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Selling Ideas: The Determinants of Patent Value in an Auction Environment

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Abstract: Although previous empirical studies have found relationships between patent characteristics and value, none have determined how specific attributes relate to auction value or even the probability of a successful auction sale. Using a Heckman two-step model, we regress thirteen independent variables against unique patent auction data, finding that publicly-owned and frequently referenced patents are more valuable, and that other things equal, there is an optimal time to offer a patent up for auction.

Keywords: auction, patent, citation, valuation

JEL codes: O31, O32, O33, O34

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I. Introduction

Patent rights have gone through a revolutionary period in the U.S. over the last twenty-five years. In 1980 the Bayh-Dole Act permitted organizations receiving grant funding to apply for patents on the results of those grant-supported activities. In 1982, the Federal Circuit Court of Appeals clarified patent litigation, shifting rulings from ten percent in favor of patent-holders to seventy percent in favor (McDaniel, 1). U.S. law converged to World Trade Organization standards in 1994, limiting patent terms to twenty years from date of application. The American Inventors Protection Act of 2001 curtailed the period of secrecy to eighteen months after application, again in accordance with international standards. In short, it has been a period of remarkable change.

At the same time, "intellectual property is becoming more and more crucial to a company's overall operations and financial health. Since intellectual property (IP) accounts for a large percentage of corporate assets in today's companies, understanding IP valuation is critical" (Suchy, 2006). The last ten years have been a period of exponential growth in the IP sector and the U.S., as of March 2007, has issued more than 7 million patents. Even more striking, twenty-two percent of all patents in U.S. history have been granted in the last ten years. Those patents are held for strategic reasons, for market capture reasons, and often as revenue generators. IBM earns $1.5 billion annually in revenue by sharing its IP with others (Davis and Harrison, 2001).

Given those trends, it is surprising that more work has not been done in the academic literature on the financial valuation of patent rights. Granted, most analysis must be done on a case-by-case basis, as patents are by their nature creative and idiosyncratic in their scope, depth, strength and importance. The IP valuation industry has grown and matured to deal with precisely this problem, but is often centered around brokered deals between interested parties rather than a free market sale of IP to the highest bidder.

In December 2004, freepatentauction.com was created to provide a free venue for inventors to post their inventions for licensing or sale. The website does not provide any guidance or support to buyers or sellers but prides itself on the free service it provides. To date their have been over thirteen hundred patents posted on this site, but no information is available regarding actual sales.

Similarly, in April 2006, Ocean Tomo, a Chicago-based IP firm, introduced the idea of holding a public auction, selling patent lots put up for sale by current owners. Outside of these two forums, we know of no other known market-based IP sales institutions, leaving little prior work in this area.

In this paper, we use unique data on patent auctions to determine whether known objective patent characteristics lend value to a patent offered for sale, or add to the probability of a successful sale. Section II reviews the current literature on patent valuation, Section III introduces our dataset, while Section IV builds the model. Section V presents our estimates, leaving conclusions for Section VI.

II. Literature Review

Ultimately this paper will evaluate how well an auction environment predicts the value of a patent using a combination of predictive (a priori) and reflective (a posteriori) variables. In order to measure the worth of a patent, it is first necessary to decide upon the definition of value. Our interest is primarily in financial value at auction, rather than, for example, social value to subsequent innovators, although there may be strong correlation between those values. As a single sales value, we are also considering only the "representation of all future benefits of ownership, compressed into a single payment" (Smith and Parrs, 2005).

Lanjouw and Schankerman (1997; 1999) did seminal work in this literature, finding that a patent's quality was a strong function of its number of claims and number of forward citations most prominently, with some role for backward citations, family size, technology group (International Patent Class, or IPC) and nationality of the patentee. They also demonstrated that litigated patents were more valuable than non-litigated patents, ceteris paribus, number of claims, backward and forward citations, family size, IPC, and nationality of the patentee.

Reitzig (2003) provides not only a good review of the existing patent valuation literature on patent valuation, but an empirical study on how some characteristics of a semiconductor patent affect economic value. Built upon a model by Harhoff et al. (2003), he uses a survey of 127 patent-holders to determine that the most important indicators of the present value of a patent are primarily firm-specific: the level of importance the IP has to a specific firm, the inter-related importance of current IP as related to other IP held, the usefulness of the IP to other firms, and the

difficulty in legally creating a similar invention. Unfortunately, the dependent variable and the importance of each independent variable were described by survey respondents using a seven-point Likert scale, making interpersonal comparisons challenging and making financial conclusions impossible.

Harhoff et al. (2003) expanded in this direction, adding renewal behavior to the standard list of descriptive characteristics and deepening the measure of value. Using over eleven thousand German patent in 1977, they surveyed each patent-holder for their subjective financial range of valuations. Using an ordered probit model, they found that patents upheld in legal opposition, representing large international families, and containing many backward and forward citations had significantly higher patent value. Technological field (IPC) was insignificant.

