Market Valuation of Patent Characteristics

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Abstract

Measuring the returns to R&D has been an endeavor pursued by economists with vast interest in an effort to learn more about the characteristics of successful R&D. This paper empirically measures the market valuation of firms using patent statistics as a proxy for the success of R&D. It finds that self-citation and generality patent measures are largely insignificant likely due to a tendency for newer patents to be measured incorrectly. It also attempts a measure of companies' reputation for innovation for valuation and proposes a new method of quantification. Lastly, it finds that the market valuation of R&D investment is potentially myopic during years of stock market downturns.

JEL Codes: O30 O39

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Introduction:

It has become common in today's society to hear that a firm or industry or even a nation's innovation drives its success. In a 2005 survey by Cisco, business' and technology's leaders touted innovation as the most critical factor in their company's success (Cruz, 2005). Thus, quantifying innovation and its role in a firm's success is a key question that economists have sought to answer. In the following paper, Tobin's Q will be used in an attempt to determine the returns to innovation proxied through various patent statistics.

This fundamental idea of technological progress affecting economic growth and social welfare was first broached by economists beginning with Schumpeter who wrote on the topic in the early 20th century. However, it wasn't until Solow's seminal work regarding economic growth and its association with technological change that a large amount of empirical work was done on the relationship of innovative activity and firm performance. While the bulk of the research done on innovation has been on the relationship between size, market concentration and the innovation of a firm, this paper will focus primarily on the returns to investment in a firm's R&D.

The returns to investments in a firm's R&D and other innovation assets interests accountants, firm managers, policy makers, and economists due to its expensive nature. Specifically, accountants and firm managers are interested as the information would help guide and evaluate their investment decisions into R&D. Policy makers are interested in the issue because social or economy-wide returns to R&D investment can be greater or less than the private returns to individual firms. Lastly, economists are interested in the incentives firms face in undertaking the investment into R&D (Hall, 2010).

The most common method used to measure the returns to R&D is a production function or its cost profit minimization and maximization duality. However, this approach has several complications due to inherent limitations of its framework. Recently for firm level data, research has used stock market measures to address these limitations. In this formulation, R&D investments result in knowledge assets that contribute positively to a firm's cash flows and thus their market value. Since the R&D process is stochastic, some R&D expenditures are more successful than others. Empirical testing of this formulation has used several different measures of patents for greater information on R&D success. In this paper, the usage of previous patent characteristics such as patent count, citation count, and self-citations of a company will be examined with modifications. Additionally, the valuation of patent generality and perception of a firm will be examined. Patent generality can be used to provide a proxy for the general applicability of the R&D, which is a measure that has not been fully explored. While the measurement of the perception of the innovation of a firm is difficult to create, a valuation would be able to substantively answer the question of whether there is a discount or premium on a firm's reputation for innovation.

Literature Review:

As previously mentioned, Schumpeter made the first serious mention of the role innovation plays in economic growth (Schumpeter, 1947). His premise of creative destruction where innovative entry by entrepreneurs was the force that sustained economic growth sparked debate and was widely controversial for its political implications, but later became one of the foundations of innovation economics. This premise would go unexamined for a period of time until Solow's growth analysis used the assumption that technological advancement was the missing element to the production function that included labor and capital (Solow, 1956; Cohen, 2010). Following Solow's seminal work growth analysis (Solow, 1956; Cohen, 2010), research on measuring the returns to R&D began approximately half a century ago. Most of this literature has used the standard growth accounting framework added with measures of R&D at levels of aggregation from plant level up to the macroeconomic measures. This approach assumes the residual growth factor in production not accounted for by the usual inputs (capital, labor, intermediate inputs) to be a product of R&D that produces technical change (total factor productivity). The most common econometric approach to measuring returns to R&D is based on using the production function or its cost or profit duality function. Empirically, estimates of R&D elasticity and the rate of return based on the production function centers around .08 and 30% respectively with ranges from .01-.25 and 8%-128% (Hall, 2010). When using the duality function, the rate of return ranges from 6-56% centered around 15% with the highest results coming from data obtained from Canada (Hall, 2010). However many of the same issues mentioned by the first survey on measuring the returns to R&D have yet remain to be conclusively addressed by this body of literature (Grilliches, 1979). Namely, the issues of how best to measure innovation while accounting for lagged effects, depreciation of knowledge capital, input measurement, correct measurement of outputs , simultaneity of stock and output, and accounting for the effects of knowledge spillovers all still exist and can create significant errors in research(Grilliches, 1982, Grilliches, 1984, Grilliches and Mairresse, 1984, Hall, Grilliches, & Hausman, 1986). While considerable research has been done to determine an acceptable depreciation rate of knowledge capital (15%) this has recently been called into question by a recent study although no one has yet proposed a new depreciation rate (Hall, 2007). Due to the fact that there are a varying time lags between R&D and final output, measurement of input into R&D is quite difficult. Measurement of the R&D output itself through using price indices is difficult since there is a time lag between new improved products entering price indices. Additionally, much or R&D is performed in industries where the product is badly measured such as service industries or defense companies. Finally, determining the relationship between innovation and output is difficult due to the simultaneous nature between the two.

Although much less commonly used than the production or duality functions, this paper will attempt to use and improve an alternative model involving stock market measurements for productivity to analyze the impact of R&D at the firm level. This has the advantage of not having to adjust for output measurement issues as the stock market should theoretically reflect the correct value of a firm including all tangible and intangible aspects. This model accounts for the previously mentioned problems of input and output measurement. The obvious downside to this is that using stock market valuations makes it impossible to separate and correlate results to an individual R&D input made by a division of the firm. Additionally, several researchers have proposed financial markets are not always efficient in evaluating R&D investments due to existing information asymmetries (Aboody and Lev, 2000; Hall, 2002; Lev, 2004) However, a considerable amount of research has been done using this method as outlined by Grandi, Oriani, and Hall (2008).

