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Strategic Patenting Decisions and their Influence on Firm Patent Valuation

Abstract

The economic rents associated with patent portfolios are highly skewed with only a small portion having value. This leads researchers and industry to ask what early strategic patenting decisions around the patent itself will impact the future value of the patent, specifically within the context of small firms. To address this question the paper modeled these *ex-ante* strategic patenting decisions by using a common measurement of forward citations as a proxy for patent value. The six indicators of family size, breadth, claim count, jurisdiction count, provisional basis and priority claim were modeled using a sample of 386 patents granted in the Mechanical and Electrical field. A focus on the small firm as well as the two strategic patent decision indicators provisional basis and priority claim are areas that have not been explicitly investigated in previous research. Controlling for industry and firm patenting experience resulted in differences of predictors between small and large firms, with a higher likelihood of strategic patenting decisions influencing small firms over large firms. A stronger relationship was found for small firms with indicators of breadth and priority claims, as compared to a weaker relationship of only claim counts for large firms. Research also indicated that from a small firm management perspective the most potential valuable patent is one that covers a broad scope of technology is a new filing and does not claim priority to other applications.

1.0   Introduction

The financial and strategic benefits of intellectual property are increasingly important decision points in today's business community. For some firms having intellectual property protection is the difference between failure and success in a competitive marketplace. Firms that can successfully manage intellectual property gain tangible bottom line value from the intellectual intangible asset, all while helping to protect and position themselves for future growth. Research has shown intellectual property is a relative measure of R&D output with the potential to return high economic rents over time. However it is highly skewed with only a small portion being extremely valuable (See generally Griliches 1990; Trajtenberg 1990; Jaffe and Trajtenberg 1998; Harhoff, Narin et al. 1999; Lanjouw and Schankerman 1999; Hall, Jaffe et al. 2000; Lemley and Allison 2000; Ernst 2001; Harhoff, Scherer et al. 2003; Allison, Lemley et al. 2004). This value skew means patent business issues for small firms are magnified given their limited budgets and filing ability during the rapid evolution of today's industry. These firms have been forced to focus on increasing returns on patent value by employing intellectual property strategies. Common business practice has given firms a variety of tactics to choose from: they can defend against or work around existing competitors patents; or they can enter the patent race themselves by developing a portfolio to generate royalty revenues, create bargaining chips or block competitors from moving into the protected space. Accurately executing these

options is difficult, however, for the average small firm. Patents are expensive to obtain and can take several years to grant with no certainty that the innovation will be worth even at least the cost associated with filing it, let alone the cost of enforcing it.

These business dilemmas are an issue for small firms. With limited financial and personnel resources to dedicate to the patent they must be able to identify the valuable patents early on and create a portfolio where the value is focused and not highly skewed. In particular the importance is exaggerated if the firm has more patentable ideas than resources allow or if a small or start-up venture has few sales and little ability to invest in creating and protecting complementary or new products for new revenue. Finally, with the same financial investment needed to acquire a patent for both large and small firms, there is a larger relative risk for small firms to pick the most valuable innovations to pursue.

This paper seeks to address these issues by researching the early strategic patenting decisions around the patent itself that will help firms predict the future value of the patent with a focus on small firms. By operationalizing patent value from citation counts, this paper proposes a model to enable managers of small firms to predict patent value *ex-ante*. The current state of research shows that the majority of patent valuation analysis is done *ex-post*. This provides business information about the firm's patent portfolio value or quality but only after considerable resources (financial, personnel or other) have been used to acquire the granted patent. Additional research value is created as the paper will address the literature gap that currently exists in patent valuation predictors specific to small firms. In doing so this paper will introduce two variables which have not been directly researched: priority claims, which are accounted for in current literature through linkages to highly litigated patents (Allison, Lemley et al. 2004) or value measured *ex-post* through maintenance fee payments (Barney 2002), and provisional basis which has been included in patent family counts along with priority claims (Dernis and Guellec 2003). The model will be valuable to industry as it will provide a focus to patenting firms on how to apply available patent filing indicators to increase portfolio value over time, who are constrained by budgetary and other internal business limiters. Finally, characteristics for both small and large firms are discussed in order to provide guidance on how intellectual property strategies are unique across small and large firms.

When using forward patent citations as a proxy for value, the results are encouraging as they show that *ex-ante* indicators can be used as predictors. The priority claim indicator had significance when controlling for the firm experience and industry type but provisional basis was not a significant indicator. There was a stronger relationship when considering small firms over large firms, with the industry type, breadth of a patent and its priority claim basis having significance for small firms (R^2 =32%) and claim counts having significance for large firms (R^2 =9%). From a small firm management perspective the most valuable patent is a new filing that covers a broad scope of technology. Results also supported previous research that a model can not be generalized across industries.

This paper is organized in the following sections: Section 2 will be a background discussion on the impact of intellectual property, specifically patents, in a working business environment. Section 3 will be a discussion of the valuation research currently existing in literature, and Section 4 will describe the research question and hypothesis. Section 5 will outline the methodology and Section 6 will conclude with a discussion of the results.

2.0 Patents in the business environment

Patents give a legal right to exclude your competition from making, using or selling your innovation. The historic policy driving this legal 20 year monopoly is to encourage firms to be first to innovate while supporting three requirements: it must be novel, it must have utility, and it must be non-obvious. From a business strategy perspective it is not enough to simply think of a patent as an isolating mechanism for a product in the industry. Through both offensive and defensive portfolios, patents can be used to create not only high barriers to entry but also freedom to a firm to innovate and operate in the industry when competitors have similar patents, licensing revenue, or negotiation leverage. Patents are useful for valuation purposes during IPOs and venture capital backed opportunities, and as tax write-offs if donated to a non-profit entity such as a university. With these considerations a patent savvy company has the potential to lead the market and create intellectual property rents, whether it be through taking first mover advantage and prohibiting the competition from following or simply charging others a royalty for being in the market even if they are not in the market themselves. (Rivette and Kline 2000; Sullivan 2000; Davis and Harrison 2001; Jaffe and Lerner 2004).

Though not a perfect measure of R&D output, patents are a relative measure of the effectiveness of R&D innovations (Griliches 1990). In extending the patented innovation to a product there are links between patent filings and subsequent increases in company sales, with a time lag equal to the average time to grant of 2-3 years (Ernst 2001; Harhoff, Scherer et al. 2003). Regardless of the firm type and size, it is not just an increase in sales that adds value directly to the bottom line. IBM, for example, earns $1 billion per year in patent royalties, which accounts for 20% of their R&D expenses and 9.3 % of their pretax profit[1]. Spurred by some patent focused litigation in the early 1990's, technology companies such as Microsoft and Dell have moved towards aggressively building and defending their portfolios[2]. However it is not just the large established product companies that are taking advantage of patents. Venture-backed, pure research or license-based companies are also benefiting. Lerner's (1994) research indicated that in the venture-backed bio-tech field a 1% increase in the standard deviation of the average patent scope, as measured by the number of IPC classifications given, awards the firm with a 21% increase in valuation. Qualcomm owns a large portion of the current wireless technology (2G) and next generation wireless technologies (3G) patents based on their cellular CDMA technology. From this IP ownership the firm derives most of its revenues from intellectual property royalty and license fees, accounting for $984 million in 2003 which was 1.8x their

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[1] IBM 2003 Annual Report.

[2] For example at the USPTO Microsoft filed approximately 12 US applications in 1990, 274 in 1995 and 424 in 2000. Similarly Dell filed approximately 11 US applications in 1990, 129 in 1995 and 104 in 2000. These are estimates based on publicly available data US filing estimates which count only published or granted applications, and does not include abandoned applications or any unpublished applications. Given the increasing grant time for applications, in particular business method applications which both Microsoft and Dell have been seen to file I suspect the 2000 estimates are lower than actuality due to unpublished pending applications. The increase can be confirmed as both Microsoft's applications peaked at 596, with Dell's applications a year later at 191 applications which would account for the longer grant times.

annual R&D expenditures and 76% of their pretax profit[3]. In 2002 an intellectual property holding company called NTP Incorporated sued Research in Motion for patent infringement and was ultimately awarded damages of $53.7 million US, with a 8.6% royalty on its Blackberry sales, and an injunction from selling or servicing its devices in the US. During the litigation, cellular partners of Research in Motion such as Nokia were hedging their bets by actively taking out licenses on the NTP patents. Even though a settlement was struck in early 2005 for $450 million, Research in Motion still continues to lobby the USPTO for a re-examination of the patents while they finalize the deal.   Starting in 1976, Kodak learned first hand the cost of ignoring a rival's patent portfolio with the total accumulated financial loss 14 years later of $3 billion in infringement damages, attorney fees, layoffs, repurchasing of sold products and closed R&D facilities due to Polaroid's seven instant camera patents.