Reitzig (2004) incorporated indicators from the corporate level, including a separate estimation for the probability of subsequent litigation. Using a Probit model, Reitzig found that family size, number of inventors, backward citations, and the technological field were all highly significant predictors of future litigation (and in correlated fashion, higher valuation).

Unlike Reitzig, Hall et al. (2005) "explore[d] the usefulness of patent citations as a measure of the 'importance' of a firm's patents, as indicated by the stock market valuation of the firm's intangible stock of knowledge". The authors used alternative measures of knowledge stock (R&D, patent counts and patent citations), to compare with stock-market based measures of value (total market value, book value, and Tobin's Q). Using over twelve thousand observations collected from data on publicly held corporations, they found market and book value to be skewed and R&D stocks

to be more highly correlated to market value than to patent value. They further concluded that patent citations offer an important element of information in addition to R&D and simple patent counts, in the determination of value.

Hall and MacGarvie (2006) focused specifically on software patents, using an event study of the stock market impact of software patent issuance, and a further estimation of the effect on Tobin's Q of software patents using patent related measures. They found that R&D has a strong relationship with Tobin's Q while patents or cited patents have a weaker but significant relationship, concluding that software patents are more widely valued then other patents and holding a citation makes a firm more valuable.

Wu and Tseng (2006) and Amram (2005) studied value using the real options model. Wu and Tseng found unsurprisingly that the underlying assets, time to maturity, and risk free rate all have a positive and significant effect on patent value while volatility, measured as the immeasurable change of stock pricing, has a negative effect, but is insignificant.

To our knowledge, the current study is the first to use auction sales valuation as a dependent variable, so should buttress the existing literature, or challenge it with an alternative and objective measurement of financial value.

III. Auction Data

The financial data were collected at the first two Ocean Tomo live patent auctions, in April and October of 2006, and consist of 172 patent lots including 51

sales. Full supporting infor mation was only available for 49 sold and 52 unsold lots, resulting in 101 observed lots as the basis for this paper.

Each patent lot consisted of patents in identical industries with similar technologies and ranged from single patents to 22 patents per lot. The lots constitute a final list of 373 patents (list available from the authors). Information on each patent was collected from U.S. Patent and Trademark Office and European Patent Office sources, but in order to compare lots, the mean lot value of each variable has been used in the results which follow.

Table 1 presents summary statistics at both the individual patent and patent-lot level. We now turn to briefly explain each independent variable and its potential significance for valuation.

Log value

Since financial values ranged from $2,200 to $1,540,000 we use the log to improve the fit of our proposed explanation.

Scope

Upon application, every patent is assigned one or more nine-digit International Patent Classes (IPCs) to denote the technology. Scope is the number of IPCs assigned, and ranges in our sample from one for very precise and limited innovations to twenty in the case of broad or more general purpose technologies. Preceding literature predicts that patent lots with broader average scope will have lower value.

Family size

A patent family consists of all applications related to the granted patent filed in other jurisdictions, ranging in our sample from 0 (U.S. only) to 64 (a widely protected, almost global patent). The literature shows that family size has a strong, positive effect on value.

Forward citations

In order for a patent to be granted it must cite all relevant prior inventions related to the work. Forward citations are references from subsequent patents to patents in our sample. Patent lots in our sample range from an average of zero (no subsequent citations in the entire patent lot) to 213. The current literature is consistent in finding that forward citations have great impact on financial value.

Backward citations

Backward citations are references to prior art by patents in our sample lots, and range from a lot average of zero to 138. Previous findings show that cited or backward citations have little impact on value.

Claims

The "claims" constitute the patent, describing the novelty and features of the innovation. Naturally, there is an incentive to claim as broad a technological space as possible (Lanjouw and Schankerman, 1999). In our sample, claims also range from one to an average of one hundred, reemphasizing the variation in importance in the 373 patents. Literature predicts that claims positively affect financial value.

Lag

The date on which a patent application is received by the U.S. Patent Office is recorded as the application date, and may be separated from the subsequent grant date by many months or years. We measure the lag as the number of consecutive months between the application and grant dates, in our sample ranging averaging 27 months. In our sample, very few patents fail to be granted in less than one year or after more than three years. We anticipate that lag will have a negative effect on value, because while the literature has found a positive correlation between forward citations and lag (Johnson and Popp, 2003), holding forward citations constant a longer lag implies an older idea that is potentially less timely, and therefore of less interest.

