53] Merrill, S.A., Levin R., and Myers, M. (2004). "A Patent System for the 21st Century." Board of Science, Technology and Economic Policy. National Research Council of the National Academies. The National Academies Press, Washington D.C.

[54] Tratjenberg, M. (1990), "A Penny for your Quotes: Patent Citations and the Value of Innovations." *The Rand Journal of Economics*, Spring 1990, 21(1), 172-187.

[55] Tratjenberg, M., Jaffe, A. and Henderson, R. (1997). "University versus Corporate Patents: A Window on the Basicness of Innovation," Economics of Innovation and New Technology, 1997, 5(1), pp 19-50.

Appendix

In this section, we discuss the methodology used to create a panel of patents that details their histories of trades and renewal decisions. First, we explain the raw data that we obtained from the USPTO. Second, we present the methodology to identify subsequent assignments, or "reassignments", (i.e., other assignments than the ones from an individual inventor to, generally, the firm that he/she works at). Third, we discuss two caveats of the data. Finally, we describe the sampling of cohorts and the construction of the panel of patents used to derive the main patterns of the transfer of patents.

The Raw Data and the Methodology to Identify Reassignments

The Raw Data

The information obtained from the patent office contains all patent assignments recorded in the USPTO from August 1980 until December of 2001. An assignment as defined by the US Patent Law is a writing document that acknowledges the transfer by a party of all or part of its right, title and interest in a patent or patent application. The data, in principle, includes all patents assigned from inventor to firms, from firms to inventors, from inventor to inventor, and from firm to firm. The total number of patents assigned is very large. There are 2,753,320 records.

Each assignment contains substantial information. In particular, it contains (i) a unique identifier ("Reel Frame"), (ii) the date the assignment was recorded at the USPTO ("Recorded Date"), (iii) the date the private transaction was executed ("Date Signed"), and information on the patents or patent applications that contain such as ("Patent Number", "Application Number", "Issue Date", "Application Date" and "Patent Title"), (iv) the buyer ("Assignee"), (v) the seller ("assignor"). Finally, (vi) a brief comment that summarizes the rational behind the transaction ("Brief").[41]

We separate assignments concerning administrative events using the information contained in the "Brief" field of a patent assignment from the raw data. They are "Assignment of Assignors" (77.66%), "Merger" (3.01%), "Security Interest" (10.08%), "Change of Name" (5.18%), "Nunc Pro Tunc" (0.13%), etc. Later, we will restrict our work to "Assignment of Assignors" and "Merger" (i.e., type 1 and 2). Assignments with brief "Assignment of Assignors" contain both first assignments (i.e., from an inventor to the firm he/she works for) and reassignments (i.e., transactions that potentially represent the transfer of the ownership of a patent across firm boundaries). The rest of the type of assignments (i.e., types 2 to 9) only take place after a first assignment has taken place.

There are few preliminary procedures we follow before identifying reassignments. First, we focus on utility patents. Second, we delete patents assigned more than once within the same assignment. Third, we delete patents eventually withdrawn by the USPTO. Fourth, we consider patents that were granted before January 1, 1975 because are the ones in which both the name of inventors and assignees are available. Finally, we trim commas, dots, slashes, etc. and rename few names of assignees, buyers and sellers.

Identifying reassignments

The main objective is to differentiate first assignments from reassignments. We use of patent characteristics such as the patent's grant date, patent's application date, inventor's name and the name of the owner of the patent by the time the patent is granted (i.e., the "assignee" as of the grant date of the patent).

There are several key reasons that makes identifying reassignments difficult. First, an assignment might occur at the application date or at any date thereafter. Consequently, the first

[41] The information concerning the patents issue date is sometimes missing. We use patent characteristics information related to issue date, application number and date from other sources such as the NBER patent database or the USPTO patent grant data.

assignment of patents granted or applied before August 1980 is not necessarily contained in the raw data on assignments we obtained.[42] Second, we also found (but very rarely) that inventors (only when there is more than one inventor in the patent application) of the same patent might assign it to the same firm using separate assignments. Third, sometimes the same patent is assigned more than once stating same buyer and seller but having different execute and recorded date (this can be as a result of corrections to previous assignments, etc). These caveats of the raw data require some explicit methodology.

The methodology we use has two general principles. First, we conjecture that patents that appear to be the first time recorded as an assignment in the raw data are the patents more likely to be considered as "first assignment". However, not all first recordations are first assignments, patents applied before 1980 might appear to be assigned for first time in the raw data but maybe they were already (first) assigned at their application date. Second, we consider that transactions including only one patent with brief of type 1 are more likely to be a first assignment than others. In general, assignments first time recorded that include a single patent should be treated differently in the cleaning process.

First assignments with one patent and brief containing the words "Assignment of assignor"

The number of first assignments with one patent is 1,521,869. The method to identify redundant assignments consists in grouping assignments according to their characteristics, and then categorize them in 'types of matches'. There are some general rules that we consider when we define what a redundant and a non-redundant assignment is. In particular, redundant assignments are those that would be consistent with first assignments (i.e., an inventor appears as the seller and the buyer is the owner of the patent as of the grant date). Another one is that assignments (other than individual assigned patents) in which the inventor appears as the seller will be considered redundant.

(i) Match 1 assignments are those in which the name of the seller coincides with the inventor and the name of buyer coincides with the name of the assignee as of the granted patent date.[43] Match 1 represents 83.77% of all assignmetns.