Three main questions have been examined by research using this methodology. First, a number of papers have examined whether R&D investments create value for the firm with research suggesting that firms are positively affected by R&D investments although the valuation is volatile over time and industries and countries (Hall, 2000; Czarnitzki et al., 1996; Oriani and Sobrero, 2003; Hall, 1993a, 1993b; Jaffe, 1986; Cockburn and Grilliches 1988; Hall and Oriani 2006). The stock market has also been shown to react positively to announcements of new R&D investments (Woolridge and Snow, 1990; Szewczyk et al., 1996). Second, expected results from R&D investment are subject to a high degree of uncertainty and thus predicting their impact is hard to predict (Mansfield et al., 1977; Oriani Sobrero, 2008). Third, corporate governance at the country and firm level can affect the market valuation of R&D investments (Hall and Oriani, 2006). This paper will focus on the first question on precisely how firms are affected to R&D investment.

In addition to returns to R&D research, there have been several papers on how characteristics of R&D affect returns. Hall, Jaffe, and Trajtenberg (2005) found positive association between R&D intensity, patent output, and the importance of patents measured by average number of patent citations with Tobin's Q. Industry characteristics are also found to be highly significant with drug- and computer- related innovations. Hall (1993) also created a working regression using a model that found a drop off in the relative stock market valuation of intangible assets. This paper will attempt to update and create a more nuanced model that can answer how patent characteristics and the perception of research can affect market valuations. Such research can provide further explanatory power of R&D inputs and R&D reputation.

Theoretical Framework

The theoretical framework for this paper most closely resembles the accepted valuation of different types of capital based on Hayashi and Wildashin (1982) and later modified by Hall (1993). Namely, the valuation of corporate assets both tangible and intangible is the solved expected present discounted cash flow given a portfolio of assets. Therefore since these assets cannot be changed without cost the present position of a firm's assets is important in determining its optimal value. Therefore a firm's value in any given period is a function of its assets or 'capital' as illustrated in equation 1 where V is market value of the Capital, Q is analogous to Tobin's Q, A's are various tangible assets, K's are intangible assets, and sigma is included to measure departures from constant returns to scale.

(1)

$$V(\{C_{it}\}) = f(C_{1t}, C_{2t}, \ldots,)$$

Or

$$V(A_1, A_2, \ldots, K_1, K_2, \ldots) = Q\ (A_1 + \lambda_2 A_2 + \ldots + \gamma_1 K_1 + \gamma_2 K_2 + \ldots)^{\sigma}$$

Using such a valuation equation with Tobin's Q on the left side does have three major defects. First, it assumes market efficiency, which while support by economic research is still under controversy (Fama, 1970; Fama, 1991; Hall, Oriani, Grandi, 2008). Second, it assumes the marginal value of the capital in a firm is equal to its average value. This has been proven valid under constant returns to scale and an adjustment cost function that is linear homogenous in investment and capital. However, the above conditions are unlikely to apply in practice. Finally, it assumes capital aggregates in production with unit weights multiplying the book values of different types of capital. In simpler terms, a dollar worth of capital is equal no matter the type. Despite these flaws, using accounting measures to compute returns to investment is a poor alternative due to inaccuracy and poor measurement of long-run profitability resulting from investment. However, the usage of a production function or a duality function is far less accurate in terms of input and output and even if perfected gives little information useful to the assumed object of a manager's actions; a firm's profitability from investment decisions. Usage of a financial market valuation such as Tobin's Q solves both of these problems in theory as the financial market is one of the best functioning markets and measures exactly what should motivate a firm's decisions. Despite this key issue Tobin's Q has been shown to be the best indicator of a firm's performance over p/e ratios and other measures by Harney and Tower (2003)

Previous work by Hall (Hall, 1993) as well as Hall, Jaffe, and Trajtenberg (Hall, Jaffe, Trajtenberg 2005), have established the viability of the Tobin's Q approach for examining the relationship between firm performance and various intangible assets. This paper will build on such results with data from the NBER (National Bureau of Economic Research) patent database. The data also allows for examination of Schumpeterian hypotheses mentioned earlier although this is not the focus of the paper. Finally, the relationship between patent generality and firm performance as well as the relationship between the perception of a firm's innovation and firm performance will be investigated. Neither of these relationships have previously been conclusively examined due to data constraints on patent information and firm reputation.

However, updated datasets that include generality and a new dataset used for firm reputation of innovation make the examination of these relationships possible. The relationship between the generality of patents and firm performance is anticipated to be positive due to the anticipated profitability of a more general patent. Whether a firm's market performance is significantly influenced by the perception of its innovation is much more theoretically questionable and would represent a market premium based on information.

Empirical Framework

As Equation One shows, a firm's value is assumed to be a function of its assets, which can be classified as either tangible or intangible. The tangible assets or the physical capital of the firm is defined as the sum of net plant and equipment, inventories, investments in unconsolidated subsidiaries, intangibles, and others (adjusted for inflation) measured individually as A_1, A_2, and A_3. The intangible assets of a firm that will be measured are knowledge capital, which will be proxied using R&D intensity, patent yield, average citations and patent generality first individually and then eventually determined using a single weighted combined measure. R&D intensity is defined as ratio of R&D expenditure to the book value of assets (K_1), patent yield as ratio of patent count to R&D expenditure (K_2), average citations as the average ratio of citations to patents for the company (K_3), self-cites as the amount of patents cited by the company that it owns (K_4), and patent generality (K_5) as the average HHI index that a patent's categories span for a company. This is calculated by summing the squares of the frequency that a patent occurs in a given patent category. The first two variables have been previous examined, but average citations and self cites have only been examined categorically. Patent generality, for which data only recently became available, has yet to be examined by a market valuation equation although the idea was proposed in Hall's paper Market Value and Patent Citations (2005). Additionally R&D intensity is interacted with patent yield (K_6), average citations (K_7), own patents (K_8), and patent generality (K_9).