Elapsed time

Most patents in our sample were granted from the late 1980s through 2004. We include a measure of elapsed time, the number of months between the grant date and the auction date, to capture both the age of the technology and the diminishing period of protection offered by the patent. The average in our sample is roughly eight years of elapsed time. We include a squared version of this variable as well, to permit what we see as an obvious potential nonlinearity in effect: while new technologies are relatively untried and may have low value as a result, old technologies may be nearing the end of their protection period or useful life and may also have low value as a result.

Ownership

We include dummy variables to represent whether each lot-holder is a private corporation, a public entity or an individual.

Importance of owner

Patents owned by a technology leader or frequent patenting agent may be of different value than patents owned by an infrequent patenting agent. Thus, we include a variable for the "importance of the owner" as the fraction of total granted US patents that the lot-owner has held since 1980 (chosen as the starting date since most application dates fall in that decade). The average in our sample was 0.10 percent, and all values are multiplied by 10^5 for readability of the coefficients. Notice that we are clearly dealing with primarily large, actively patenting firms.

Number of patents in the lot

Obviously, the lot value may depend on the number of patent documents in the lot offered for sale. The average sample lot held 4 patents but there were two lots that held more than twenty patents.

Collinearity between variables is not a problem, but we use weighted estimation as a correction for heteroskedasticity in the work which follows.

IV. Model

The auction setting did not guarantee that all lots sold. Therefore, half of our data have unobserved dependent variable values, not because they are worthless but because they did not sell. We use the standard Heckman two-step model to extract meaningful information from the lots which did not sell.

The sample selection equation models which attributes of a patent lot make it more likely to sell, for which we postulate the ownership, scope, number of forward and backward citations, number of claims in each document, family size, and lag

Table 1: Summary Statistics by Patent and by Lot

Variable	Patent-level				Lot-level			
	Mean	St Dev	Min	Max	Mean	St Dev	Min	Max
Value	na	na	na	na	209696	364811	2200	1540000
Scope	4.08	3.20	1	20	3.43	2.57	1	18
Family size	10.42	13.54	0	64	10.54	14.91	1	64
Forward citations	8.13	15.17	0	213	10.74	23.74	0	213
Backward citations	17.97	24.52		138	15.44	14.91	0	79
Claims	18.31	14.71	1	100	22.40	18.24	1	95
Lag (months)	27.35	14.00	5	142	31.30	12.41	15	78
Elapsed time (months)	106.15	53.17	1	250	90.86	47.40	6	203
Private firm owner (dummy)	0.37	0.48	0	1	0.35	0.47	0	1
Public owner (dummy)	0.45	0.50	0	1	0.27	0.44	0	1
Individual owner (dummy)	0.18	0.38	0	1	0.37	0.49	0	1
Importance of owner	20.02×10^{-5}	41.48×10^{-5}	0	36.65×10^{-4}	10.33×10^{-5}	28.36×10^{-5}	0	22.72×10^{-4}
Number of patents in lot	na	na	na	na	3.56	4.84	28	3.56
Number of inventors	2.38	1.82	1	13	2.20	1.62	1	12

between grant and application data. The inventor is omitted due to the assumption that the number of inventors does not effect the likelihood that an item will sell.

$$s = \beta_1(\textit{scope}) + \beta_2(\textit{family size}) + \beta_3(\textit{forward citations}) + \beta_4(\textit{backward citations}) + \beta_5(\textit{claims}) + \beta_6(\textit{lag}) + \beta_7(\textit{elapsed time}) + \beta_8(\textit{private owner}) + \beta_9(\textit{individual owner}) + \beta_{10}(\textit{importance of owner}) + \beta_{11}(\textit{number of patents}) + \varepsilon \quad (1)$$

The value equation models which attributes contribute to the auction sales value, given that a lot was sold, for which we postulate

$$v = \gamma_1(\textit{scope}) + \gamma_2(\textit{family size}) + \gamma_3(\textit{forward citations}) + \gamma_4(\textit{backward citations}) + \gamma_5(\textit{claims}) + \gamma_6(\textit{lag}) + \gamma_7(\textit{elapsed time}) + \gamma_8(\textit{private owner}) + \gamma_9(\textit{individual owner}) + \gamma_{12}(\textit{number of inventors}) + \gamma(\textit{Inverse Mills Ratio}) + \mu \quad (2)$$

V. Results

The estimates for the selection equation are presented in the left columns of Table 2 below, while the results for the value equation are presented in the right columns.

From the selection equation, the characteristics significant in determining whether or not a patent sells are scope, family size, lag, and elapsed time (including its nonlinear term). In line with the preceding literature, broader scope means less value, and here in particular adding one more technology class to a patent lot decreases the probability of sale by twelve percent. Presumably, this reflects the fact that buyers are looking for concisely packaged lots rather than broadly defined lots.

Larger families are less likely to sell at auction, as an increase of one nation in the average lot family size decreases the probability of sale by just under four percent.