(ii) For the rest of assignments, a match 2 assignment is one where the assignee's name coincides with the buyer's name. For instance, this could account for cases in which other inventor than the first one assigns the patent to the assignee (by the grant date). Match 2

[42] In principle all patents with an application date posterior to August 1980 that have been assigned should be included in the raw data. Of course, this does not apply to unassigned patents. Moreover, we have found some (but few) missing assignments for some patents, especially in the last months of the year 1980.

[43] First, we eliminate all commas, dots, spaces between of the stream of characters. Then we compare the first four characters. We consider that two streams of characters coincide if the first four characters are exactly the same.

represents 3.19% of all assignmetns.

(iii) For the rest of assignments, a match 3 consists of those assignments where the inventor coincides with the seller, and the type of assignment type is: "not assigned" (i.e., 1), assigned to an "U.S. individual" (i.e., 4), or assigned to a foreign individual (i.e., 5). Match 3 represents 3.01% of all assignmetns.

(iv) For the rest of the assignments, match 4 are those that the seller coincides with the inventor and the assignee type (as of the grant date) is a "U.S. firm" (i.e., 2), a "foreign firm" (i.e., 3), a "U.S. federal government agency" (i.e., 6) or a "foreign government" (i.e., 7). For instance, in some of these assignments an inventor migh be assigning the patent to the firm he/she work but the name of the assignee might be slightly different from the buyer's name (e.g. buyer as Kabushiki Kaisha Toshiba (or other names) and the assignee is Toshiba Corporation). Match 4 represents 8.15% of all assignmetns.

(v) Finally, match 5 is left for the rest of assigned patents. Match 5 represents 1.88% of all assignmetns.

The redundant assignments are the following. First, assignments that are match 1, 2 and 4. Second, assignments that date recorded coincides with the applications date. The rest of the assignments are not redundant. It is not surprising that a larger number of all assignments considering only one patent are redundants (i.e., 95.4%) because first assignments contain only one patent. This is because in the U.S. patent system inventors act as applicants rather than firms. We have 70,296 non-redundant patent assignments. The conditions for single patent assignments are more restrictive than with the rest of assignments because in principle they are more likely to be redundant.

The rest of assignments

There are 607,057 in this sample. The same rules are applied to clean the rest of assignments with only one exception, assignments under match 4, as defined above, are not considered redundant. This is based on the fact that inventors assign their patents to the firms they work in a one by one basis rather than in bundles. As a result, assignments in this sample are indeed less likely to represent first assignments (i.e., from inventor to assignee) than the ones in the previous sample. After the cleaning process, we find that 6.97% of the patent assignments in this sample are redundant, which implies that in this sample there are 564,745 non-redundant patent assignments.

Finally, considering first assignments of one patent and the rest of assignments, we have 635,041 non-redundant patent assignments.

Other cleaning issues

We examine four more issues. First, we do not consider transactions in which the buyer and seller are the same entity. In practice, we delete assignments when the first characters of the buyer and seller field coincide only when the patent was originally assigned to corporations or government agencies. The remaining number of patent assignments is 506,510.

Second, we exclude patent assignments in which the word "bank" was contained in either buyer or seller, but only when the word "bank" was initially contained in the name of the assigne of the patent as of its grant date. The reason for this is that we want to minimize the effect of potential labeling mistakes of the USPTO between "Security Interest" and "Assignment of Assignors". The patent assignments left are 490,960.

Third, we exclude patent assignments where the execution date is before the application date. These patents might be as a result of a private contracts either between inventors and firms, or between two firms before the application date of the patent. The remaining number of patent assignments is 464,343.

Fourth, we exclude patent assignments executed when patents were already expired. Sometimes and especially in large bundles of patent assigned, expired patent numbers are included in the records. This leaves us with 453,477 patent assignments.[44]

Finally, out of 453,477 patent assignments, 418,846 are due to "Assignment of Assignors", and 34,631 due to "Merger".

General caveats of the reassignments data

A first caveat is that the USPTO does not distinguish whether patents are traded as a result of an acquisition of a firm or when patents individually acquired. If patents are recorded due to the acquisition of a firm, especially a large firm, then the rational of the transaction can be other than the quality of the patent portfolio of the acquired firm. For instance, the motivation may be expanding market power, etc. To assess the importance of trades associated with firm acquisition, we analyze the time series of patent transfers. In particular, we study the merger waves of mid 1980's and late 1990's. We consider that during acquisition waves firms are less likely to be acquired because of the value of their patent portfolio. According to Mitchell and Mulherin [39], a substantial number of acquisitions in the wave of mid 1980's could be explained by major shocks such as deregulation, increased foreign competition, financial innovations, etc. Next, we study how the average number of patents contained in a transaction varies at every year in the period 1983-2000. This rate more than doubles only at years in the mid 1980's and late 1990's. In addition, we also find that the proportion of patents traded in bundles of more than 100 patents disproportionately increases in the same periods, but the number of patents included in transfers of smaller sizes, such as less than 30 patents, does not increase at the same pace. Therefore, we conclude that patents owned by large innovators are more likely to be recorded for

[44] We conjecture that technologies/innovations are associated pool of patens, thus when a technology is acquired, all patent number associated to that innovation are recorded in a single assignment at the UPSTO. The cost of an assignment are independent of the number of patents included. So, there are little incentives of not recording those patents.

other reasons than their intrinsic technological value than those of small innovators and individual inventors.

A second caveat is that the recordation of transfers of patents at the USPTO is not mandatory. We argue that this is a very minor issue. Firms and individuals who buy patents have strong financial incentives to record them at the USPTO because only recorded transfers at the USPTO act as evidence in courts of a bona fide purchase. Furthermore, anecdotal evidence from interviews with patent lawyers strongly support the effective recordation of patents traded.