   While these accounts of multi-million dollar returns from their intangibles may awaken many firms, they must be aware that the cost of creating and enforcing a patent portfolio may not in fact result in positive cash flow. First, one must keep in mind that a single patent application costs between $10,000 and $40,000[4] depending on the application complexity. Second, dwarfing these costs are the enforcement remedies provided through the court system. While estimates vary, enforcement through the court system will be, on average, between $0.5 and 3.0 million depending on the amount of money at risk and how far it goes into trial[5]. For the average dispute, where $1-$25 million is at risk, the American Intellectual Property Law Association reports the median cost of patent litigation for a dispute will cost each party $0.5 million to the end of discovery, and $0.8 million to the end of trial and appeals[6].

   But not all patents will find these large economic rents. The patent value distribution is highly skewed with the median far below the mean (see Griliches 1990; Barney 2002; Davis and Harrison 2002; Harhoff 2003; Harhoff, Scherer et al. 2003; Harhoff, Scherer et al. 2003) and for each of these valuable patents, only a select few are worth a large value. This distribution is further validated by the fact that nearly two-thirds of all granted patents lapse due to failure to

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[3] Qualcomm 2003 Annual Report

[4] Average industry estimates vary widely, between $10,000 and $40,000 to obtain a patent depending on the complexity, and USPTO data indicates that at least two-thirds of issued patents are abandoned due to failure to pay the maintenance fee before the end of their term *See* Lemley, M. A. (2001). "Rational Ignorance at the Patent Office." Northwestern University Law Review **95**(4)., Lanjouw, J. O., A. Pakes, et al. (1998). "How to Count Patents and Value Intellectual Property: Uses of Patent Renewal and Application Data." Journal of Industrial Economics **46**(4): 405-432. and AIPLA (2001). Report of Economic Survey 2001. Arlington, Virginia, American Intellectual Property Law Association. The abandonment is presumably because the firm no longer sees a potential return at least higher than the maintenance fees. Maintenance fees are paid every 3 ½, 7 ½ and 11 ½ years from the grant date at a cost of $830, $1,900 and $2,910 respectively (35 USC§ 41(b)).

[5] AIPLA (2001). Report of Economic Survey 2001. Arlington, Virginia, American Intellectual Property Law Association. AIPLA indicates that for smaller patent disputes (<$1 million at risk) the median total cost to end of discovery is $250k, and all inclusive costs at $499k. For mid-size disputes ($1-$25 million at risk) the median total cost to end of discovery is $797k, and all inclusive costs at $1.5M. For the large disputes (>$25 million at risk) the median total cost to end of discovery is $1.5M, and all inclusive costs to $3M.

[6] *Ibid.* Note this does not include cases settled short of trial.

pay the maintenance fees, suggesting the patent has a lower expected value than the maintenance fee (Lemley 2001). ection, for any given portfolio.

Figure 1 depicts this skewed patent portfolio value distribution, which is split into three parts: The first 5% of the portfolio is where the high value patents exist that can be used for enforcement and high economic rents. The middle 70% of the distribution houses patents of some value, as measured through product protection or business license transactions. The final 25% tail of the distribution offers little or no value to the firm and is either left abandoned or donated for an accounting value on the balance sheet. It is the intent of this research to investigate how to *ex-ante* identify and maximize the number of patents in the high value section, for any given portfolio.

Figure 1 Portfolio Patent Distribution[7]
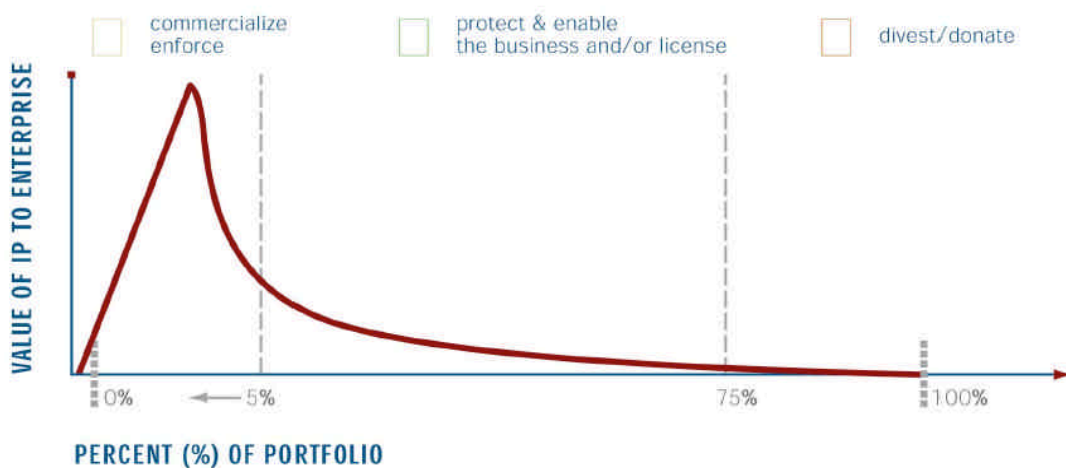
3.0   Discussion of Current Research

In considering the portfolio or patent weighting, there has been considerable research into operationalizing the value and technological impact of a patent with known information linked with the patent data itself. This research has been split into three general groups, one from an industrial economic perspective, the second from a legal perspective and the third based from the management perspective, with the latter as a recent addition to the research field. While portions of the research may support or influence more than one area, the economic perspectives have typically been focused on using patent based indicators as measures of innovation and R&D output (Pakes, Hall et al. 1988; Griliches 1990; Trajtenberg 1990), or investigation of knowledge and technical spillovers across industries and geographic boundaries (Jaffe, Trajtenberg et al. 1993; Jaffe and Trajtenberg 1996; Jaffe, Trajtenberg et al. 2000). They have used the premise that patent citations are an indicator of patent importance or economic value (Hall, Jaffe et al. 2000) with a large portion of the analysis done on *ex-post* information. The majority of legal

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[7] Source: Joe Daniele, Acorn Technologies. Davis, J. L. and S. S. Harrison (2002). How Leading Companies Realize Value from their Intellectual Assets, ICMG. And Daniele, J. (2004). Telephone Conversation.

research perspectives have been heavily based of the economic perspectives with a focus the relationship between litigated patents and their value (Lanjouw and Lerner 1996; Lanjouw and Schankerman 1997; Allison and Lemley 1998; Lemley and Allison 2000; Somaya 2002; Somaya 2003), with a focus on trial decisions including trial length, validity and industry type. The management perspective has approached the research to validate and provide valuation approaches using patent indicators from publicly available information (Reitzig 2002), including information to support strategic patenting prosecution decisions such as renewal choices (Harhoff, Narin et al. 1999), opposition arguments (Harhoff and Reitzig 2002; Harhoff, Scherer et al. 2003), litigation influences (Somaya 2002; Somaya 2003) and prosecution time (Lemley and Allison 2000). This approach has provided a patent strategy foundation for industry to apply to patent filing, prosecution and enforcement decisions.

Supported and influenced across these three groups are well researched indicators which include forward and backward citations, family size, patent breadth, number of claims, geographic location of applications and jurisdiction, litigation indicators, and type of firm size and ownership. **Table 1** summarizes the research variables as well as their research focus, with a discussion of the variables in the methodology section.

