THE MARKET VALUE OF PATENTS AND R&D: EVIDENCE FROM EUROPEAN FIRMS

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ABSTRACT

This paper analyzes the private value of patents and R&D in a sample of European firms. We find that firm's Tobin's q, defined as the ratio of market value to the replacement value of firm's physical assets, is positively and significantly associated with R&D and patent stocks.

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INTRODUCTION

This paper provides novel empirical evidence on the private value of patents and R&D in Europe. A large body of studies have addressed this issue, mostly focusing on US data and drawing on a variety of methodologies, such as profit or production function estimation and market value estimation (e.g., Hall, 1993; Hall and Mairesse 1995). The absence of direct measures of the economic value of patents has suggested the use of patent 'quality' indicators such as forward (received) citations.

There only few studies focusing on European firms which analyze the economic value of R&D or patents with market value estimations.

Patents have captured the attention of large numbers of studies based on US data but there are very few systematic attempts to examine their implications for the market value of the patent holder in the European context (see Hall, Thoma and Torrisi, 2006 for a survey). Most of these studies focus on one country. To our knowledge, this is the first work that explores the impact of R&D and patents in firms from different EU countries. We also analyze the market value of patents in the software field. Although computer programs 'as such' are not patentable in the European Patent Office (EPO), the rising number of software-related patents has prompted a lively debate amongst business practitioners and policy makers in Europe.

ESTIMATING THE ECONOMIC VALUE OF INTANGIBLE ASSETS

There are two streams of the literature that attempt to evaluate the economic returns to innovative activities. First, a series of studies have examined the impact of innovation on total factor productivity or profit growth (e.g., Griliches, 1979). Second, other scholars have focused on the private returns to innovation by using the valuation of R&D and patent stock relative to physical assets in the stock market. The two approaches have both merits and weaknesses. We opted for the market value approach because it combines accounting data with financial data (Montgomery, and Wernerfelt, 1988; Hall, 1993; Hall, Jaffe and Trajtenberg, 2005).

DATA

Our sample includes 731 publicly traded firms in all sectors whose headquarters are located in France, Germany, Great Britain, Switzerland and Sweden over the period 1980-2005 for which reported data on R&D expenditures for at least one sample year. Our main source of data on balance sheet is Bureau van Dijk's Amadeus. Data on market capitalization were obtained from Thomson Financial's Datastream while patent data were extracted from EPO/OECD PATSTAT and Delphion datasets.

Our dependent variable is the firm Tobin's q, that is, the ratio of the firm's market value to tangible assets. Firm's market value is defined as the sum of market capitalization (price multiplied by the number of outstanding shares at the end of the year) and non current liabilities less a correction for net current liabilities plus inventories. Tangible assets are the net costs of tangible fixed property and inventories used in the production of revenue, and are obtained as the sum of gross fixed assets plus inventory stocks less depreciation, depletion, and amortization (accumulated), investment grants and other deductions.

Our main regressors are the stock of intangible assets (R&D and patents) over tangible assets. R&D and patent stocks were obtained using a declining balance formula and the past history of R&D spending and granted patents respectively. $K_t = I_t + (1-\delta)K_{t-1}$, where I_t is the flow of R&D expenditures or patents and δ is the depreciation rate. We chose a 15 per cent depreciation rate (see Hall, 2006 for a detailed discussion of this topic).

Software-related patents have been identified by combining two methods adopted by earlier works on US patents (These methods and the background literature are discussed in Hall, Thoma and Torrisi, 2006).

Our controls include firms' annual sales, which account for scale effects in the market value equation, industry dummies, country dummies and year dummies. Firms' R&D and sales have been depreciated by the annual GDP deflators.

Table 1 shows some descriptive statistics for the sample of 368 firms, an unbalanced panel with 1,779 observations.

Table 1 about here

RESULTS

The market value equation is non linear in the main regressors and therefore it was estimated using nonlinear least squares (NLLS). The results are shown in Table 2 and the main findings can be summarized as follows. The estimates of the basic model with R&D stocks, total patent stocks and software patent stocks are reported in columns 1 and 3 of Table

2. We also computed the semi-elasticity of Tobin's q with respect to the main regressors and averaged them across all observations (see the buttom panel of Table 2).

The ratio between R&D stock and physical assets is positively and significantly related to Tobin's *q* across different specifications of the market value equation. The magnitude of the coefficient (around 1 across all specifications) is consistent with most of those reported in earlier works on single or multiple countries. Moreover, in all specifications a firm's patent stocks are significantly related to value, above and beyond the R&D stock that generated them. The magnitude of the coefficient is substantially higher than the coefficient obtained by Hall, Jaffe and Trajtenberg (2005) using the same methodology for U.S. firms and U.S. patent data during the 1980s. The semi-elasticities computed at the variable means indicate that a one standard deviation increase in the ratio of R&D stock to physical assets yields an increase in market value of approximately 31 per cent, whereas a one standard deviation increase in the number of patents per million euros of R&D stock yields a 7.8 per cent increase in market value.