Other details about the data set and patterns

The data set we have constructed is a panel containing 1,933,470 patents with 198,310 patent assignments, where a patent might have multiple assignments during its life cycle. In particular, there are 170,470 patents traded. Table 5 presents the number of patents granted and the number of patents sold by different types of patentees.

The statistics and patterns reported in the paper using the data set have been constructed by weighting each patent cohort by its number of patents granted or in some cases the number of patents that were not previously expired (i.e., still active). There are positive effects of weighting cohorts and using a large number of patents. In particular, time series effects such as merger waves and economic business cycles are smoothed out through this aggregation.

Table 5: Summary Statistics of the Number of Patents Traded and Not Traded over their Life Cycle

	Individually Owned		Corporations			Gov. Agencies
	Unassigned	Priv. Inventors	Small	Medium	Large	
Total	304,087	17,654	453,683	567,081	565,582	25,383
Traded	28,044	2,185	54,533	53,359	31,540	809
Not traded	276,043	15,469	399,150	513,722	534,042	24,574

Table 6: Predicted probability of Patents Traded and Expired by Type of Patentees

Individual owners		Corporations (Innovators)			Govt. Agen.
Unassigned	Priv. Inv.	Small	Medium	Large	
A. Predicted probability of patents traded over their life cycle					
14.1	18.6	18.3	14.1	8.8	4.1
B. Predicted probability of patents expired up to the last renewal fee					
85.0	78.4	61.7	54.0	48.7	89.1

Table 7: Predicted probability of Patents Traded and Expired by Patent Category

Chemical	Computer & Comm	Drugs & Medical	Elec. & Electro.	Mechanical	Other
A. Predicted probability of a patent being traded over the life cycle					
14.4	13.6	13.2	13.4	11.3	11.8
B. Predicted probability of patents expired up to the last renewal fee					
61.3	51.7	58.6	56.5	60.2	63.8

Table 8: Estimates of the Logit Regressions of the Decision to Trade or Allow a Patent to Expire Conditional on the Number of Patent Citations Received

	All	Individually Owned			Corporations (Innovators)				Govt. agen.
		All	Unassigned	Priv. inv.	All	Small	Medium	Large	
A. Trading Decision									
With age dummies									
total_citations	0.00689	0.0192	0.0192	0.0185	0.00498	0.0132	0.00562	-0.00614	0.00306
	(0.000295)	(0.000672)	(0.0007)	(0.00245)	(0.000309)	(0.000445)	(0.0005521)	(0.000934)	(0.0063)
With age and patent category dummies									
total_citations	0.00703	0.0163	0.0162	0.0174	0.00537	0.0109	0.00491	-0.00250	0.00432
	(0.000297)	(0.000683)	(0.000710)	(0.00254)	(0.000311)	(0.000463)	(0.000527)	(0.000910)	(0.00603)
With age, patent category and patentee dummies									
total_citations	0.00744	-	-	-	-	-	-	-	-
	(0.00029)	-	-	-	-	-	-	-	-
Obs	12876456	1969075	1856048	113027	10732311	3064018	3948742	3719551	175070
B. Expiration Decision									
With age dummies									
total_citations	-0.0579	-0.0450	-0.0448	-0.0445	-0.0557	-0.0478	-0.0594	-0.0527	-0.0518
	(0.000346)	(0.000820)	(0.000848)	(0.00318)	(0.000385)	(0.000677)	(0.000663)	(0.0006531)	(0.00265)
With age and patent category dummies									
total_citations	-0.0532	-0.0406	-0.0406	-0.0394	-0.0522	-0.0834	-0.0572	-0.0480	-0.0529
	(0.000350)	(0.000835)	(0.000864)	(0.00324)	(0.000388)	(0.00866)	(0.000667)	(0.000654)	(0.00271)
With age, patent category and patentee dummies									
total_citations	-0.0499	-	-	-	-	-	-	-	-
	(0.000349)	-	-	-	-	-	-	-	-
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, ***Not statistically significant at the 10% level.

Table 9: Estimates of the Logit Regressions of the Decision to Trade and Expire a Patent for Previously Traded Patents

A. Trading Decision

	All	Individual Owners			Corporations (Innovators)				Govt. agen.
		All	Unassigned	Priv. inv.	All	Small	Medium	Large	
Controls: age dummies									
Previouslytraded	1.0401	1.1221	1.1376	0.8926	1.0085	0.8591	0.8904	1.1814	0.9091
	(0.00691)	(0.0156)	(0.0162)	(0.0570)	(0.00774)	(0.0116)	(0.0130)	(0.0177)	(0.1530)
Controls: age and patent category dummies									
Previouslytraded	1.0317	1.0926	1.1052	0.8894	0.9976	0.8425	0.8793	1.1451	0.8631
	(0.00692)	(0.0156)	(0.0163)	(0.0570)	(0.00775)	(0.0116)	(0.0130)	(0.0178)	(0.1533)
Controls: age, patent category dummies and citations									
Previouslytraded	1.0277	1.0716	1.0844	0.8684	0.9952	0.8307	0.8776	1.1447	0.8588
	(0.00692)	(0.0157)	(0.0163)	(0.0572)	(0.00776)	(0.0117)	(0.013)	(0.0178)	(0.1537)
Controls: age, patent category, patentee dummies and citations									
Previouslytraded	0.9428	-	-	-	-	-	-	-	-
	(0.00697)	-	-	-	-	-	-	-	-
Obs	10942986	1647334	1551961	95373	9145965	2610335	3381661	3153969	149687