Table 1 Patent Value Indicators and Research Perspectives

Indicator	Research perspective	Study (Author)
Forward and backward citations	Industrial Economic	(Trajtenberg 1990; Jaffe and Trajtenberg 1996; Jaffe, Trajtenberg et al. 2000; Hall, Jaffe et al. 2001; Lanjouw and Schankerman 2001)
	Management	(Albert, Avery et al. 1991; Harhoff, Narin et al. 1999; Reitzig 2002; Harhoff, Scherer et al. 2003)
Family size	Legal	(Putnam 1996; Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999; Lanjouw and Schankerman 2001; Barney 2002; Allison, Lemley et al. 2004)
	Industrial Economic	(Putnam 1996; Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999; Lanjouw and Schankerman 2001; Barney 2002)
	Management	(Barney 2002; Reitzig 2002; Harhoff, Scherer et al. 2003)
Patent breadth / scope	Industrial Economic	(Lerner 1994; Harhoff, Narin et al. 1999; Hall, Jaffe et al. 2001)
	Management	(Lerner 1994; Harhoff, Scherer et al. 2003)
Number of claims	Legal	(Lemley and Allison 2000)
	Industrial Economic	(Lanjouw and Schankerman 1997; Lanjouw and Schankerman 2001)
	Management	(Tong and Frame 1994; Lemley and Allison 2000)
Geographic location of applications and jurisdiction	Industrial Economic	(Jaffe, Trajtenberg et al. 1993; Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999)
	Management	(Tong and Frame 1994; Harhoff, Narin et al. 1999; Lemley and Allison 2000; Harhoff, Scherer et al. 2003)
Litigation Indicators	Legal	(Lanjouw and Schankerman 1997; Allison, Lemley et al. 2004)
	Industrial Economic	(Lerner 1994; Lanjouw and Schankerman 2001)
	Management	(Somaya 2003)
Type of firm ownership or size	Legal	(Lemley and Allison 2000; Allison, Lemley et al. 2004)
	Industrial Economic	(Lanjouw and Schankerman 2001)
	Management	(Mogee 2000; Harhoff and Reitzig 2002)

4.0   Research Question and Hypothesis

The research question this paper will address is "For small firms what early strategic patenting decisions around the patent itself will impact the future value of the patent?" In viewing the interaction between the patent filing strategy and known relationships of patent value and their filed properties it is seen that there are several research supported variables that can be a proxy for patent value, such as family size, jurisdiction count, claim count and breadth[8]. The two additional variables of priority claims and provisional patent claims, are results of *ex-ante* strategic patenting decisions made by the firm and are been indirectly linked through incorporation in family size counts (Lemley and Allison 2000; Dernis, Guellec et al. 2001; Barney 2002). All of these measured variables are a result of a firm's strategic patenting decision that are based on the patent characteristics. From this one can presume that if a firm presumes a particular patent will have the ability to produce a future economic benefit there will be higher family sizes, jurisdiction and claim counts, broader scope, with a basis on priority claims and provisional filings. Alternately if a firm does not presume future value in the patent, they will not continue to invest resources which will also be represented with the indicators. Strategic patenting decisions are typically influenced by inventors and patent agents who are knowledgable in the technical field as to what patent characteristics ultimately produce a valuable patent. Thus it is reasonable to conclude variables may be correlated with patent value. The following section will introduce the hypothesis H_1 to test these variables.

H_1: Firm level of strategic patenting decisions up to the time of filing are related to the future value of the patent.

When considering financial size generally smaller firms may have relatively fewer resources to devote to patents than larger firms. As the financial investment needed for patent prosecution similar for all firms this puts a larger relative risk for small firms to pick the most valuable innovations to pursue as their sunk costs from prosecuting less valuable patents have a larger bottom line impact. While Lemley and Allison (2000) found that firm size did not hold a significant relationship to number of applications filed, they later found that small firms were more likely to litigate patents (Allison, Lemley et al. 2004). As litigated patents are seen as more valuable, this leads towards the possibility that small firms may be more adept at patenting valuable innovations. Building on the previous hypothesis H_1 it is reasonable to conclude small firms are likely to have more targeted filings to optimize their use of resources. Strategic patenting decisions which result in a patents value will be different between small and large firms, with more predictive variables weighted towards the small firms. A result of H_2 will be to model patent value for both small and large firms in order to see which significant strategic patenting decisions are unique across firm sizes.

H_2 – There exists a higher likelihood of strategic patenting decisions and patent value relationship between small firms than large firms.

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[8] See **Table 1** for a detailed list of value indicators and research citations.

5.0   Methodology

5.1   Data Sources

The data collected was tested using patent data collected for US patents granting in January 1999[9] within the International (IPC) patent classes related to Electrical Devices[10] and Mechanical Devices[11]. The Electrical Device class relates to basic electrical elements, covering all electrical units and the general structure of the circuits whereas the Mechanical Device class relates to mechanical devices for producing or operating machines or installations, such as shafts, springs, pistons, joints or frames.   These particular classes were chosen as they were relatively opposite technically based categories allowing for a clear comparison across industries. A total of 847 samples drawn from the USPTO with both expired patents[12] and those granted to non-US based firms removed from the sample. The remaining 386 samples were coded into Small and Large Entity status[13], as listed by each patent application record available from the USPTO. Patents assigned to individuals, and not-for-profits (universities) were included in the small entity status, of which there were 40 and 7, respectively. Finally, the remaining data was manually checked to ensure it belonged in the appropriate industry type.

5.2   Dependent Variable: Forward Citation Counts

The dependent variable, forward citations, is measured by the number of citations the granted patent has from other patents. The variable was operationalized by counting the frequency of citations that the particular patent receives from subsequent patents as filed in the USPTO. Due to the skewed nature of citation counts, the dependent variable was transformed logarithmically. First introduced by Trajtenberg (1990) forward citations have been validated by other research, showing that a general conceptual patent value or quality definition can be linked to the number of citations and external references it receives (Harhoff, Narin et al. 1999; Hall, Jaffe et al. 2001; Lanjouw and Schankerman 2001)[14]. The reasoning for the use of citations as a

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[9] A data-set from pre-November 29, 2000 was also consciously chosen as the law of the US now requires all US patent applications filed on or after this date to be published 18 months after the earliest filing date for which the benefit is being sought, unless the application will not be filed in a foreign country that provides for 18-month publications. Data collected after this date would cause issues as there would effectively be 2 data sets to consider: citations granted applications that had an earlier publication date and citations for granted applications that were not published.

[10] IPC class H01; Defined as "Basic Electrical Elements"

[11] IPC Class F16; Defined as "Engineering Elements or Units; General Measures for Producing and Maintaining Effective Functioning of Machines or Installations; Thermal Insulation in General"

[12] Based on failure to pay renewal fees

[13] The small and large firms used in this paper were defined based on the USPTO "Small and Large Entity Status", which notates a small entity as either an independent inventor or collaboration of independent inventors or a company with under 500 employees.

[14] There has been considerable work in the creation of a National Bureau of Economic Research and Case Western Reserve patent database of the past 30 years of US patents (Hall, B., A. Jaffe, et al. (2001). "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools." NBER Working Paper (No. 8498).) Hall

measure of value is the same for scientific literature: the economic importance of a work should be correlated with the frequency to which it is cited as a benchmark for further developments. Other literature exists which validates this reasoning, linking both a firm's stock market value and the high cost to litigate a patent to forward citations. Both Hall et al. (2000) and Narin et al. (2001) linked a firms stock market value as correlated with their patent stocks and their citations. Hall noted the existence of a higher correlation between highly cited patent portfolios and market value than traditional patent portfolio's themselves. There are also linkages between highly cited valuable patents to an abstract level of financial value. It has been suggested that given the high cost of litigation, patents which are litigated are also typically considered valuable patents. Research with litigated patents have been correlated to high patent citations (Lanjouw and Schankerman 1997; Allison, Lemley et al. 2004) with Allison arguing strongly for the bi-directional relationship between litigated patents and value. Their research argument is based on the premise of the high relative cost of litigation as compared to the cost of merely obtaining the patent with almost 75x the cost to enforce through litigation compared to filing.

5.3   Independent Variables: Strategic Patenting Decisions

To support the strategic patenting decisions of the patent the paper will focus on six leading variables: Family size, Breadth, Number of Claims, Provisional Basis, Jurisdiction size and Priority Claims. Again, each of these variables can be measured or estimated by the innovator *ex-ante* at the time of filing the patent.

Family Size. Family size is all related applications (continuations, continuation-in-part and divisionals) filed worldwide and was operationalized by a simple count of all related applications to each patent. Initially introduced by Putnam (1996), further studies show that the patent family size, as measured by the granted applications in different jurisdictions which protect the same invention, is correlated with patent value as measured by time from grant to non-renewal or expiry date (Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999; Lanjouw and Schankerman 2001). Harhoff (2003) linked these independent variables to an actual monetary price in which the inventor would have been willing to sell the rights had they known the future outcome, thereby tying jurisdictional patent family size to external financial valuations. The relationship between an increase in family size as measured by an increase in continuations and priority claims was seen with the likelihood of maintenance fees payment, a common measure of value (Barney 2002), and higher litigated patents (Allison, Lemley et al. 2004), an indicator of value. From a management perspective a firms willingness to devote resources to additional patents indicates the presumption of future value, as well as the potential to exploit the technology into multiple countries. Creating a large family size from an application is a strategic patenting decision because it will enable stronger and potentially broader patent protection through multiple filings.