The intangible assets also include proxies for brand name value name that results in product reputation as well as differentiation (K_{10}), market power or long run profitability not related to the above (K_{11}), prospects for future growth that are not completely captured by the current level of R&D capital or spending (K_{12}), and the perception of a firm's technology (K_{13}). Brand name value will be proxied by the ratio of advertising expenditure to the firm's size as this is the closest measure available for the rents accruing to reputation as per a previous paper by Hall. Market power will be proxied using a 2 year moving average of past cashflow (measured as operating income less interest payments). Growth rate will be proxied using the previous year's growth rate of sales. Perception will be proxied by using a count of mentions of innovative activity in media weighted by firm size relative to its industry. Finally, fixed effects for industries will be included as well. The final general form of the expanded regression in log form and for computing elasticity of various measures is shown below in equation 2.

(2)

$$\log V = \log Q + \sigma\left(\log A + (\lambda_2 - 1)(A_2/A) + .. + \gamma_1(K_1/A) + \gamma_2(K_2/A) + ..\right) + e$$

Here, the constant is interpreted as the log of Tobin's Q and coefficients can be interpreted as the scalar (sigma) divided by the market discount of the asset as demonstrated below in equation 3. Sigma is included to measure departures from constant returns to scale in the value function.

(3)

$$\log V - \sigma \log A \sim \sigma \, PDV(rents)/A$$

Both tangible and intangible assets should have a positive coefficient due to their theoretical positive relationship with firm performance. Theoretically, the significance of the coefficient for the perception of innovation should be positive. With a significant value, the coefficient for the perception of innovation can be interpreted as the market premium for reputation of innovation.

Data

This paper uses two large datasets that have been linked through a matching process similar to that of Hall, Jaffe, and Trajtenberg (Hall, Jaffe, & Trajtenberg, 2005). The first is all patents granted by the USPTO between 1975 and 2007, including their patent citations from the NBER patent database maintained by Bronwyn H. Hall. This represents roughly 50-60% of all patents of US origin that were assigned to corporations during 1976-2006. The data has previously been cleaned and matched to assignees. Companies are then matched to assignees of which there can be multiple and have movements between companies per year. Compustat (CRSP) data comprises of all publicly traded firms between 1975 and 2007 that matches the USPTO patent data. The firms were all publicly traded on the New York, American, and regional stock exchanges, or over-the-counter on NASDAQ. The variables used from the Compustat dataset are the market value of the firm at the close of the year, the book value of the physical assets (capital expenditures +current assets +intangible assets), and the book value of the R&D investment. The definition of the book value is the sum of net plant and equipment, inventories, and investments in unconsolidated subsidiaries, intangibles, and others (Hall, 1993). The R&D capital stock is constructed using a declining balance formula and the past history of R&D spending with a 15% depreciation rate (Hall 1990). Using the patents and citation data matched to the Compustat firms, we constructed patent stocks and citation-weighted patent stocks, applying the same declining balance formula used for R&D.

Due to matching constraints the period of the fiscal year of 1998-2005 was used with a balanced set of 306 firms from an unbalanced panel of 486 firms. While this is approximately half the amount of firms that previous research has established with a balanced set it is also over a longer period of time (8 continuous fiscal years vs. 5). Additionally, for the perception of innovation Google Trends data on companies and innovation was used from 2004-2006 as a measure of the perception of a company's innovation. This is measured as the amount of searches made on the company and innovation with aggregated over the year. While this is not the ideal measurement for the perception the aggregate measure through each year will be used as a stock of its reputation for innovation. When included this further lowers the sample to 129 firms.

Estimates:

Table 1 shows the means, medians, and interquartile ranges of the variables from 1998 to 2006. Table 2 shows the means of the variables from 1998 to 2006, together with the means at the beginning and end of the period to give some idea of how the variables change. Noticeable differences are the decrease in companies' average patent citations, the increase in self-citations as well as the increase in the operating income and the growth of sales over time. The increase in self-citations could be due to a firm's entrenched position in a certain field or technology or simply a result of self-bias where firms prefer to cite their own patents. As expected, all the values are extremely skewed as expected by the differences between large and small firms. The measurement for reputation in innovation has a high standard deviation and is extremely skewed. Finally, Tobin's Q ratio appears to be much higher than previous literature suggests, likely due to the sample selection from the data matching.

Table 3 explores the specification of the Log V regression first with all variables including the perception measure then with only bookvalue along with a comparison between the different patent characteristics as measures for R&D success or intangible values and finally one with all values excepting the measure for perception. Table 3b does the same, except with the inclusion of industry effects. Inclusion of the perception of innovation measure lowers the r squared value, which could be due to the smaller sample size and increased variability of the measurement. Note that most of the variation comes from the firm size variable, which is to be expected since the firm market valuations ranged from \$1.9 million to \$500 billion. The scale coefficient or the coefficient of the book value of assets is far less than unity, which could arise from measurement error in the decreasing returns in the value functions in addition to sampling bias. The coefficient for the cash flow variable is extremely low and significant suggesting that the use of the operating income is flawed and a full cash flow derived from the balance sheet would be valued more highly. Additionally, for the full regression R&D intensity is a surprisingly poor measure for market value: contradictory to past literature.

In a comparison between the patent characteristic valuation equations none of the patent characteristics outperformed the R&D intensity of a firm for market valuation and none were significant on their own although when combined with the R&D intensity patent count ratio and prospects for future growth were significant and positive. This implies that patent characteristics can add value and importance to the market valuation equation, but cannot provide more information than the R&D intensity alone. Since, all of these coefficients are subject to variation over time (Hall, 1993) a further look should be taken as to how the regression changes over time.