B. Expiration Decision

Controls: age dummies									
Previouslytraded	-0.3011	-0.8969	-0.8993	-0.8264	-0.1552	-0.3440	-0.1136	-0.1379	-1.0576
	(0.00573)	(0.0128)	(0.0132)	(0.0490)	(0.00647)	(0.0101)	(0.0103)	(0.0148)	(0.0746)
Controls: age and patent category dummies									
Previouslytraded	-0.3155	-0.8723	-0.8730	-0.8355	-0.1663	-0.3341	-0.1060	-0.1762	-1.0472
	(0.00576)	(0.0128)	(0.0133)	(0.0492)	(0.00649)	(0.0102)	(0.0104)	(0.0148)	(0.0751)
Controls: age, patent category dummies and citations									
Previouslytraded	-0.2904	0.8270	-0.8280	-0.7882	-0.1482	-0.2906	-0.0910	-0.1913	-0.9873
	(0.0058)	(0.0129)	(0.0134)	(0.0495)	(0.00654)	(0.0102)	(0.0104)	(0.0150)	(0.0759)
Controls: age, patent category, patentee dummies and citations									
Previouslytraded	-0.3554	-	-	-	-	-	-	-	-
	(0.00589)	-	-	-	-	-	-	-	-
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, ***Not statistically significant at the 10% level.

Table 10: Estimates of the Logit Regressions of the Decision to Allow a Patent to Expire or Being Traded Conditional on Patent Generality

	All	Individually owned			Corporations (Innovators)				Govt. agen.
		All	Unassigned	Priv. inv.	All	Small	Medium	Large	
A. Trading Decision									
With age dummies									
generality	0.1902	0.2144	0.2127	0.2132	0.1978	0.2011	0.1833	0.2099	-0.0860***
	(0.00697)	(0.0160)	(0.0166)	(0.0591)	(0.00777)	(0.0121)	(0.0126)	(0.0169)	(0.1020)
With age and patent category dummies									
generality	0.2119	0.2109	0.2092	0.2051	0.2146	0.1975	0.1749	0.2125	-0.0928***
	(0.00699)	(0.0162)	(0.0168)	(0.0602)	(0.00779)	(0.0122)	(0.0127)	(0.0169)	(0.1020)
With age, patent category dummies and citations									
generality	0.2073	0.2034	0.2015	0.1997	0.2109	0.1903	0.1710	0.2151	-0.0978***
	(0.00702)	(0.0163)	(0.0169)	(0.0606)	(0.00781)	(0.0123)	(0.0127)	(0.0169)	(0.1025)
With age, patent category, patentee dummies and citations									
generality	0.1977	-	-	-	-	-	-	-	-
	(0.00703)	-	-	-	-	-	-	-	-
Obs	12876456	1969075	1856048	113027	10732311	3064018	3948742	3719551	175070
Used	11395526	1717383	1617743	99640	9527208	2707508	3485280	3334430	150170
B. Expiration Decision									
With age dummies									
generality	-0.1862	-0.0982	-0.0965	-0.1056*	-0.1765	-0.1418	-0.2099	-0.1828	-0.1145
	(0.00508)	(0.0106)	(0.0109)	(0.0459)	(0.00596)	(0.0101)	(0.00978)	(0.0114)	(0.0350)
With age and patent category dummies									
generality	-0.1681	-0.0958	-0.0940	-0.1110	-0.1666	-0.1407	-0.2012	-0.1670	-0.1224
	(0.00510)	(0.0108)	(0.0111)	(0.0465)	(0.00597)	(0.0101)	(0.00980)	(0.0114)	(0.0352)
With age, patent category dummies and citations									
generality	-0.0502	-0.0386	-0.0386	-0.0369	-0.0492	-0.0435	-0.0538	-0.0455	-0.0511
	(0.000359)	(0.000856)	(0.000887)	(0.0033)	(0.000399)	(0.000707)	(0.000687)	(0.000671)	(0.0281)
With age, patent category, patentee dummies and citations									
generality	-0.0818	-	-	-	-	-	-	-	-
	(0.00513)	-	-	-	-	-	-	-	-
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882
Used	2084493	331408	312327	19081	1721853	501791	637128	582934	31232

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, ***Not statistically significant at the 10% level.

Table 11: Estimates of the Logit Regressions of the Decision to Trade and let a Patent Expire Conditioning on the Number of Years Since the Last Transfer