Breadth. Patent breadth or scope is a measure of the technological influence or boundaries that the patent encompasses. This paper will operationalize patent breadth based on

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et al, have collated data on 3 million US patenting from 1963 – 1999 which include 16 million citation data points such as backward and forward citation lags, indices of "originally", "generality" and self-citations.

the IPC which counts the number of four-digit IPC classes the patent examiners assign each patent. In research the indicator of scope or breadth has been addressed in three different ways, all based on classification codes in the patent documents. First proposed by Lerner (1994) and later used by Harhoff (2003), a breadth indicator is based on the number of four digit International Patent Classification (IPC) codes in the patent document[15]. Hall (2001) created six general categories for all US patent applications, all of which are separated by US classification codes. The third system is a constructed variable of "generality", which is calculated as a percentage of citations received by the patent that belong to that patent class out of the total number of patent classes (Trajtenberg, Hendersen et al. 1997; Hall, Jaffe et al. 2001). Breadth is included as a strategic patenting decision. A patent with a high measure of breadth should reflect a wide degree of technological significance and application, which in turn reflects a higher value than a narrowly defined or used innovation. From this flows the presumption that firms may be more willing to invest in protection of patents with wide technological footprints.

Claim Count. Claims define the legal boundaries of the patent rights, thus the firm typically has incentive to claim as much and as widely as possible while the examiner may narrow or reduce the claims to ensure validity before granting. This paper will operationalize claims as the total claim count for the patent applications. Tong and Frame's (1994) initial research suggests that claim counts consistently outperform patent counts, strictly as an indicator of the size of technical innovation. Other research notes two relationships with claim counts. First the number of claims may be a proxy for the size and complexity of the invention (Lemley and Allison 2000). Second, litigated patents (as equated as at least a subset of the most valuable patents) have several characteristics, one of them being that they contain more claims than ordinary patents (Lanjouw and Schankerman 1997; Allison, Lemley et al. 2004). There is a strategic patenting decision in having a high claim count as it will offer broader and more detailed legal protection of the patented technology. Based on the innovation claimed, a patent savvy applicant with knowledge in the technology area would generate a larger patent claim scope and count that would produce a broader, valid and valuable patent.

Jurisdiction. Jurisdiction size is computed as the number of separate country jurisdictions in which patent protection was sought for the same application. Jurisdiction count has been positively correlated to forward citations when measured as the number of jurisdictions in which a patent grant has been sought (Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999; Harhoff 2003) while other research highlights the relative weighted value of patents increased with jurisdiction size counts (Lanjouw, Pakes et al. 1998; Lanjouw and Schankerman 1999; Harhoff 2003). To have global patent protection one must file in multiple jurisdictions,

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[15] Lerner argues the use of the IPC over the US classification scheme will have benefits in three ways. First, the US scheme is in comparison poorly monitored and thus the quality of schemes differs. The World Intellectual Property Organization (WIPO) periodically reviews the schemes, while the USPTO is more focused on ensuring the arrangement of the sub-classes, even giving power to the examiners to introduce sub-classes with little review, citing U.S. Patent and Trademark Office (1984). Examiner Handbook on the Use of the U.S. Patent Classification System. US Department of Commerce Patent and Trademark Office. Washington, D.C., Government Printing Office. Second, the two schemes have different underlying motivators to classify patents; while the US scheme is technically focused the IPC scheme is administered reflecting the economic importance of inventions. Finally, the IPC classifications are nested, while the US scheme is not consistently nested.

each having their own filing and legal costs to prosecute, inferring that firms must see a higher economic future value in innovations which are protected in multiple jurisdictions. Similarly to family size counts, one can make the presumption that when firms do file in multiple jurisdictions and are investing a higher financial commitment, they see a greater potential of increased patent rents back to the firm, which is seen in their strategic patenting decision by the count of jurisdictions filed in.

Provisional Basis. Provisional applications allow an inventor to file information relating to their invention claim priority to that filing date up to 1 year from the original provisional filing date[16]. In practice there are several reasons why a provisional application may be filed; there may be a lack of time or finances to prepare a formal application, or the firm may wish to defer the innovation to allow for time to study the market or allow technologies to develop. Provisional basis was measured as if the patent data point was based on a provisional application and coded as a nominal Yes / No measure. Previous research only indicated provisional basis which has been included in patent family counts along with priority claims (Dernis and Guellec 2003). No direct nominal measurements of this as an indicator has been researched. Disaggregating this variable will give researchers insight into which information that compose family counts provide value to the patent. The strategic patenting decision of filing a provisional application presumes that the firm believes the innovation is of some expected future value that should be fully protected within the next 12 months and an early patent filing date should be sought to protect this value. As to the management influence on this strategic patenting decision it is reasonable to conclude that the perceived future value by inventors who are knowledgeable in the technological field as to what is novel and should be protected as soon as possible with a provisional application and may be correlated with patent value.

Priority Claim. Priority claim is the basis of whether the patent application was based on a previous application, such as a continuation or divisional and was operationalized by a nominal Yes / No measure. The USPTO allows an inventor to file an application which references related applications. There are several types of related applications which may be an indicator of patent value. First, applications which may claim benefit of an earlier priority date are continuations, divisionals, and continuation-in-part applications. A second type of related applications are co-pending applications which allow applications related to each other to be referenced between them; typically the applications are technically related to each other and are filed by the same assignee. As with the variable provisional basis, there has been little direct discussion in the literature about the effects of related applications as indicators of patent value. As a subset of family size counts, previously priority claims correlated to highly litigated patents (Allison, Lemley et al. 2004) or were seen to increase likelihood of maintenance fees payment which is a common measure of value (Barney 2002). However there has been no direct nominal measure of this variable. Along the same reasoning as with provisional applications the strategic patenting decision to use a priority claim is to retain the best possible filing date, which gives

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[16] A provisional application allows for filing without formal claims, oath or declaration, or any information disclosure statements 35 U.S.C. §111(b). It allows for a firm or inventor to establish an early filing date 35 U.S.C. §111(a) but within 12 months from the date the provisional is filed, the applicant must file a non-provisional application which claims priority to the provisional 35 U.S.C. §119(e).

favorable patent position during prosecution.   Thus, it is reasonable to conclude that applications which are filed based on the knowledge of previously filed applications and filing dates, or applications that will be filed with co-pending may be correlated with patent value.

5.4   Control Variables

Controlling for the firm's patent experience may improve the performance of the empirical model. There are two control variables which may impact the patent value which relate to the general patent experience and knowledge of the firm: portfolio size and self-citation tendencies (Hall, Jaffe et al. 2001). While patent portfolio size has not been a good indicator of patent value, it can be assumed that companies with larger patent portfolios have more experience in patenting and enforcing innovations and may are adept at creating valuable patents. For large firms the portfolio size will be highly skewed and therefore the log of the total portfolio count for each patent's assignee was taken; this control variable is notated as Experience in the data analysis. The bias of a firm "self-citing" their own patents was removed by reducing the forward citation count by the number of references that belonged to the same firm.

A third control variable, industry type, is also used as there are substantial differences in how industries use patents (Levin, Klevorick et al. 1987; Choen, Nelson et al. 2000; Somaya 2002). For example, the chemical industry uses patents as blocking mechanisms for competitors while the telecommunication and semiconductor industry tend to use patents as a negotiation tactic, mutual hold-up, or other defensive positions with rivals (Hall and Ziedonis 2001). Further, different industries and technological fields have citations that vary considerably (Jaffe, Trajtenberg et al. 1993), which may impact the accuracy of the proposed model. To accommodate this influence, the data will be controlled across the two specific industries data collected within. Based on the International Patent Classification, classifications of Electrical Devices (H01) and Mechanical Devices (F16) were used which aligns with the technology separations during prior literature (Hall, Jaffe et al. 2001; Lanjouw and Schankerman 2001). Focusing on two specific industries will also help account and reduce error introduced for differences in industry citation trends.

5.5   Assumptions, Limitations & Errors

As different countries also utilize patents and patent citations differently, the data focuses only on US granted patents by US domestic owners. This is key as it controls for international differences in the patent systems and international firm types, as patent quality, strategy and filings may vary across countries, as highlighted by Lanjouw and Schankerman (2001).