The software patent stock, which is only two per cent of the total patent stock on average, has a significant negative discount in the market value, which implies that the net effect of having software patents is near zero (see the bottom panel of Table 2).

Table 2 about here

Research on the economic importance of patented inventions have demonstrated that the distribution of patent value is very skewed (e.g., Harhoff, Narin, and Vopel 1999). The large majority of patents have an extremely limited value and only few represent an important source of revenues to the assignee. A variety of indicators have been adopted to correct for variation in the importance of patents, the most popular of which is the stock of forward citations. Because of the short time the EPO has been in existence, our analysis relies on counts of forward citations over a five year period between the publication date of the cited patent and the application date of the citing patent.

A further indicator of patent 'quality' used in this paper is the stock of backward citations. Some scholars have suggested that large numbers of citations to others reveal that a particular invention is likely to be more derivative in nature and, therefore, of limited importance (Lanjouw and Schankerman 2004). But a large number of backward citations may also indicate a novel combination of existing ideas. In fact, Harhoff, Narin, and Vopel (1999) have found that this variable is positively correlated with patent economic value.

The number of citations to any patent is truncated in time because only citations received until the end of the dataset are observed. We corrected for truncation by using a statistical method developed by Caballero and Jaffe (1993) and Hall, Jaffe and Trajtenberg (2005).

Another indicator of patent value is the number of different technological classes assigned by patent examiners to a given patent. The latter can be viewed as a measure of technological scope or generality of the patent even though, as noted by Guellec and Pottelsberghe de la Potterie (2000), it may be also a measure of ambiguity reflecting the difficulty of the examiner in locating the invention in the technological space.

To adjust for variations in the technological and economic value of patents in our estimations we use, alternatively, forward citations and a composite index of patent 'quality' derived from a model developed by Lanjouw and Schankerman (2004). This index is obtained as the linear combination of backward citations, forward citations, and number of IPCs (see Hall, Thoma and Torrisi, 2006, for a more detailed account of the methodology).

Columns 3 and 4 of Table 2 report the results of the specification with forward citations to the firm's total patents and software patents respectively. Both variables are insignificant at the conventional levels, in contrast to the results in Hall *et al.* 2005 and Hall and MacGarvie 2006, where citations entered positively. Therefore, while EPO patents held by European firms are more closely associated with market value than USPTO patents held by US firms, the opposite is true of the average rate at which they are cited. We should note that European patent citations are fewer in number and largely added by the examiner, which may help to explain at least part of this finding. But the fact remains that it seems as though the EPO patents are more closely associated with value and therefore have less need of citation-weighting.

In contrast to the result for patent citations, the composite index of patent 'quality' discussed before is significantly associated with the market value of the firm (models 5 and 6). This suggests that, beyond and above the mere counts of patents, patent stocks characterized by a consistent set of technical characteristics (e.g., many backward and forward citations, and a wide technology scope) are valued positively by the market. In the presence of patent stocks, the marginal effect of the composite quality index is somewhat less than that of these stocks. A one standard deviation increase in the average quality per patent yields a 5.5 per cent increase in the value of the firm. The market value premium for the average software patent quality index is negative but insignificantly, implying that their quality is evaluated roughly in the same way as other patents. The significant effect of the composite index of 'quality' is in line with the results obtained by Lanjouw and Schankerman (2004) and shows that some patents (those of high technical 'quality') are an important source of economic value.

Various robustness checks of the above results have been done using regressions that excluded extreme values of R&D stocks, patent stocks, the composite 'quality' index and software citation stocks. The qualitative results are very similar. Since the disclosure of R&D expenditures is an endogenous variable (fiscal and accounting regulation in most European countries do not require the disclosure of this variable on the balance sheet of the firm), we have also accounted for sample selection bias in the R&D variable. We estimated a generalized tobit model. For this purpose we collected accounting data on a matching sample of publicly-listed firms from the same five countries which have reported no R&D data over the period 1980-2005. Preliminary results show that there is little evidence of sample selection except for Swedish firms. Finally, our estimations do not account for bias due to unobserved firm-specific heterogeneity which will treated in future research.