	All	Individual Owners			Corporations (Innovators)				Govt. agen.
		All	Unassigned	Priv. inv.	All	Small	Medium	Large	
A. Trading decision									
With age dummies									
tradedyearsago	-0.1236	-0.1932	-0.2013	-0.0819***	-0.1092	-0.0968	-0.1642	-0.0274***	0.5787*
	(0.00815)	(0.0177)	(0.0183)	(0.0714)	(0.00919)	(0.0136)	(0.0150)	(0.0232)	(0.2831)
tradedyearsago^2	0.00548	0.00938	0.00999	0.000386***	0.00466	0.00457	0.0102	-0.00825	-0.0729*
	(0.000725)	(0.00156)	(0.00160)	(0.00681)	(0.000819)	(0.00123)	(0.00128)	(0.00227)	(0.0294)
With age and patent category dummies									
tradedyearsago1	-0.1235	-0.1929	-0.2014	0.0788***	-0.1091	-0.0964	-0.1639	-0.028***	0.5869*
	(0.00815)	(0.0177)	(0.0183)	(0.0715)	(0.00919)	(0.0136)	(0.0150)	(0.0232)	(0.2830)
tradedyearsago^2	0.00547	0.00939	0.0100	0.000421***	0.00463	0.00461	0.0101	-0.00795	-0.0728*
	(0.000725)	(0.00156)	(0.00160)	(0.00681)	(0.000819)	(0.00123)	(0.00128)	(0.00226)	(0.0293)
With age, patent category dummies and citations									
tradedyearsago1	-0.1234	-0.1934	-0.2018	-0.0798***	-0.1089	-0.0962	-0.1635	-0.028***	0.5849*
	(0.00815)	(0.0177)	(0.0183)	(0.0715)	(0.00919)	(0.0136)	(0.015)	(0.0232)	(0.2839)
tradedyearsago^2	0.0055	0.00949	0.0101	0.000652***	0.00466	0.00461	0.0101	-0.00789	-0.0729*
	(0.000725)	(0.00156)	(0.0016)	(0.00682)	(0.000819)	(0.00123)	(0.00128)	(0.00226)	(0.0293)
With age, patent category, patentee dummies and citations									
tradedyearsago1	-0.1291	-	-	-	-	-	-	-	-
	(0.00815)	-	-	-	-	-	-	-	-
tradedyearsago^2	0.00582	-	-	-	-	-	-	-	-
	(0.000724)	-	-	-	-	-	-	-	-
Obs	10942986	1647334	1551961	95373	9145965	2610335	3381661	3153969	149687
Used	833270	156274	144592	11682	672783	271308	260889	140586	4213
B. Expiration decision									
With age dummies									
tradedyearsago	0.3699	0.4013	0.4099	0.2959	0.3589	0.3166	0.3565	0.4271	0.4828
	(0.0080)	(0.0188)	(0.0196)	(0.0693)	(0.00890)	(0.0138)	(0.0143)	(0.0202)	(0.1123)
tradedyearsago^2	-0.0225	-0.0230	-0.0236	-0.0149	-0.0222	-0.0201	-0.0210	-0.0278	-0.0364
	(0.000643)	(0.00148)	(0.00154)	(0.00534)	(0.000720)	(0.00113)	(0.00114)	(0.00164)	(0.00939)
With age and patent category dummies									
tradedyearsago	0.370	0.4047	0.4141	0.2999	0.3594	0.3192	0.3565	0.4298	0.4984
	(0.00802)	(0.0189)	(0.0196)	(0.0694)	(0.00892)	(0.0139)	(0.0143)	(0.0202)	(0.1130)
tradedyearsago^2	-0.0226	-0.0231	-0.0237	-0.0151	-0.0223	-0.0204	-0.0210	-0.0279	-0.0374*
	(0.000645)	(0.00148)	(0.00155)	(0.00535)	(0.000721)	(0.00113)	(0.00114)	(0.00165)	(0.00945)
With age, patent category dummies and citations									
tradedyearsago	0.3691	0.4080	0.4172	0.3087	0.3574	0.3193	0.3498	0.4309	0.5085
	(0.00807)	(0.0190)	(0.0197)	(0.0701)	(0.00897)	(0.0139)	(0.0144)	(0.0204)	(0.1143)
tradedyearsago^2	-0.0226	-0.0232	-0.0239	-0.0154	-0.0223	-0.0204	-0.0207	-0.0285	-0.0362
	(0.00065)	(0.00149)	(0.00156)	(0.0054)	(0.000727)	(0.00114)	(0.00115)	(0.00167)	(0.00959)
With age, patent category, patentee dummies and citations									
tradedyearsago	0.3641	-	-	-	-	-	-	-	-
	(0.00807)	-	-	-	-	-	-	-	-
tradedyearsago^2	-0.0225	-	-	-	-	-	-	-	-
	(0.00065)	-	-	-	-	-	-	-	-
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882
Used	212705	39844	36906	2938	171754	69986	66495	35273	1107

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, ***Not statistically significant at the 10% level, and ****The valididty of the model fit is questinable.

Table 12: Estimates of the Logit Regressions of the Decision to Sell and Expire a Patent Conditional on its Age by Type of Patentees (With Age Dummies)