When considering patent valuation, it is assumed that regardless of citations received the patent assignees will only pay maintenance fees on the applications when they expect the remaining patent term has a higher value the fee itself[17]. Harhoff (1999) noted German and US patents renewed to full term were significantly more highly cited than patents allowed to expire before their full term. Lemley (2001) shows data that nearly half of patents expire due to

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[17] In the US, patent maintenance fees are paid every 3 ½, 7 ½ and 11 ½ years from the grant date at a cost of $830, $1,900 and $2,910 respectively. 35 USC§ 41(b)

maintenance fee lapses by the midpoint of their full term and 2/3 of all patents are abandoned before the end of their full term. The proposed model assumes that unpaid patent maintenance fees or lapsed patents will be considered of no value, which for the purposes of this paper have zero citations.

As noted earlier there will be a bias in the citation counts because of the citation lag present. The data counts the actual number of citations received not the projected total. One must note the patent citation lag distribution is industry dependant, with the electrical and mechanical based US applications having a citation peak at approximately 3.6 and 4.6 years respectively from the original grant date[18]. To accommodate this a 6 year citation lag will ensure that for both industry types the yearly volume of citations is on the decline, and there are no expected citation increases which would impact the data.

6.0   Results

I performed a hierarchical regression analysis to test both the hypothesis with the enter method for the control variables and the stepwise method for the independent variables. The analysis was sorted across large and small firms to enable a comparison as well as to allow for detailed analysis of small firm patent characteristics. Descriptive statistics and sample size counts are presented in

Table 2 and Table 3 which shows 81 patents represented were from small firms, while 304 were from large firms. Several differences between the small and large firms can be seen with this data. Variables of breadth, jurisdiction and priority claim have similar mean and standard deviations distributions relative to each other but differences can be seen in the skewness and kurtosis values which gives both the breadth and priority claim larger peaks for the large entity and the opposite for the jurisdiction.   The claim count also has similar positively skewed mean and standard deviation distributions once the outlier data point of 165 claims was removed from the large firm dataset, although the small firm claim count distribution was less positively skewed than the large entity distribution as well as a significantly lower kurtosis value (2.46 vs. 34.28). Family size is larger both in count and at the mean for large firms, which is seen in the larger kurtosis value (19.29 vs. 7.42).   The control variable log of Experience shows large differences across the small and large firms. With negative skewness (-0.58) and kurtosis (-.457) for the large firms and positive skewness (1.25) and kurtosis (1.452) for the small firms, it can be

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[18] Based on calculations based on patent citation modeling in Jaffe, A. B., M. Trajtenberg, et al. (1993). "Geographical Localization of Knowledge Spillovers as Evidenced by Patent Citations." The Quarterly Journal of Economics. which accounts for variables of technology field, country and institution type (government, corporate or university). The model also accounts for citing and cited year effects and is only current up until 1993 data, thus the mean estimates for the citation peaks may be slightly skewed, but adequate for the purposes of ensuring that grant date of 1999 was sufficiently prior to the peak of expected lifetime forward citations.

seen that small firms have less experience than large firms, as measured by filed applications (Figure 2, Appendix A).

Table 2 Descriptive Statistics

Descriptive Statistics

Entity Size		N	Minimum	Maximum	Mean	Std.	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Small Entity	Forwared Citations (Unbiased log)	81	.000	1.914	.45112	.451309	.775	.267	.196	.529
	Family Size	81	1	28	4.27	5.128	2.539	.267	7.427	.529
	Breadth of patent	81	1	4	1.47	.743	1.608	.267	2.150	.529
	Number of claims	81	1	62	17.41	12.031	1.359	.267	2.463	.529
	Based on Provisional	81	0	1	.06	.242	3.711	.267	12.071	.529
	Jurisdiction size	81	1	14	2.64	2.566	2.300	.267	6.591	.529
	Priority Claims	81	0	1	.31	.465	.844	.267	-1.321	.529
	Log of Experience	81	.000	4.013	.91406	.914857	1.259	.267	1.452	.529
	Valid N (listwise)	81								
Large Entity	Forwared Citations (Unbiased log)	304	.000	1.949	.53886	.456027	.469	.140	-.479	.279
	Family Size	304	1	72	6.17	8.160	3.654	.140	19.292	.279
	Breadth of patent	304	1	4	1.50	.844	1.590	.140	1.481	.279
	Number of claims	304	1	163	16.51	14.897	4.432	.140	34.283	.279
	Based on Provisional	304	0	1	.04	.187	4.992	.140	23.071	.279
	Jurisdiction size	304	1	15	3.22	2.857	1.752	.140	3.452	.279
	Priority Claims	304	0	1	.36	.479	.608	.140	-1.641	.279
	Log of Experience	304	.000	4.745	3.04936	1.057741	-.588	.140	-.457	.279
	Valid N (listwise)	304								

Table 3 Data Sample Sizes

Descriptive Statistics

	Large Firm	Small Firm	Total
Mechanical	70	40	**110**
Electrical	234	41	**275**
Total	**304**	**81**	**385**

The hypothesis H_1 tested the relationship between strategic patenting decisions and the future value of the patent. In controlling across Firm Experience and Industry, a hierarchical regression analysis was performed using predictors of Family Size, Breadth, Claim Count, Jurisdiction Count, Priority Basis and Provisional Basis. Controlling for both Industry and Experience the R^2, coefficient and significance results are shown in
Table 4 and **Table 5**. The results show support for the H_1 hypothesis for both small and large firms at the $p < 0.05$ level. For the small firm the model was significant at the p-value < 0.05 level for the independent variables of Industry Type, Priority Claim and Breadth of Patent whereas the Large firm had significance at the p-value < 0.05 level for the independent variables of Industry

Type and Number of Claims. The R^2 was 32% for the small entity, but only 9% for the large entity.

Table 4 Controlling for Industry and Experience Model Summary

Model Summary

Entity Size	Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Small Entity	1	.477[a]	.227	.207	.401816
	2	.527[b]	.278	.249	.391003
	3	.563[c]	.318	.282	.382523
Large Entity	1	.263[a]	.069	.063	.441423
	2	.297[d]	.088	.079	.437597

[a] Predictors: (Constant), Industry Type, Log of Experience

[b] Predictors: (Constant), Industry Type, Log of Experience, Priority Claims

[c] Predictors: (Constant), Industry Type, Log of Experience, Priority Claims, Breadth of patent

[d] Predictors: (Constant), Industry Type, Log of Experience, Number of claims

Table 5 Controlling for Industry and Experience Model Coefficients

Coefficients [a]

Entity Size	Model		Unstandardized Coefficients		Standardized Coefficients		
			B	Std. Error	Beta	t	Sig.
Small Entity	1	(Constant)	.203	.070		2.881	.005
		Log of Experience	.069	.053	.139	1.305	.196
		Industry Type	.366	.096	.408	3.815	.000
	2	(Constant)	.289	.078		3.706	.000
		Log of Experience	.075	.051	.151	1.454	.150
		Industry Type	.322	.095	.359	3.379	.001
		Priority Claims	-.223	.096	-.229	-2.318	.023
	3	(Constant)	.120	.110		1.090	.279
		Log of Experience	.069	.050	.139	1.364	.177
		Industry Type	.309	.093	.345	3.315	.001
		Priority Claims	-.220	.094	-.227	-2.345	.022
		Breadth of patent	.122	.058	.201	2.110	.038
Large Entity	1	(Constant)	.306	.083		3.694	.000
		Log of Experience	.005	.025	.013	.222	.825
		Industry Type	.281	.062	.260	4.534	.000
	2	(Constant)	.234	.087		2.690	.008
		Log of Experience	.009	.025	.020	.349	.727
		Industry Type	.271	.062	.251	4.406	.000
		Number of claims	.004	.002	.139	2.507	.013

a. Dependent Variable: DV Citations without bias

The hypothesis H_2 built upon H_1 by examining the relationship between small and large firms, testing if small firms have a higher likelihood of predictors of patent value than large firms. This hypothesis was exploratory in nature in that a priori it was uncertain as to what variables would be different in small and large firms, and what the strength of the relationships would be. Comparing and analyzing the descriptive statistics across the data for small and large firms showed support for H_2.