CONCLUSIONS

Our results demonstrate that there is a market value premium to EPO patents held by European firms beyond and above the value of R&D stocks. This result is in line with the rising importance of legal strategies for appropriating the rents of intangible assets. However, software-related patents have no impact on the firm market value. Why are these patents valued so poorly by the capital market? It is possible that the market anticipates that software-related patents in particular are mostly used for strategic reasons rather than signalling the outcome of real inventive activity. The limited value of these patents may also indicate that the financial market accounts for their weak enforceability due to the legal ambiguity about software patentability.

This paper provides a novel contribution to measurement of the economic value of intangible assets, an important issue in a knowledge-based economy, where immaterial resources and capabilities are a fundamental determinant of the firm sustainable competitive advantage.

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Table 1. Descriptive statistics

1779 observations, 368 firms, 1985-2000

Variable	N	Mean	s.d.	Median	1Q	3Q	Min	Max
Annual sales*	1779	4400	10683	389	75	2800	1	150000
Tobin's q	1779	3,24	14.24	1,9	5.45	14.52	4.04	24,51
R&D stock/assets	1779	11.31	0,62	6.28	2.38	0,60	0.00	4,91
Pat stock/R&D stock*	998	0,24	0,53	0,07	0,02	0,20	0	5,09
SW pat stock/R&D stock*	385	0,05	0,24	0	0	0,01	0	3,1
Citation stock/Patent stock	809	3,32	3,48	2,55	1,44	3,9	0,03	22,8
Soft pat cite stock/Soft pat stock	277	3,9	3,65	2,98	1,77	4,53	0,08	18,94
Composite 'quality' Index stock/Pat stock	347	0,49	0,71	0,24	0,10	0,56	0	3,19
Composite 'quality' Index stock/Pat stock (SW patents)	121	0,69	0,60	0,47	0,23	1,10	0,03	2,14

* millions of current euros

Table 2 Market valuation equation estimates with quality-adjusted patent stocks

Dependent variable: Log Q
1779 observations, 368 firms, 5 countries, 1985-2000

Variable	(1)		(2)		(3)		(4)		(5)		(6)	
R&D stock/assets	1.02	(0.14)	0.98	(0.15)	1.05	(0.14)	0.99	(0.15)	1.00	(0.13)	0.94	(0.14)
Pat stock/R&D stock	0.30	(0.09)	0.32	(0.10)	0.31	(0.09)	0.33	(0.10)	0.29	(0.09)	0.31	(0.10)
D (no patents)	0.020	(0.038)	0.027	(0.038)	0.057	(0.046)	0.064	(0.044)	0.004	(0.037)	0.011	(0.036)
SW pat stock/R&D stock			-0.28	(0.11)			-0.29	(0.11)			-0.29	(0.11)
D (no sw patents)			-0.026	(0.006)			-0.052	(0.047)			-0.030	(0.040)
Cit stock/Pat stock					0.015	(0.010)	0.015	(0.010)				
SW cit stock/ SW pat stock							-0.009	(0.007)				
Index stock/Pat stock									0.154	(0.045)	0.155	(0.045)
SW index stock/ SW pat stock											-0.054	(0.034)
log (sales)	-0.040	(0.006)	-0.040	(0.006)	-0.041	(0.007)	-0.041	(0.006)	-0.040	(0.006)	-0.041	(0.006)
D (sales missing)	2.71	(1.77)	2.63	(1.73)	2.78	(1.79)	2.63	(1.72)	2.63	(1.71)	2.54	(1.67)
Adjusted r-squared	0.299		0.299		0.299		0.299		0.302		0.302	
Standard error	0.688		0.688		0.687		0.687		0.686		0.686	
Mean semi-elasticities (mean standard errors)												
R&D stock/assets	0.509	(0.082)	0.488	(0.085)	0.532	(0.090)	0.500	(0.091)	0.497	(0.079)	0.471	(0.081)
Pat stock/R&D stock	0.148	(0.047)	0.161	(0.053)	0.158	(0.051)	0.168	(0.056)	0.144	(0.047)	0.156	(0.052)
SW pat stock/R&D stock			-0.141	(0.056)			-0.148	(0.058)			-0.144	(0.055)
Cit stock/Pat stock					0.008	(0.006)	0.009	(0.006)				
SW cit stock/ SW pat stock							-0.004	(0.004)				
Index stock/Pat stock									0.077	(0.023)	0.078	(0.023)
SW index stock/ SW pat stock											-0.027	(0.017)

Standard errors robust to heteroskedasticity are reported in parentheses.
All equations include country dummies, year dummies, and industry dummies
Estimation of the basic model with R&D stock has been omitted for reasons of space. The size and significance of the R&D stock coefficient do not change substantially when patent stock is added to the basic model