Table 2: Regression results for selection and value equations

Variable	Selection Equation			Value Equation		
	Coefficient	z-stat		Coefficient	z-stat	
Constant	5.36	(4.13)	***	13.60	(10.88)	***
Scope	0.32	(2.82)	***	-0.12	(1.73)	**
Family size	-0.22	(5.19)	***	-3.81×10^{-2}	(1.91)	**
Forward citations	0.02	(2.79)	***	1.82×10^{-2}	(1.20)	
Backward citations	-0.04	(2.70)	***	2.60×10^{-3}	(0.27)	
Claims	0.10	(0.84)		-9.60×10^{-3}	(1.00)	
Lag	-3.82×10^{-3}	(0.19)	**	-3.91×10^{-2}	(2.28)	**
Elapsed time	-0.05	(2.32)	***	-7.36×10^{-2}	(3.80)	***
Private owner	-1.29	(2.03)	**	0.56	(1.30)	
Individual owner	0.06	(0.10)		0.33	(0.74)	
Importance	-0.50	(2.86)	***			
Number of patents	-0.42	(2.52)	***			
Number of inventors				-0.11	(0.79)	
Observations					99	
Wald χ^2					70.36	***

Note: * indicates ten percent significance, ** five percent, *** one percent.

As a more international lot means more international renewal fees and potential jurisdictions for litigation, other things held equal, buyers are less apt to buy large family lots.

Short lag patents are more likely to sell, perhaps because they are in a sense newer (and perhaps have a longer remaining period of applicability, regardless of the actual protection period) than longer lagged patents. An extra month on the average pendency lag of a lot decreases the probability of sale by roughly four percent.

The effect of elapsed time since grant is convex nonlinear, meaning that lots are more likely to sell when they are young, become less likely to sell, then rise in probability again late in their life. Specifically, the lowest probability is found at almost the halfway mark of a patent's life, 9 years and 9 months after grant.

In the value equation results, most proposed variables have a significant effect: scope, backward and forward citations, family size, owner importance, owner type, elapsed time, and number of patents in the lot. Our model clarifies a potent result in the preceding literature on the issue of scope, as it appears that broader scope actually leads to greater financial value, given that the patent is sold. It is in fact the lower probability of sale (modeled in the first step) that may have led other studies to find that broader patents have lower value. In fact, in our sample one additional technology class adds an average of 5.4% (or $280.34) to a lot's financial value if sold.

Forward citations are clearly associated with greater financial value, with a lot increasing by 0.95% (or $209.35) for each additional forward citation received per patent. This result confirms the Trajtenberg result that citations are indeed correlated with monetary returns.

Patent lots owned by private corporations sold for twenty-four percent ($742.48) less than comparable lots owned by individuals or public entities, a result surprising in sign and size. This may be a function of the new format of patent auction, influenced by either the particular lots on sale or the way in which financial values were determined (it is our suspicion that many private corporate lots were traded off of the auction floor in private after the event).

Family size not only decreases the probability of sale, but also decreases the value of the lot when traded. An increase of one more nation will on average decrease value over four percent, presumably for the same precautionary reasons as mentioned above for the probability of sale.

More patents in a lot surprisingly lead to a lower financial value (an average fall of 2.69 percent or $235.80 for each additional patent), but it is unclear why buyers prefer a single strong patent to a larger number of equally strong patents. While potential renewal and litigation fees increase, presumably the underlying protected technological space increases as well, so we are left with something of an enigma.

Patents from less important inventors garnered higher values than lots from important inventors, perhaps because of a suspicion that larger inventors know more about the technological space and are selling off unimportant patents while saving the critical areas for themselves.

Elapsed time is once again convex and nonlinear, meaning that the worst possible time to sell a patent lot, other things being equal, is at month 96 (eight years) after patent grant.

VI. Conclusions

The results are consistent with the previous literature, although we introduce a new dataset to measure specific financial values at auction and use a two-step model to accommodate those patent lots which were offered but did not sell. However, it is clear that forward citations are positively correlated with value, while broader scope detracts from value.

We hope to continue this study as subsequent patent auctions occur, hopefully adding more depth to our model and confidence to our conclusions. It would be interesting, for example, to interact variables or to test for the importance of technology classes or nations of origin or the impact of opposition data (while not available in the U.S., opposition data are public in most of the rest of the world). Similarly, the National Bureau of Economics Research (NBER) has a measure of originality and generality.[1] These variables were not used because they are currently limited in duration (available only through 2002) but are in the process of extension through 2006 so could be included in future versions of this research.

With an increase in data, auction theory could be directly applied, but limitations were simply too great with the limited information currently available.

In conclusion, this study provides a framework to analyze the impact that objectively observable patent characteristics have on the auction value of a patent, and first estimates of the relationship between those attributes and market value.

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