	All	Individually Owned			Corporations (Innovators)				Govt. agen****
		All	Unassigned	Priv. inv.****	All	Small	Medium	Large	
A. Trading decision with age dummies									
intercept	-4.8354	-4.7893	-4.7185	-	-4.8341)	-4.7686	-4.6403	-5.170	-
	(0.0448)	(0.1392)	(0.1393)	-	(0.0473	(0.0894)	(0.0692)	(0.0943)	-
age_year1	0.8306	1.2407	1.1498	-	0.7586	1.1072)	0.6722	-0.3664	-
	(0.0451)	(0.1396)	(0.1397)	-	(0.0477)	(0.00899	(0.0692)	(0.0955)	-
age_year2	0.7499	0.8487	0.7586	-	0.7281	1.0352	0.6248	0.4421	-
	(0.0451)	(0.1399)	(0.1400)	-	(0.0478)	(0.090)	(0.070)	(0.0955)	-
age_year3	0.6861	0.6726	0.5869	-	0.6915	0.9748	0.5513	0.5043	-
	(0.0452)	(0.1400)	(0.1402)	-	(0.0478)	(0.0901)	(0.0710)	(0.0956)	-
age_year4	0.6807	0.6586	0.5685	-	0.6869	0.9644	0.5173	0.5443	-
	(0.0453)	(0.1401)	(0.1403)	-	(0.0479)	(0.0902)	(0.0702)	(0.0957)	-
age_year5	0.7119	0.8275	0.7376	-	0.6934	0.9835	0.4826	0.6330	-
	(0.0454)	(0.1405)	(0.1406)	-	(0.0481)	(0.0904)	(0.0706)	(0.0957)	-
age_year6	0.5990	0.6301	0.5455	-	0.5937	0.8854	0.3877	0.5172	-
	(0.0456)	(0.1409)	(0.1411)	-	(0.0482)	(0.0906)	(0.0708)	(0.0963)	-
age_year7	0.5559	0.5490	0.4615	-	0.5613	0.8259	0.3311	0.5593	-
	(0.0457)	(0.1412)	(0.1414)	-	(0.0484)	(0.0908)	(0.0711)	(0.0964)	-
age_year8	0.5446	0.5972	0.5132	-	0.5412	0.8163	0.2659	0.5834	-
	(0.0458)	(0.1413)	(0.1415)	-	(0.0485)	(0.0910)	(0.0711)	(0.0966)	-
age_year9	0.6311	0.7974	0.7124	-	0.6039	0.8441	0.3283	0.7258	-
	(0.0462)	(0.1425)	(0.1428)	-	(0.0490)	(0.0918)	(0.0724)	(0.0972)	-
age_year10	0.5971	0.6849	0.5949	-	0.5837	0.7573	0.4074	0.6565	-
	(0.0465)	(0.1432)	(0.1436)	-	(0.0492)	(0.0923)	(0.0725)	(0.0979)	-
age_year11	0.5500	0.6849	0.5515	-	0.5331	0.6968	0.3173	0.6565	-
	(0.0468)	(0.1432)	(0.1445)	-	(0.0496)	(0.0929)	(0.0733)	(0.0979)	-
age_year12	0.4789	0.5853	0.5190	-	0.4607	0.6097	0.2553	0.6008	-
	(0.0473)	(0.1451)	(0.1455)	-	(0.0501)	(0.0938)	(0.0743)	(0.0993)	-
age_year13	0.5954	0.8155)	0.7331	-	0.5627	0.6960	0.4627	0.5816	-
	(0.0487)	(0.1488	(0.1496)	-	(0.0517)	(0.0965)	(0.0763)	(0.1028)	-
age_year14	0.5378	0.6785	0.6197	-	0.5172	0.6994	0.2806)	0.6638	-
	(0.0500)	(0.1529)	(0.1537)	-	(0.0530)	(0.0982)	(0.0796	(0.1042)	-
age_year15	0.3606	0.5766	0.4955	-	0.3270)	0.4864	0.1981*	0.3550	-
	(0.0523)	(0.1578)	(0.1593)	-	(0.0556	(0.1027)	(0.0830)	(0.1104)	-
age_year16	0.3114	0.2433)	0.1992***	-	0.3141	0.3213	0.1552**	0.5464	-
	(0.0552)	(0.1729	(0.1743)	-	(0.0584)	(0.1098)	(0.0878)	(0.1125)	-
Obs	12876456	1969075	1856048	113027	10732311	3064018	3948742	3719551	175070
B. Expiring decision with age dummies									
intercept	-0.6941	-0.2969	-0.2900	-0.4012	-0.7631	-0.7075	-0.7265	-0.8504	0.0895*
	(0.00395)	(0.0108)	(0.0112)	(0.0437)	(0.00429)	(0.00811)	(0.00690)	(0.00744)	(0.0368)
age_year5	-0.8806	-0.3888	-0.3809	-0.5512	-1.1018	-0.7820	-1.1864	-1.4035	-1.2133
	(0.00458)	(0.0117)	(0.0121)	(0.0479)	(0.00515)	(0.00931)	(0.00840)	(0.00942)	(0.0402)
age_year9	-0.2293	-0.0126	-0.0126	-0.0185***	-0.3133	-0.1809	-0.3417	-0.4122	0.1703
	(0.0202)	(0.0125)	(0.0129)	(0.0506)	(0.00521)	(0.00967)	(0.00840)	(0.00917)	(0.0412)
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, *** Not statistically significant at the 10% level, ****The valididty of the model fit is questionable.

Table 13: Estimates of the Logit Regressions of the Decision to Sell and Expire a Patent Conditional on its Age by Type of Patentees (With Age and Patent Category Dummies)