As the independent variable variances are overlapping it is useful to consider the statistical significance and the Pearson Correlation for each variable individually without the interaction amongst other variables, including the control variable. This is done as the independent variable variances may be overlapping and a relationship may be suppressed when analyzed in aggregation. As summarized in

Table 6 there are four independent variables for the small entity and one independent variable for the large entity that show statistical significance at the *p*-value < 0.05 level and below. However as seen by the small r^2 values the Pearson Correlations for both firm sizes, under 2.2% for the large entity and under 9.1% for the small entity, indicating that there is a

weak linear relationship between the dependant variable log of forward citations and each individual independent variable.

Table 6 Individual Independent Variables (r^2)

	r-squared	
	Small Firm	Large Firm
Family Size	0.015	0.004
Breadth of patent	0.063*	0.000
Number of claims	0.087**	0.022**
Provisional Basis	0.001	0.003
Jurisdiction size	0.056*	0.000
Priority Claims	0.091**	0.000

* Correlation is significant at the 0.05 level (2-tailed)
** Correlation is significant at the 0.01 level (2-tailed)

Viewing the scatter plots of each of the variables with significance illustrates differences in trends between the small and large entity firms. A weak r^2 relationship can be seen in each of the figures. Considering claim counts as the independent variable (Figure 3, Appendix A) with no control variables, significance at the *p*-value < 0.01 level was seen. Jurisdiction size (Figure 4, Appendix A) shows significance at the *p*-value < 0.05 level for small entity. Priority claim (Figure 5, Appendix A) has significance at the 0.01 level for small entity and Patent Breadth (Figure 6, Appendix A) has significance at the 0.05 level for small entity.

7.0   Conclusions

This research paper validated and created a predictive model for researchers and managers to apply *ex-ante* to a patent, with a focus on indicators specific to a small firm. It addressed the research gap with the inclusion of priority basis and provisional claims as a unique strategic patenting decision indicator of value. The results were promising with priority basis as an indicator of patent value for small firms. The paper also answered the research question as what early strategic patenting decisions impact the future value of the product, which are industry type, firm patenting experience, patent breadth and priority claims. The research question focused on the interest with small firms and thus implications for practitioners can also be drawn from the results accordingly. The results are promising for R&D managers and executives in small firms as it will allow them to focus their patenting efforts into creating valuable patents in their portfolio. This is key for industry as it provides insight into what has the characteristics of a valuable patent before significant time and finances are invested. A discussion of the findings follows each of the hypotheses below.

H$_1$: Firm level of strategic patenting decisions up to the time of filing are related to the future value of the patent.

The empirical results show support for H$_1$ in that there are internal predictors that are associated with the value of the patent. They varied across firm size and there was a relatively low R^2 value for large firms (9%) as compared to small firms (32%) indicating a moderately to weak relationship when considering the impact of predictors from a practical managerial perspective. This implies that while predictors of significance were found for both small and

large firms, it is more so the predictive results for small firms that should be contemplated for inclusion into business practices by industry. Although small firms have less patenting experience than large firms as seen by their experience distribution plots, surprisingly the firms patenting experience was not a significant predictor in the model. This suggests to industry that small firms with little or no patenting experience still have potential to create valuable patent portfolios from inception. A second implication from the research shows that basing applications off provisionals was not an indicator of value, which was an unexpected result. However there was support for linking patent value to previously filed applications for small firms which was an expected result, but unexpected that it did not translate across to large firms as well. This is a serendipitous result in that as priority basis can be considered a subset of family size, it brings to light the question what characteristics of the family size weigh more heavily on its predictive nature of value as linked in previous research.

Secondary research done controlling for the industry type (see Appendix B) offered decreasing significant predictors for Mechanical technology patents but increasing significant for Electrical technology patents. This aligns with previous research that the model it not generalizable across industries and trends across industries are present. Contrary to previous research I did not see a statistical significance between family size and citations, of which I attribute to the combination of the small sample size and technology field studied (Electrical and Mechanical), particularly after secondary research (see Appendix B) indicated that the Electrical industry data was influencing the majority of the significance. Previous research contained larger sample sizes across all industries and noted higher influence in industries such as computer, semiconductor and pharmaceutical.

H_2 – There exists a higher likelihood of strategic patenting decisions and patent value relationship between small firms than large firms.

Again the results show support for H_2, suggesting two possible explanations. First small firms may be more adept at creating valuable patents than small firms or, second, small firms have a higher vested interest or need to create valuable patent thus "pick and choose" the ones to proceed with more carefully. This has implications for all size firms that want to create the most valuable patent portfolio. Simply having a patenting strategy that is focused on creating large patent portfolio counts, or having a standard procedure to patent all innovations across a pre-defined batch of jurisdictions will not necessarily lead to a portfolio with a high volume of valuable patents. They must consider each new innovation separately and make filing decisions according and not based on pre-determined business decision procedures.

The small firm model showed significance at the p-value < 0.05 level for experience, industry type, priority claims and breadth, with moderate R^2 values of 32%. There was a positive relationship with the breadth of technology and the two control variables experience and industry, but a negative relationship with the patent's claim of priority on another application. In practice this implies that a small firm may see higher cited patents with those that cover broad technology and do not claim priority to other cited applications, inferring these valuable patents are new and original application with a focus on covering a broad range of technology. Controlling for experience and industry type, the following predictive equation can be seen for small firms:

Log (Forward citations) $_{\text{small firm}}$ = 0.120 + 0.069*log(Experience) + .309*(Industry) – 0.220*(Priority) + 0.122 *(Breadth)

Industry (0=Mechanical; 1=Electrical) and Priority (0=no; 1=yes); R^2 = 32%; n=81

Considering now the large firm significance at the *p*-value < 0.05 level gave positive relationships with industry type and claim counts. The following predictive equation can be seen for large firms:

Log (Forward citations) $_{\text{large firm}}$ = 0.234 + 0.009*log(Experience) + .3271*(Industry) + 0.004*(Number of Claims)

Where Industry (0=Mechanical; 1=Electrical); R^2 = 9%; n=304

However, with the B coefficient so small (0.004), low R^2 value and the lack of significance of the second control variable experience, one may question the actual industry impact of using claim count for predicting large firm patent value. At a large firm level this has the implication that while statistically predictors can be found, one should be wary of basing business patent strategies for large firms on the results.

7.1   Future Research

Future research can take this conclusion to the next level in two distinct directions. The first direction is to conduct surveys with the patent holders to directly link the patent citations to actual financial value, thereby allowing management to model the strategic patenting decisions with an outcome of financial value. A similar research direction would be to perform a longitudinal study on patents that are being filed today, taking their inventor's predicted value, and following the data five to seven years after granting to measure the relationship between the *ex-ante* predicted value with both the *ex-post* actual value and citations received. The second direction would be to conduct larger and detailed in-depth data analysis on a specific industry, which would reduce the industry specific noise seen in the current results. This research direction would include considerable more analysis into the disaggregating of family counts, of which is the new variable of priority claim as it has provided another promising indicator of what components of patent family counts influence patent value.

7.2   Management Applications

As eluded to earlier, small firms can benefit from this research by seeking to increase the value of their future patent portfolio by filing new patents that do not claim priority to other applications, yet cover a broad scope of technology. While this may appear an obvious point to many there are many firms that have distinctly different filing strategies. Motorola's patent filing strategy through the 1990's was focused on becoming high volume, low cost of filings in order to propel them onto the Top-10 US issuance list for patent filings. Dow Chemical's filing strategy was historically driven by R&D, with patents reflected in promotion rates within the company and not necessarily the technical direction the company was moving. Their non-business oriented filing strategy was reflected in 1992 when they moved to align the patent ownership with the business direction, which resulted in $40M in future annuities being saved through abandoning irrelevant patents. It can most likely be inferred that with the realignment of the filing strategy for both Motorola and Dow Chemical, that the value of their patent portfolio was highly skewed due to dilution with irrelevant innovations. Based on an informal patent

based business studies I have done, two other well known firms in the electrical industry, General Electric and Asea Brown Boveri (ABB), appear to have polar opposite strategies. One has filings that focus on incremental innovations on existing technology while the other moves towards filing broad and innovative provisional applications very early on in development phase. These large companies illustrate the wide range of patent filing strategies that have been taken, with only one of them aligned with the direction of the research results.   As a small firm it is important to realize the initial strategic patenting decisions that are made can have a large influence on the future strength and direction of their portfolio. From a business context this research gives small firms the potential to focus on more relevant and valuable patents before poor patenting decisions become magnified as they grow into larger firms.

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Appendix A

Small and large firms patenting experience distribution, as measured by filed applications.