The Change in the Valuation Relation over Time:

Tables 4a and 4b show the change in the valuation equation including all variables except the measurement for perception of innovation with and without industry effects. For these regressions, the coefficient of A is extremely close to unity. Therefore the intangible variables' stock and flow values for are almost equal. In Graph 1 one can see that for fiscal years the stock market took a downturn (2000, 2002, and 2005), the coefficient and significance of R&D intensity sharply declined. 2000 was the year of the dotcom bubble, 2002 marked the beginning of the economic downturn and the 2005 fiscal year coincided with the stock market reaching an all-time low (White, 2005). Additionally as shown in graphs 2 and 3, the coefficients for self-cites and generality were insignificant throughout the years. This data in combination with the panel results indicates the variables provide no significant additional information for returns to R&D during this period. Finally, there is a steady increase in the valuation of prospects of future growth as shown in Graph 5. For all of these findings, regressions including industry effects show the same general trend although the with slight variations in magnitudes.

Conclusions:

Measures of a company's patents self cites and generality have both been shown to be insignificant for a company's market value in almost all formulations. This is likely due to the inability to correct for the possible truncation of the two. This inability stems from the lack of data on the behavior of patent citations by companies. Previous research that was done to determine the behavior of a patent citation over its lifetime produced a correction value for this truncation (Hall, 2005). However, research has yet to be published on the distribution of patent citations by the same company over time. Thus, newer patents will tend to result in lower values for the self cites and generality measures. Additionally, the addition of a coefficient for measuring the reputation of a company's innovation lowered the r squared to extremely low values. This is likely due to limitations of using Google Trends as a measurement; the tool provides a limited time series matching to companies and the usage relative traffic value rather than absolute number of searches. An alternative measure, if it can be obtained, would be the amount of mentions a company receives per year related to innovation by news sources from a reputed news database such as LexisNexis. However, LexisNexis and databases of its kind have yet to offer a programming interface for such a search.

Finally, an examination of the data across fiscal years yields the surprising result that market valuation of R&D falls and fails to provide significance during years of significant stock market downturns (2000, 2002, and 2005). It seems unlikely that a long term rate of return would exhibit such behavior and that the private rate of return to R&D would have in fact fallen. This could result because of sample bias as the sample size and time period in Compustat is smaller than previous samples obtained in literature despite having similar characteristics to previous sample data. An alternative explanation is that during times of recession the stock market becomes myopic and discounts cash flows from R&D capital at a very high rate. While not implausible the implication that people ignore long term returns to investment during an economic downturn warrants more detailed research. This can be examined in the future through recent economic turbulence in conjunction with further updated NBER patent data.

Tables:

VARIABLES	
logQ	log(Tobin's Q)
logmkvalt	log(total market value of the firm)
logbookval	log(total book value of the firm= capital expenditures+current assets+intangible assets)
intan1	R&D intensity (R&D expenditure/ total bookvalue of the firm)
intan2	Patent Count Ratio (Total Patents Firm owns/ R&D expenditure)
intan3	Average citations (Average ratio of Citations to Patents)
intan4	Self cites (Amount of Patents Cited by the company that it owns)
intan5	Patent Generality (Average number of CIS categories a patent spans that a company owns)
intan6	Interaction term between Patent Count Ratio and R&D Intensity
intan7	Interaction term between Average Cites and R&D Intensity
intan8	Interaction term between Self Cites and R&D Intensity
intan9	Interaction term between Patent Generality and R&D Intensity
intan10	Brand name value (Advertising expenditure / Bookvalue of the firm)
intan11	Market power (2 year moving average of operating income after depreciation)
intan12	Prospects for Future Growth (Previous year's growth rate of sales)
intan13	Perception of a firm’s technology (Google Trends Count)
Gsector	Industry Sector of the Firm from Compustat (10 different sectors ie: energy, industrial etc..)
Lowintan4	Self cites in the bottom 25%
Midlowintan4	Self cites in the 25%- 50%
Midhighintan4	Self cites in the 50%-75%
Highintan4	Self cites in the top 25%

Table 1 Summary Statistics of all Variables

VARIABLES	Mean	S.D.	Min.	0.25	Med.	0.75	Max
logQ	0.44	1	-4.46	-0.15	0.41	1.02	7.17
logmkvalt	6.59	2.5	0.18	4.62	6.56	8.46	13.14
logbookval	6.24	2.22	-3.38	4.53	6.26	7.92	11.5
intan1	0.07	0.43	0	0	0.02	0.07	22.79
intan2	0.38	2.07	0	0.01	0.03	0.14	48.55
intan3	0.8	0.72	0	0.38	0.59	0.97	6.58
intan4	203.95	2228.84	0	0	12	47	45151
intan5	0.63	1	0.15	0.43	0.53	0.66	18.11
intan10	0.47	4.06	0	0.18	0.31	0.48	195.79
intan11	1025.25	3979.46	-2241	6.05	61	436.45	51879.5
intan12	0.09	0.32	-1	-0.03	0.06	0.16	3.92
intan13	198.46	582.79	0	0	0	0	3644

Table 2 Mean of Variables across Years

Mean of VARIABLES	Fyear 1998	Fyear 1999	Fyear 2000	Fyear 2001	Fyear 2002
logQ	0.5	0.4	0.4	0.37	0.21
logmkvalt	6.17	6.36	6.41	6.5	6.41
logbookval	5.72	5.94	6.12	6.23	6.31
intan1	0.07	0.06	0.05	0.06	0.06
intan2	0.46	1.05	0.38	0.29	0.23
intan3	0.8	0.8	0.82	0.83	0.79

intan4	184.7	202.13	240.99	201.14	183.04
intan5	0.6	0.61	0.62	0.62	0.63
intan10	0.39	0.38	0.37	0.4	0.38
intan11	688.83	761.8	979.48	1027.93	967.25
intan12	0.09	0.09	0.13	0.02	0.01
intan13					