	All	Individually Owned			Corporations (Innovators)				Govt. age.****
		All	Unassigned	Priv. inv.****	All	Small	Medium	Large	
A. Trading decision with age and patent category dummies									
intercept	-4.7716	-4.9988	-4.9320	-	-4.7036	-4.8248	-4.6152	-4.9348	-
	(0.0450)	(0.1395)	(0.1395)	-	(0.0476)	(0.0897)	(0.0698)	(0.0958)	-
age_year1	0.8584	1.2533	1.635	-	0.7617	1.0819	0.6687	0.3968	-
	(0.0451)	(0.1397)	(0.1397)	-	(0.0477)	(0.0899)	(0.0699)	(0.0955)	-
age_year2	0.7475)	0.8623	0.7733	-	0.7305	1.0121	0.6219	0.4689	-
	(0.0452	(0.1399)	(0.1400)	-	(0.0478)	(0.0900)	(0.0700)	(0.0956)	-
age_year3	0.6835	0.6869	0.6024	-	0.6932	0.9541	0.5490	0.5276	-
	(0.0452)	(0.1401)	(0.1402)	-	(0.0479)	(0.0901)	(0.0701)	(0.0956)	-
age_year4	0.6780	0.6743	0.5853	-	0.6883	0.9461	0.5157	0.5640	-
	(0.0453)	(0.1401)	(0.1403)	-	(0.0479)	(0.0902)	(0.0702)	(0.0957)	-
age_year5	0.7110	0.8324	0.7432	-	0.6964	0.9655	0.4808	0.6529	-
	(0.0454)	(0.1405)	(0.1407)	-	(0.0481)	(0.0904)	(0.0706)	(0.0959)	-
age_year6	0.5986)	0.6365	0.5527	-	0.5967	0.8694	0.3866	0.5342	-
	(0.0456	(0.1409)	(0.1411)	-	(0.0482)	(0.0906)	(0.0709)	(0.0963)	-
age_year7	0.5554	0.5572	0.4704	-	0.5640	0.8118	0.3309	0.5726	-
	(0.0457)	(0.1412)	(0.1414)	-	(0.0484)	(0.0908)	(0.0711)	(0.0965)	-
age_year8	0.5443	0.6073	0.5240	-	0.5437	0.8038	0.2667	0.5939	-
	(0.0458)	(0.1413)	(0.1415)	-	(0.0485)	(0.0910)	(0.0715)	(0.0966)	-
age_year9	0.6326	0.7953	0.7104	-	0.6085	0.8299	0.3280	0.7427	-
	(0.0462)	(0.1425)	(0.1428)	-	(0.0490)	(0.0918)	(0.0724)	(0.0972)	-
age_year10	0.5988	0.6839	0.5940	-	0.5882	0.7445	0.4077	0.6719	-
	(0.0465)	(0.1433)	(0.1437)	-	(0.0492)	(0.0923)	(0.0725)	(0.0979)	-
age_year11	0.5517	0.6507	0.5530	-	0.5373	0.6851	0.3174	0.6833	-
	(0.0468)	(0.1440)	(0.1445)	-	(0.0496)	(0.0929)	(0.0733)	(0.0984)	-
age_year12	0.4808	0.5872	0.5214	-	0.4646	0.5993	0.2551	0.6132	-
	(0.0473)	(0.1451)	(0.1455)	-	(0.0502)	(0.0939)	(0.0743)	(0.0993)	-
age_year13	0.5983	0.8100	0.7280	-	0.5679	0.6845	0.4620	0.6003	-
	(0.0487)	(0.1489)	(0.1497)	-	(0.0517)	(0.0965)	(0.0763)	(0.1028)	-
age_year14	0.5408	0.6749	0.6166	-	0.5220	0.6916	0.2805	0.6811	-
	(0.0500)	(0.1529)	(0.1538)	-	(0.0530)	(0.0982)	(0.0796)	(0.1042)	-
age_year15	0.3629	0.5742	0.4934	-	0.3306	0.4812	0.1986*	0.3688	-
	(0.0523)	(0.1578)	(0.1593)	-	(0.0556)	(0.1027)	(0.0830)	(0.1104)	-
age_year16	0.3123	0.2423***	0.1982***	-	0.3156	0.3192	0.1556**	0.5532	-
	(0.0552)	(0.1730)	(0.1743)	-	(0.0584)	(0.1098)	(0.0878)	(0.1125)	-
Obs	12876456	1969075	1856048	113027	10732311	3064018	3948742	3719551	175070
B. Expiring decision with age and patent category dummies									
intercept	-0.3483	-0.1314	-0.1270	-0.2172	-0.5601	-0.5771	-0.6523	-0.7339	0.2372
	(0.00495)	(0.0117)	(0.0121)	(0.0484)	(0.00582)	(0.00954)	(0.00961)	(0.0140)	(0.0506)
age_year5	-0.8935	-0.4045	-0.3964	-0.5712	-1.1014	-0.7795	-1.1854	-1.4110	-1.2431
	(0.00461)	(0.0118)	(0.0121)	(0.0482)	(0.00517)	(0.00933)	(0.00841)	(0.00948)	(0.0405)
age_year9	-0.2366	-0.0199***	-0.0198***	-0.0305***	-0.3157	-0.1802	-0.3428	-0.4216	0.1537
	(0.00476)	(0.0125)	(0.0129)	(0.0509)	(0.00522)	(0.00969)	(0.00842)	(0.00922)	(0.0415)
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, *** Not statistically significant at the 10% level, ****The valididty of the model fit is questinable.

Table 14: Estimates of the Logit Regressions of the Decision to Sell and Expire a Patent Conditional on its Age by Type of Patentees (With Age, Patent Category Dummies and Citations)