Figure 2 Standard Distribution of log(Experience)

Standard Distribution of log(Experience)
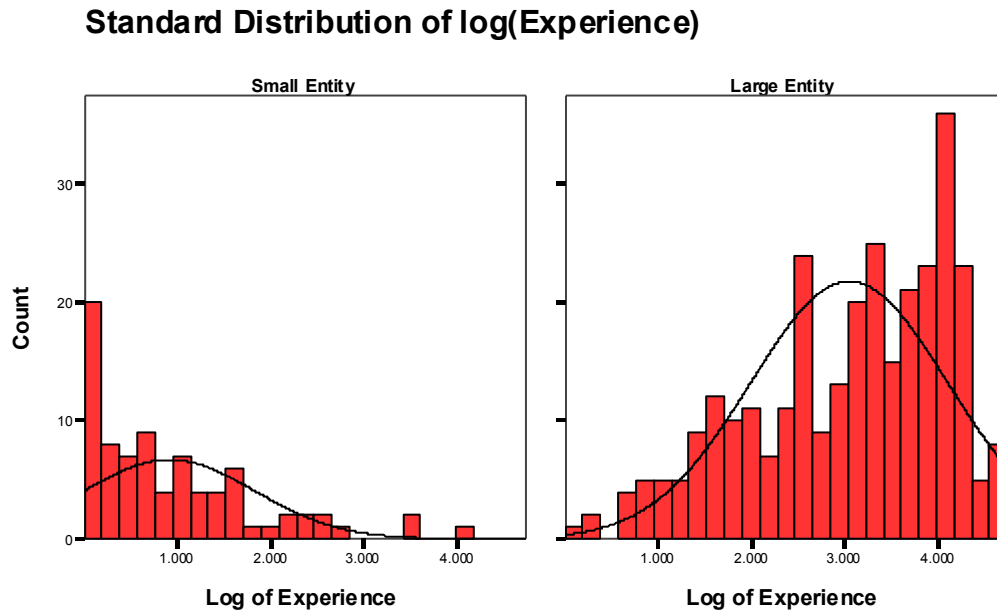
Viewing the scatter plots of each of the variables with significance illustrate differences in trends between the small and large entity firms, as well as the weak r^2 relationship can be seen in each of the figures. Considering Number of claims as the independent variable (Figure 3) with no control variables indicates a significance at the *p*-value < 0.01 level. Jurisdiction size (Figure 4) shows significance at the *p*-value < 0.05 level for small entity. Priority claim (Figure 5) has significance at the 0.01 level for small entity and Patent Breadth (Figure 6) has significance at the 0.05 level for small entity.

Figure 3 Log (Forward Citations) vs. Number of Claims

Log (Forward Citations) vs. Number of Claims   Linear Regression

Small Entity   **Large Enity**

Forwared Citations (Unbiased log)

Number of claims   Number of claims

Forwared Citations (Unbiased log) = 0.26 + 0.01 * Claims
R-Square = 0.09

Forwared Citations (Unbiased log) = 0.46 + 0.00 * Claims
R-Square = 0.02
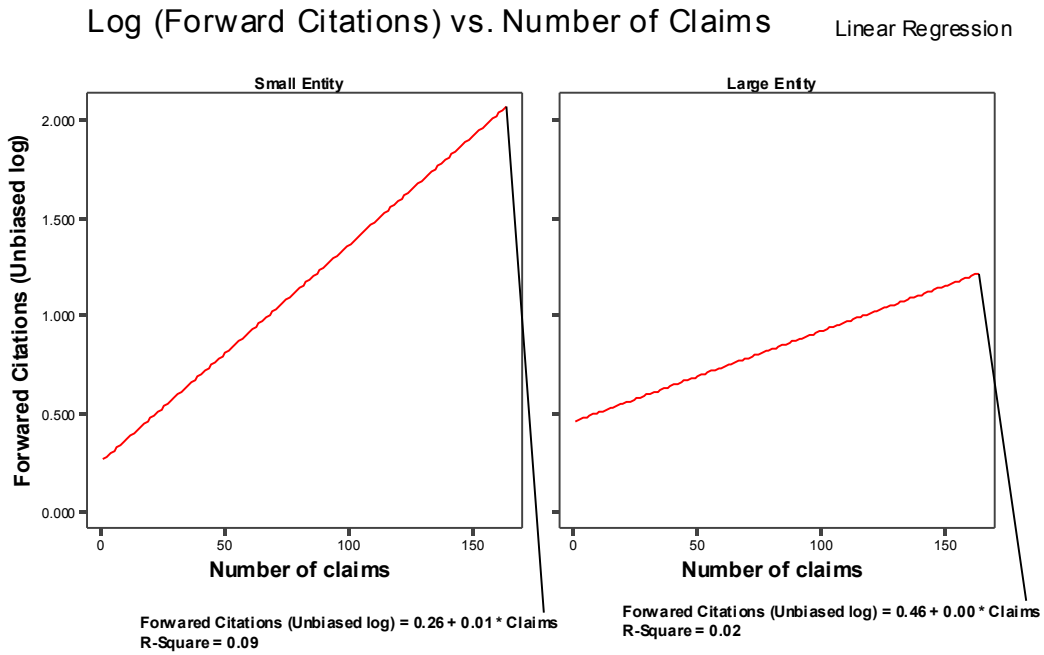
Figure 4 Log (Forward Citations) vs. Jurisdiction Size

Log (Forward Citations) vs. Jurisdiction

Small Entity   **Large Enity**

Forwared Citations (Unbiased log)

Jurisdiction size   Jurisdiction size

Forwared Citations (Unbiased log) = 0.34 + 0.04 * Jurisdiction
R-Square = 0.06

Forwared Citations (Unbiased log) = 0.53 + 0.00 * Jurisdiction
R-Square = 0.00
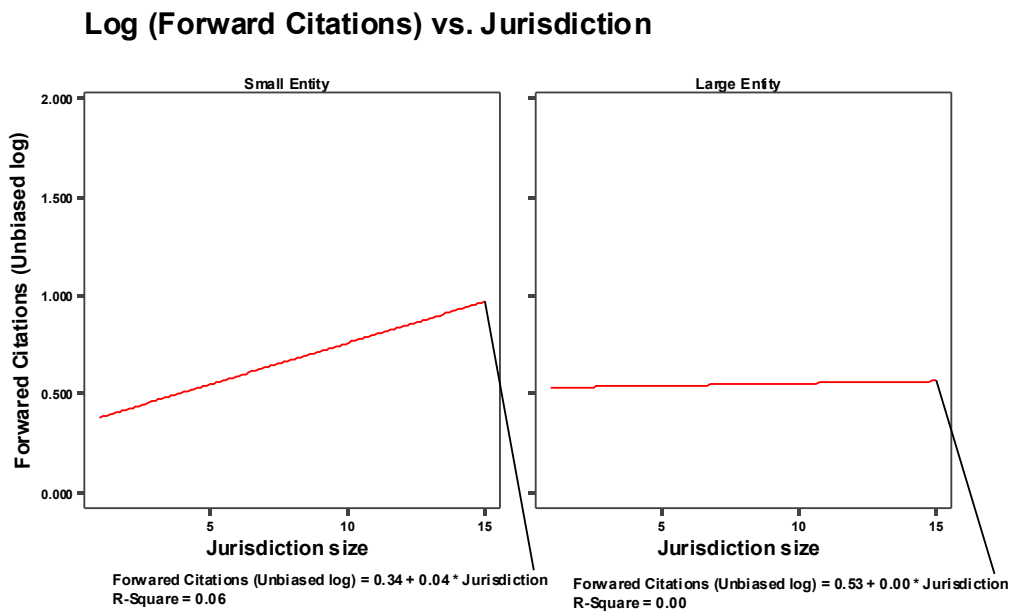
Figure 5 Log (Forward Citations) vs. Priority