Table 3a: Fixed Effects Regressions for Panel Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt
logbookval	0.443***	0.635***	0.702***	0.667***	0.635***	0.636***	0.637***	0.635***	0.658***	0.768***
	(0.162)	(0.0213)	(0.0224)	(0.0302)	(0.0213)	(0.0213)	(0.0213)	(0.0213)	(0.0228)	(0.0373)
intan1	-4.394		0.206***							0.387
	(2.772)		(0.0247)							(0.754)
intan2	-0.0908			-0.0143						-0.0149*
	(0.0989)			(0.00875)						(0.00820)
intan3	0.0402				-0.0122					-0.0155
	(0.822)				(0.0392)					(0.212)
intan4	-0.0167***					-2.54e-05				0.000161
	(0.00542)					(4.07e-05)				(0.000129)
intan5	8.001*								-0.182	-0.271
	(4.136)								(0.151)	(0.242)
intan6	-10.75***									-0.0563
	(3.375)									(0.271)
intan7	-0.604									0.697
	(1.728)									(0.435)
intan8	0.0649**									-0.00160
	(0.0323)									(0.00279)
intan10	-0.427									-0.0654
	(0.495)									(0.0749)
intan11	5.44e-05									-3.09e-06
	(0.000143)									(1.18e-05)
intan12	0.123									0.459***
	(0.0930)									(0.0547)
intan13	0.000120									
	(0.000154)									
lowintan4							0.223			
							(0.291)			
midlowintan4							0.368			

							(0.286)			
midhighintan4							0.261			
							(0.285)			
highintan4							0.287			
							(0.276)			
intan9										-0.00192
										(0.00413)
Constant	1.057	2.675***	2.251***	2.424***	2.687***	2.674***	2.382***	2.675***	2.634***	1.915***
	(3.259)	(0.131)	(0.139)	(0.182)	(0.136)	(0.131)	(0.307)	(0.131)	(0.168)	(0.374)
Observations	295	2,885	2,885	1,509	2,885	2,885	2,885	2,885	2,559	1,446
R-squared	0.0133	0.8412	0.846	0.8668	0.8401	0.8408	0.8412	0.8412	0.8265	0.8359
Standard errors in parentheses										
*** p<0.01, ** p<0.05, * p<0.1										

Table 3b Fixed Effects Regression with Industry Effects

VARIABLES	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt
logbookval	0.418**	0.630***	0.659***	0.751***	0.628***	0.632***	0.630***	0.630***	0.663***	0.775***
	(0.164)	(0.0248)	(0.0275)	(0.0376)	(0.0248)	(0.0249)	(0.0249)	(0.0248)	(0.0267)	(0.0503)
intan1	-6.885**		0.861**							0.547
	(3.091)		(0.367)							(1.102)
intan2	-0.0941			-0.0124						-0.0134*
	(0.104)			(0.00795)						(0.00768)
intan3	0.289				-0.0818*					-0.211
	(0.972)				(0.0442)					(0.230)
intan4	-0.00366					-0.000192				0.000527
	(0.0113)					(0.000265)				(0.000499)
intan5	1.004								-0.200	-0.324
	(6.359)								(0.151)	(0.233)
intan6	-12.17***									-0.924**
	(3.747)									(0.417)
intan7	2.034									2.157***
	(1.990)									(0.801)
intan8	0.0850									-0.0131**
	(0.0660)									(0.00663)
intan10	-0.511									-0.0714
	(0.534)									(0.174)
intan11	-7.94e-07									-5.95e-06
	(0.000147)									(1.15e-05)
intan12	0.119									0.465***
	(0.121)									(0.0673)
intan13	0.000101									
	(0.000148)									
lowintan4							0.345			
							(0.355)			
midlowintan4							0.378			
							(0.348)			
midhighintan4							0.429			
							(0.348)			

highintan4							0.353			
							(0.338)			
Constant	3.775	2.902***	2.678***	2.074***	2.980***	2.897***	2.548***	2.902***	2.805***	2.163***
	(4.635)	(0.159)	(0.185)	(0.235)	(0.165)	(0.159)	(0.377)	(0.159)	(0.198)	(0.488)
Observations	219	1,770	1,770	936	1,770	1,770	1,770	1,770	1,571	919
R-squared	0.2988	0.8526	0.8579	0.8932	0.8436	0.8517	0.8528	0.8526	0.8225	0.8035
Standard errors in parentheses										
*** p<0.01, ** p<0.05, * p<0.1										