	All	Individually Owned			Corporations (Innovators)				Govt. agen.
		All	Unassigned	Priv. inv.****	All	Small	Medium	Large	
A. Trading decision with age,patent category dummies and citations									
intercept	-4.8493	-5.2216	-5.1547	-	-4.7020	-4.9452	-4.6651	-4.9087	-6.4821
	(0.0452)	(0.1419)	(0.1421)		(0.0478)	(0.0899)	(0.070)	(0.0963)	(1.0095)
age_year1	0.9408	1.4837	1.3937	-	0.8238)	1.2103	0.7211	0.3698	1.1199***
	(0.0453)	(0.1422)	(0.1424)		(0.0479	(0.0901)	(0.0701)	(0.0960)	(1.00620)
age_year2	0.8258	1.0857	0.9966	-	0.7893	1.1347	0.6713	0.4436	0.9398***
	(0.0454)	(0.1424)	(0.1426)		(0.0480)	(0.0902)	(0.0702)	(0.0960)	(1.0069)
age_year3	0.7561	0.9001	0.8155	-	0.7474)	1.0681	0.5945	0.5047	0.6874***
	(0.0454)	(0.1425)	(0.1427)		(0.0480	(0.0903)	(0.0703)	(0.0960)	(1.0081)
age_year4	0.7444	0.8757	0.7867	-	0.7377	1.0504	0.5568	0.5436	0.9645***
	(0.0454)	(0.1425)	(0.1428)		(0.0481)	(0.0903)	(0.0704)	(0.0960)	(1.0067)
age_year5	0.7700	1.0185	0.9295	-	0.7400	1.0581	0.5168	0.6352	0.8431***
	(0.0456)	(0.1428)	(0.1431)		(0.0482)	(0.0905)	(0.0707)	(0.0961)	(1.0090)
age_year6	0.6512	0.8086	0.7253	-	0.6354	0.9515	0.4183	0.5188	1.2338***
	(0.0457)	(0.1432)	(0.1435)		(0.0483)	(0.0907)	(0.0709)	(0.0965)	(1.0068)
age_year7	0.6027	0.7172	0.6312	-	0.5985	0.8844	0.3590	0.5592)	0.6795***
	(0.0458)	(0.1434)	(0.1437)		(0.0484)	(0.0909)	(0.0712)	(0.0966	(1.0108)
age_year8	0.5866	0.7552	0.6727	-	0.5744	0.8675	0.2917	0.5821	0.2795***
	(0.0459)	(0.1435)	(0.1438)		(0.0486)	(0.0910)	(0.0715)	(0.0967)	(1.0160)
age_year9	0.6661	0.9179	0.8340	-	0.6329	0.8786	0.3474	0.7335	1.2004***
	(0.0463)	(0.1446)	(0.1450)		(0.0490)	(0.0918)	(0.0724)	(0.0973)	(1.0157)
age_year10	0.6279	0.7943	0.7054	-	0.6094	0.7855	0.4244	0.6640	0.8873***
	(0.0466)	(0.1453)	(0.1458)		(0.0493)	(0.0923)	(0.0725)	(0.0979)	(1.0235)
age_year11	0.5770	0.7511	0.6547	-	0.5557	0.7184	0.3319	0.6766	1.1492***
	(0.0469)	(0.1460)	(0.1466)		(0.0497)	(0.0929)	(0.0733)	(0.0984)	(1.0207)
age_year12	0.5022	0.6759	0.6120	-	0.4803	0.6262	0.2671	0.6076	1.1230***
	(0.0474)	(0.1471)	(0.1476)		(0.0502)	(0.0939)	(0.0743)	(0.0994)	(1.0244)
age_year13	0.6086	0.8632	0.7843	-	0.5754	0.6914	0.4672	0.5978	1.1614***
	(0.0488)	(0.1508)	(0.1517)		(0.0517)	(0.0965)	(0.0763)	(0.1028)	(1.0550)
age_year14	0.5471	0.7140	0.6591	-	0.5264	0.6902	0.2834	0.6794	1.1184***
	(0.0501)	(0.1549)	(0.1558)		(0.0530)	(0.0982)	(0.0796)	(0.1042)	(1.0700)
age_year15	0.3671	0.6025	0.5250	-	0.3336	0.4789	0.1987*	0.3679	1.3161***
	(0.0524)	(0.1598)	(0.1613)		(0.0557)	(0.1028)	(0.0830)	(0.1104)	(1.0701)
age_year16	0.3160	0.2544***	0.2131***	-	0.3185	0.3185	0.1568**	0.5525	1.4790***
	(0.0553)	(0.1750)	(0.1765)		(0.0584)	(0.1098)	(0.0879)	(0.1125)	(1.0813)
Obs	12876456	1969075	1856048	113027	10732311	3064018	3948742	3719551	175070
B. Expiring decision with age, patent category dummies and citations									
intercept	0.00883***	0.1336	0.1364	0.0629***	-0.2035	-0.2603	-0.2722	-0.3745	0.5870
	(0.00545)	(0.0129)	(0.0133)	(0.0533)	(0.00636)	(0.0105)	(0.0105)	(0.0148)	(0.0540)
age_year5	-1.1390	-0.5939	-0.0406	-0.7755	-1.3425	-1.0015	-1.4353	-1.6417	-1.5186
	(0.00488)	(0.0124)	(0.000864)	(0.0510)	(0.00546)	(0.00993)	(0.00862)	(0.00941)	(0.0433)
age_year9	-0.3490	-0.1113	-0.1103	-0.1316	-0.4247	-0.2821	-0.4576	-0.5228	0.0136
	(0.00487)	(0.0128)	(0.0132)	(0.0520)	(0.00534)	(0.00988)	(0.00862)	(0.00941)	(0.0427)
Obs	2321364	373918	352559	21359	1911564	559918	712799	638847	35882

*Not statiscally significant at the 1% level, **Not statistically significant at the 5% level, *** Not statistically significant at the 10% level, ****The valididty of the model fit is questinable.

Table 15: Estimates of the Logit Regressions of the Decision to Sell and Expire Patent Conditional on its Age by Type of Patentees (With Age, Patent Category, Patentee Dummies and Citations)

A. Trading decision with age, patent category, patentee dummies and citations

intercept	-6.1570
	(0.0568)
age_year1	0.9253
	(0.0453)
age_year2	0.8082
	(0.0454)
age_year3	0.7363
	(0.0454)
age_year4	0.7222
	(0.0455)
age_year5	0.7576
	(0.0456)
age_year6	0.6380
	(0.0457)
age_year7	0.5885
	(0.0458)
age_year8	0.5724
	(0.0459)
age_year9	0.6584
	(0.0463)
age_year10	0.6186
	(0.0466)
age_year11	0.5663
	(0.0469)
age_year12	0.4915
	(0.0474)
age_year13	0.6021
	(0.0488)
age_year14	0.5389
	(0.0501)
age_year15	0.3619
	(0.0524)
age_year16	0.3112
	(0.0553)
obs	12876456

B. Expiring decision with age, patent category, patentee dummies and citations

intercept	0.6308
	(0.0126)
age_year5	-1.2198
	(0.00497)
age_year9	-0.3853
	(0.00493)
Obs	2321364