Log (Forward Citations) vs. Priority   Linear Regression

Small Entity

Forwared Citations (Unbiased log) = 0.54 + -0.29 * Priority
R-Square = 0.09

Large Entity

Forwared Citations (Unbiased log) = 0.53 + 0.02 * Priority
R-Square = 0.00
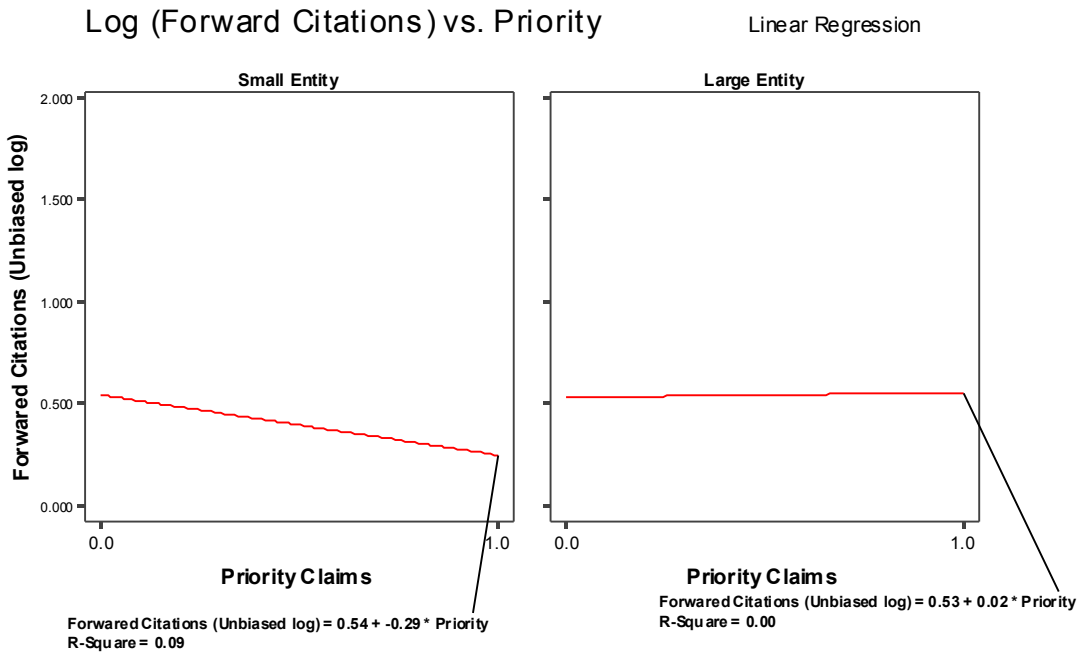
Figure 6 Log (Forward Citations) vs. Breadth

Log (Forward Citations) vs. Breadth   Linear Regression

Small Entity

Forwared Citations (Unbiased log) = 0.23 + 0.15 * Breadth
R-Square = 0.06

Large Entity

Forwared Citations (Unbiased log) = 0.53 + 0.01 * Breadth
R-Square = 0.00
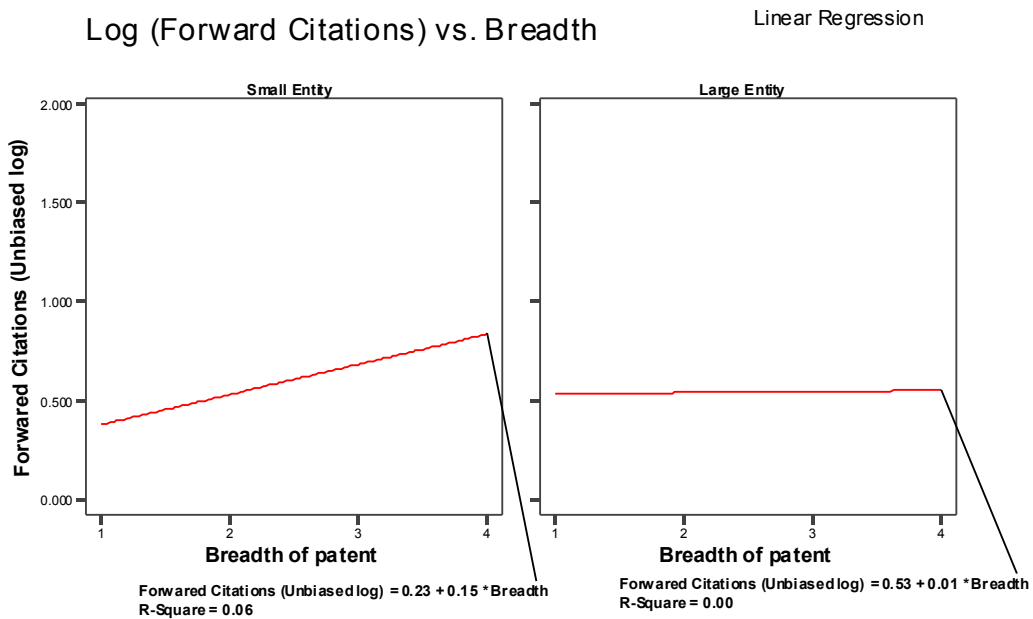
Appendix B – Separate Mechanical and Electrical Industry Analysis

A second portion of the analysis separating the Mechanical and Electrical Industry Type was done using a hierarchical regression analysis with the control variable of log(Experience) and the predictors of Family Size, Breadth, Number of Claims, Jurisdiction Count, Priority Claim and Provisional Basis. This allowed an analysis of how the two industries operate differently.

For patents filed in mechanical based technology controlling for only Experience results are shown in Table 7 and Table 8. Both models had no predictors for citations, with the exception of control variables. For the small firm the model was significant at the p-value < 0.05 level using the control variable of log(Experience), whereas the large firm had no significance at the p-value < 0.05. The R^2 was 13% for the small entity, but only 2% for the large entity.

Table 7 Controlling for Experience Model Summary; Mechanical Industry

Model Summary

Entity Size	Model	R Industry Type = F16 (Mechanical) (Selected)	R Square	Adjusted R Square	Std. Error of the Estimate
Small Entity	1	.356[a]	.126	.103	.288459
Large Entity	1	.135[a]	.018	.004	.332924

[a] Predictors: (Constant), Log of Experience

Table 8 Controlling for Experience Model Coefficients; Mechanical Industry

Coefficients [a,b]

Entity Size	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
			B	Std. Error	Beta		
Small Entity	1	(Constant)	.148	.061		2.440	.019
		Log of Experience	.163	.070	.356	2.345	.024
Large Entity	1	(Constant)	.203	.111		1.829	.072
		Log of Experience	.045	.040	.135	1.124	.265

[a.] Dependent Variable: DV Citations without bias

[b.] Selecting only cases for which Industry Type = F16 (Mechanical)

For patents filed in electrical based technology controlling for only Experience offered considerably different results (Table 9 and Table 10). For the small firm the model was significant at the *p*-value < 0.05 level for the independent variables Breadth and Priority Claims, whereas the large firm was statistically significant only for the predictor of Number of Claims. Again, neither was statistically significant for the control variable of Experience. The R^2 was 21% for the small entity, but only 3% for the large entity.

Table 9 Controlling for Experience Model Summary; Electrical Industry

Model Summary

Entity Size	Model	R Industry Type = H01 (Electrical (Selected)	R Square	Adjusted R Square	Std. Error of the Estimate
Small Entity	1	.061[a]	.004	-.022	.486067
	2	.334[b]	.112	.065	.464985
	3	.460[c]	.212	.148	.443900
Large Entity	1	.012[a]	.000	-.004	.468749
	2	.173[d]	.030	.022	.462714

[a.] Predictors: (Constant), Log of Experience

[b.] Predictors: (Constant), Log of Experience, Breadth of patent

[c.] Predictors: (Constant), Log of Experience, Breadth of patent, Priority Claims

[d.] Predictors: (Constant), Log of Experience, Number of claims

Table 10 Controlling for Experience Model Coefficients; Electrical Industry

Coefficients [a,b]

Entity Size	Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
			B	Std. Error	Beta		
Small Entity	1	(Constant)	.618	.121		5.105	.000
		Log of Experience	.029	.076	.061	.383	.704
	2	(Constant)	.368	.164		2.240	.031
		Log of Experience	.011	.073	.024	.155	.878
		Breadth of patent	.177	.082	.331	2.149	.038
	3	(Constant)	.458	.162		2.822	.008
		Log of Experience	-.001	.070	-.002	-.014	.989
		Breadth of patent	.181	.079	.337	2.295	.028
		Priority Claims	-.364	.168	-.317	-2.167	.037
Large Entity	1	(Constant)	.622	.099		6.263	.000
		Log of Experience	-.005	.030	-.012	-.182	.855
	2	(Constant)	.519	.105		4.933	.000
		Log of Experience	-.001	.029	-.002	-.026	.979
		Number of claims	.005	.002	.173	2.663	.008

[a.] Dependent Variable: DV Citations without bias

[b.] Selecting only cases for which Industry Type = H01 (Electrical