Table 4a Regression by Year without Industry Effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt
Fyear	1998	1999	2000	2001	2002	2003	2004	2005
logbookval	1.069***	1.076***	1.087***	1.070***	1.089***	1.071***	1.065***	1.049***
logbookvalse	(0.0524)	(0.0471)	(0.0487)	(0.0404)	(0.0379)	(0.0346)	(0.0277)	(0.0294)
intan1	3.280*	6.962***	0.0126	6.220***	0.359	3.994***	3.333***	2.125**
intan1se	(1.887)	(1.994)	(2.364)	(1.584)	(1.367)	(1.463)	(1.148)	(1.041)
intan2	0.0633	-0.00562	-0.0471	-0.0206	-0.0590	-0.106	0.0245	-0.0322
intan2se	(0.0701)	(0.0141)	(0.0594)	(0.145)	(0.159)	(0.133)	(0.144)	(0.125)
intan3	0.370*	0.533**	0.228	0.433***	0.186	0.605***	0.279**	0.455***
intan3se	(0.209)	(0.221)	(0.236)	(0.117)	(0.138)	(0.155)	(0.115)	(0.116)
intan4	0.000179	-7.02e-05	-0.000334	-0.000952*	-0.000150	-0.000331	-0.000128	-0.000101
intan4se	(0.00100)	(0.000737)	(0.000862)	(0.000532)	(0.000426)	(0.000510)	(0.000415)	(0.000392)
intan5	0.0226	0.0255	0.0329	0.0564	0.0166	0.0825**	0.0793**	0.0471
intan5se	(0.0412)	(0.0452)	(0.0493)	(0.0393)	(0.0389)	(0.0361)	(0.0332)	(0.0366)
intan6	-2.952*	-0.00598	-0.700	0.874	0.564	2.256***	-0.530	2.090
intan6se	(1.695)	(0.710)	(1.045)	(0.733)	(0.817)	(0.804)	(2.541)	(2.548)
intan7	-1.311	-1.576	1.809	-2.547**	-0.163	-4.142***	-1.328	-2.346**
intan7se	(1.710)	(1.703)	(2.526)	(0.994)	(1.281)	(1.510)	(0.971)	(1.131)
intan8	-0.00700	-0.00201	0.000806	0.00599	0.00126	0.00591	0.00103	-0.00132
intan8se	(0.0115)	(0.0106)	(0.0103)	(0.00627)	(0.00714)	(0.00868)	(0.00721)	(0.00695)
intan10	0.524*	-0.273	0.735**	-0.211	0.615**	0.671***	0.421*	0.603***
intan10se	(0.314)	(0.376)	(0.311)	(0.294)	(0.283)	(0.254)	(0.223)	(0.230)
intan11	0.000205**	8.84e-05**	6.99e-05**	5.34e-05*	5.34e-05**	6.61e-05**	3.32e-05**	2.10e-05*
intan11se	(7.84e-05)	(3.60e-05)	(2.79e-05)	(3.04e-05)	(2.07e-05)	(2.93e-05)	(1.36e-05)	(1.12e-05)
intan12	0.109	0.920***	0.972***	1.085***	1.261***	0.305*	0.254*	0.822***
intan12se	(0.248)	(0.320)	(0.317)	(0.224)	(0.247)	(0.167)	(0.143)	(0.210)
Constant	-0.554	-0.717*	-0.830**	-0.526	-0.764**	-0.820***	-0.485**	-0.526**
Constantse	(0.405)	(0.381)	(0.413)	(0.341)	(0.335)	(0.291)	(0.228)	(0.245)

Observations	122	124	137	147	149	163	175	178
R-squared	0.906	0.893	0.887	0.918	0.930	0.932	0.945	0.935
Standard errors in parentheses								
***** p<0.01, ** p<0.05, * p<0.1**								

Table 4b: Regression by year with Industry Specific Variables

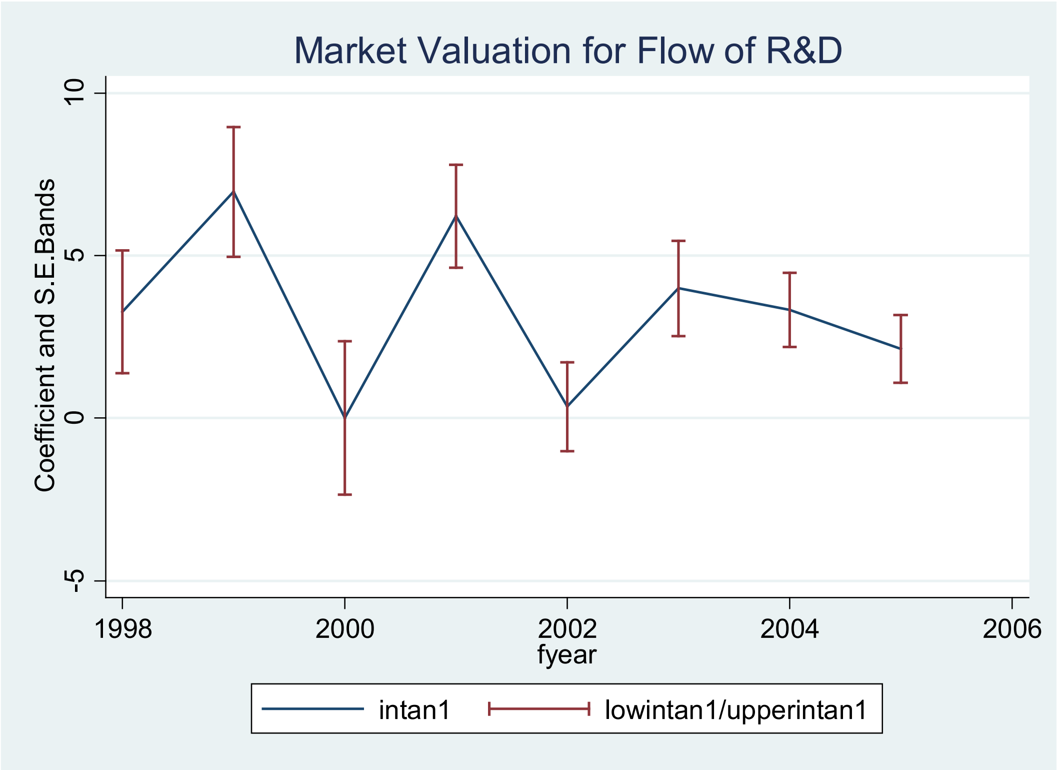
VARIABLES	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt	logmkvalt
Fyear	1998	1999	2000	2001	2002	2003	2004	2005
logbookval	1.093***	1.089***	1.187***	1.123***	1.107***	1.098***	1.091***	1.069***
logbookvalse	(0.0567)	(0.0637)	(0.0563)	(0.0488)	(0.0430)	(0.0386)	(0.0323)	(0.0352)
intan1	3.737*	8.703***	2.473	4.296**	-0.506	3.770**	2.523*	1.478
intan1se	(2.075)	(2.595)	(3.136)	(2.039)	(1.683)	(1.776)	(1.392)	(1.396)
intan2	0.0352	-0.00318	0.00473	0.0378	-0.0483	-0.168	0.0544	-0.0579
intan2se	(0.0705)	(0.0145)	(0.0581)	(0.155)	(0.156)	(0.209)	(0.166)	(0.139)
intan3	0.0950	0.126	-0.190	0.312*	0.0192	0.313*	0.192	0.345**
intan3se	(0.244)	(0.309)	(0.261)	(0.179)	(0.161)	(0.174)	(0.138)	(0.139)
intan4	0.00228	0.00264*	0.00224	-0.00104	-0.000201	0.00102	-0.000483	-0.000383
intan4se	(0.00170)	(0.00143)	(0.00169)	(0.000887)	(0.000679)	(0.00102)	(0.000609)	(0.000567)

intan5	0.0293	0.0288	0.0483	0.0613	0.0221	0.0772**	0.0878**	0.0526
intan5se	(0.0403)	(0.0458)	(0.0477)	(0.0411)	(0.0360)	(0.0356)	(0.0364)	(0.0389)
intan6	-1.909	0.580	-1.167	0.911	0.783	1.910**	0.0647	4.605
intan6se	(1.722)	(0.772)	(1.193)	(0.873)	(0.793)	(0.884)	(2.871)	(2.892)
intan7	-0.213	-0.167	3.589	-2.481	-0.360	-2.604*	-1.097	-2.537**
intan7se	(1.837)	(2.133)	(2.733)	(1.494)	(1.416)	(1.556)	(1.162)	(1.281)
intan8	-0.0255	-0.0635**	-0.0453	0.0286	0.0101	-0.0137	0.0148	0.0144
intan8se	(0.0160)	(0.0319)	(0.0415)	(0.0249)	(0.0159)	(0.0197)	(0.0132)	(0.0137)
intan10	0.777**	-0.0156	1.120***	0.0986	0.934***	1.017***	0.617**	0.631**
intan10se	(0.345)	(0.445)	(0.346)	(0.355)	(0.300)	(0.276)	(0.263)	(0.280)
intan11	0.000154*	0.000144	1.44e-05	3.72e-05	7.44e-05**	4.75e-05	3.85e-05**	1.87e-05
intan11se	(8.70e-05)	(0.000108)	(4.11e-05)	(3.25e-05)	(3.35e-05)	(2.98e-05)	(1.83e-05)	(1.42e-05)
intan12	0.0671	1.017***	1.066***	1.023***	1.263***	0.848***	0.199	0.809***
intan12se	(0.276)	(0.365)	(0.394)	(0.293)	(0.250)	(0.291)	(0.279)	(0.286)
gsector	-0.00107	-0.00703	0.00127	0.00207	0.00631	0.00646	0.00413	0.00443
gsectorse	(0.00677)	(0.00764)	(0.00749)	(0.00623)	(0.00521)	(0.00477)	(0.00454)	(0.00506)
Constant	-0.683	-0.627	-1.591***	-0.853*	-0.994**	-1.204***	-0.747**	-0.727**
	(0.476)	(0.526)	(0.534)	(0.461)	(0.385)	(0.360)	(0.291)	(0.304)

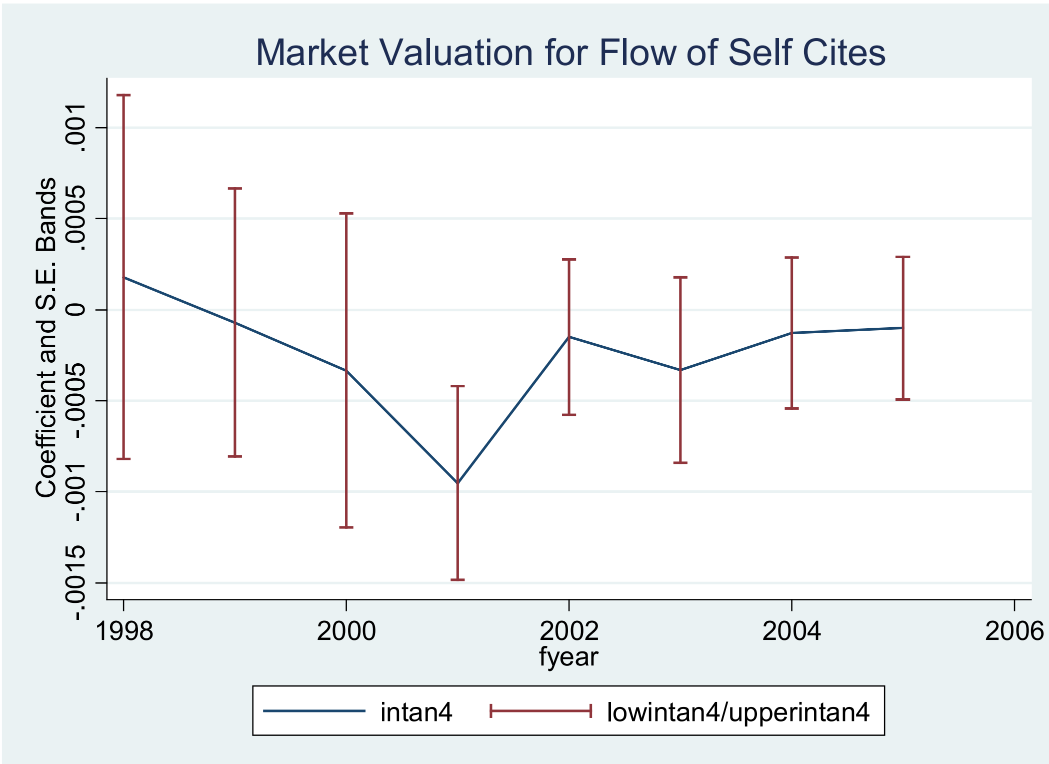
Observations	97	97	104	112	112	128	134	135
R-squared	0.918	0.900	0.904	0.923	0.945	0.944	0.947	0.936
Standard errors in parentheses								
***** p<0.01, ** p<0.05, * p<0.1**								

Graphs:

Graph 1

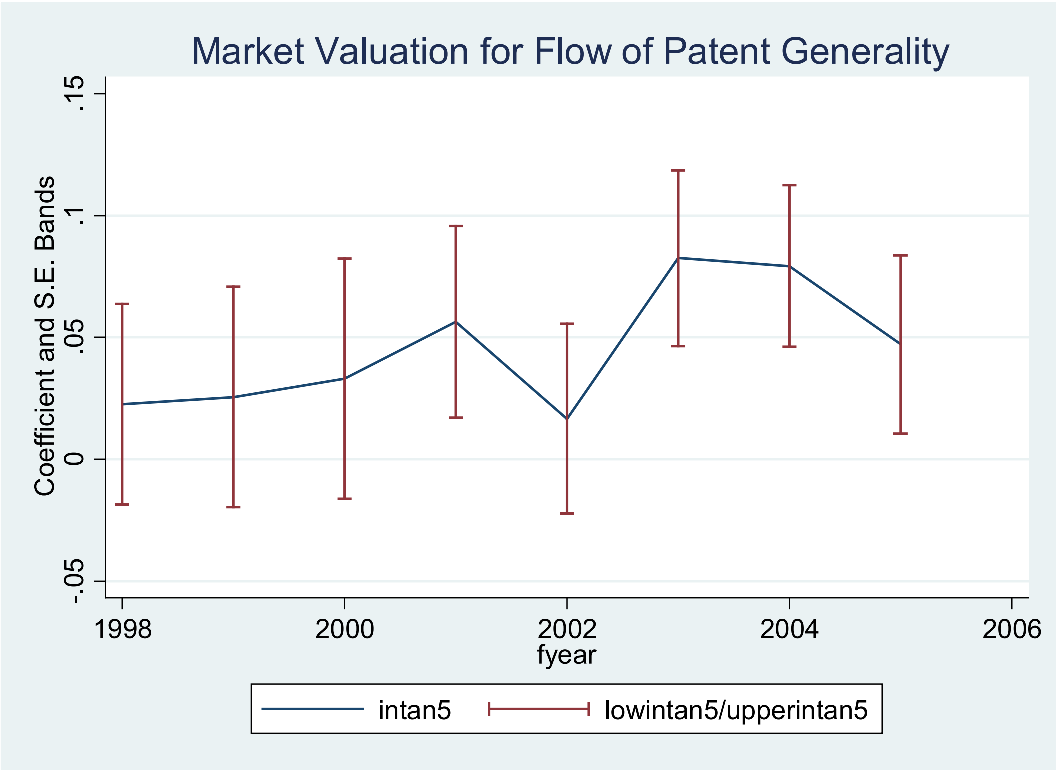


Graph 2



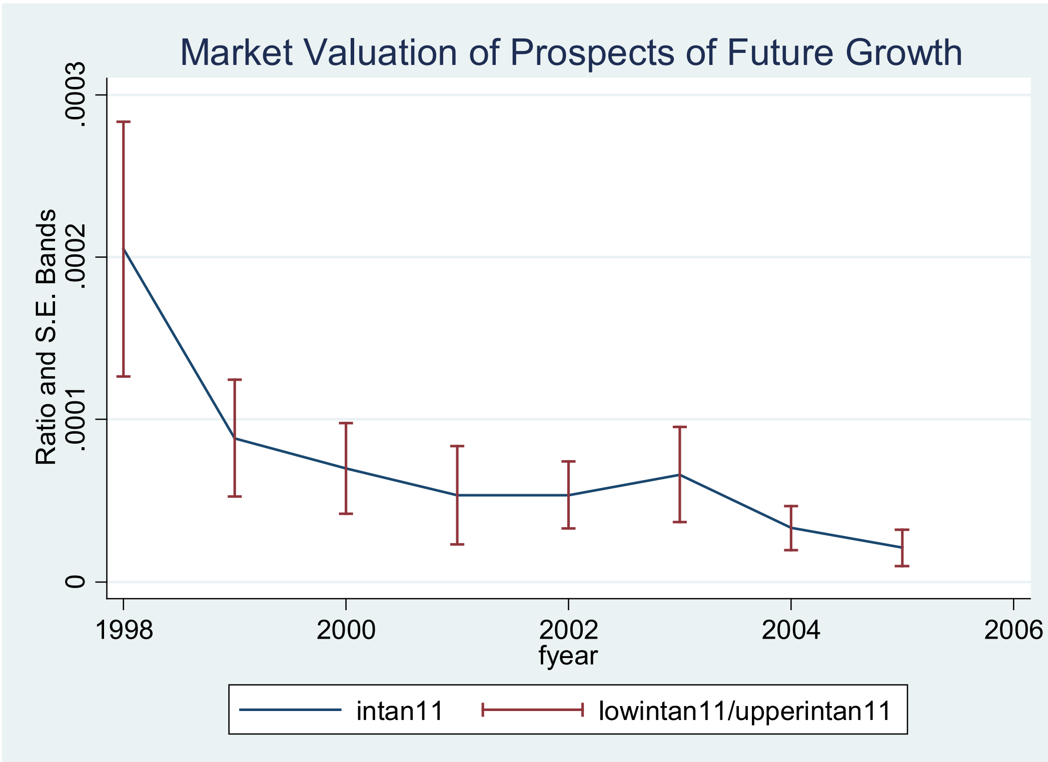
Market Valuation for Flow of Self Cites
Coefficient and S.E. Bands
-.0015
-.001
-.0005
0
.0005
.001
1998
2000
2002
2004
2006
fyear
intan4
lowintan4/upperintan4

Graph 3



Market Valuation for Flow of Patent Generality
Coefficient and S.E. Bands
-.05
0
.05
.1
.15
1998
2000
2002
2004
2006
fyear
intan5
lowintan5/upperintan5

Graph 4



Market Valuation of Prospects of Future Growth
Ratio and S.E. Bands
0
.0001
.0002
.0003
1998
2000
2002
2004
2006
fyear
intan11
lowintan11/upperintan11

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