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Measuring Corporate R&D

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Abstract

The essay critically examines measurement of R&D. R&D capital and cited patents are used in the literature to measure R&D intensity and investigate market returns for R&D. The results are ambiguous. Previous literature suggests that patents are distinct from R&D expenditure, and R&D is influenced by competition. We suggest eight new measures based on the interplay between R&D and competition. We empirically test these measures on pharmaceutical and computer software industries which have the highest R&D intensities of all industries. The new measures are more significant than R&D capital and offer further insights on R&D in these industries. These measures help in capital allocation for R&D at firm level which maximizes stock returns.

Keywords: R&D; Stock Valuation; R&D capital; Capital allocation; Measuring corporate R&D

Introduction

We focus on the long-term stock market return to R&D expenditure, arguably the riskiest of investment decisions made by a firm. The extensive literature in this area is discussed in the next section. In these studies R&D efforts by the firms are measured in two ways. R&D capital focuses on the long term nature of R&D projects and aggregates R&D expenditure over the past five/ seven years depreciated at an appropriate rate. Another measure is to calculate the number of patents registered by the firm each patent being weighted by its subsequent citations. The cited patent measure follows the logic that stock markets would value the output of R&D efforts proxied by patents rather than R&D expenditure which represents inputs. We suggest that both these measures fail to capture key elements of firm level R&D efforts. To better understand the stock market rewards for R&D, we suggest new measures which involve R&D expenditure and competitive position of the firms. Empirical tests show that these measures are superior to R&D capital and offer greater insights on R&D in the industries studied.

The growing interest in R&D by policy makers, practitioners, and academics alike is driven by the increasing importance of the high-tech sectors and firms that compete on superior research know-how. Investing in R&D is risky because of its typically long gestation period. Unlike investments in physical assets, R&D dollars are expensed thereby reducing current earnings. Despite these short-term disadvantages, the investment in R&D continues unabated. Empirical studies that investigate the returns to R&D include Megna and Klock [1], Klette and Griliches [2], Lev and Sougiannis [3], Chan et al. [4], Al-Horani et al. [5], and Eberhart et al. [6]. The results are ambiguous, with many studies finding a positive correlation while some find no significant correlation. These studies use R&D capital and/or cited patents to measure R&D [4,5].

Megna and Klock [1] find that R&D and patents are distinct and measure separate aspects of intangible capital. Hall [7], Hall et al. [8] find that in several industries, firms do not value patents for protecting their know-how but for other reasons such as financing and patent portfolio race. Hall and Ziedonis [9] report that as R&D capital includes many lags, the sum of the coefficients is roughly the same as the estimated coefficient of current R&D expenditure without lags. They therefore recommend using current R&D expenditure especially in industries with short history or technological cycles. Megna and Klock [1], Hall and Ziedonis [9], Hall [8] also emphasize the importance of competition in understanding firm level R&D an aspect both R&D capital and cited patent measures ignore.

We develop eight measures which incorporate R&D and the competitive position of the firm. We test the measures formulated on a data set of all firms in computer software and pharmaceutical firms ranked by Chan et al. [4] as the highest in R&D intensity amongst all industries. The empirical results show that the new measures are highly significant, compare favorably with R&D capital and offer useful insights in our understanding of R&D in these industries.

The rest of the paper proceeds as follows. Section 2 surveys the previous literature in this area. Section 3 formulates the hypothesis. Section 4 describes the data and methodology. Section 5 discusses the findings and their implications. Section 6 provides the conclusions.

Literature Review

Several studies have examined the impact of R&D spending by firms on the long term stock market returns and firm value. Megna and Klock [1] find a significant relationship between firm values and R&D efforts. Lev and Sougiannis [3] study the value relevance of R&D expenditure and find a significant association between R&D capital and subsequent stock returns. Eberhart et al. [6,10] examine long term stock returns following unexpected R&D increases. They observe significantly positive long-term abnormal stock returns and conclude that R&D investments are beneficial. Booth et al. [11] observe that R&D expenditure increases long-term market returns, but the effect varies across countries and samples. On the other hand Hall [7] finds that during 1980s, stock markets significantly undervalued R&D. Chan et al. [4] find that the average historical stock returns of firms engaged in R&D matches the returns of firms not so engaged. They suggest that the stock market is apparently too pessimistic about the prospects of beaten-down R&D-intensive technology stocks. Al-Horani et al. [5]

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study the long-term returns to R&D on a cross section of UK stocks and their findings confirm those of Chan et al. [4]. These studies use R&D capital or cited patents. Subsequent studies have modified the patent measure to incorporate additional information on patents. Pakes [12] suggests that the number of renewals of a patent and the number of countries covered should also be included. Megna and Klock [1] suggest that along with their own patents the patent stocks of competitors should also be considered. They observe that if the technology advance is cumulative and patents are not able to fully protect the know-how, then patents by rival firms should impact the share price of the firm positively. It would be negative otherwise. McGahan and Silverman [13] study the patent filings by 4168 firms over 25 years from 1975 to 1999 and find that firms gain both when they file for a patent as well as when their competitors file for a patent. Asthana and Zhang [14] find that a high R&D intensity in the industry as a whole leads to competition mitigation via entry barriers. In such a scenario, a high R&D intensity of the firm coupled with a high R&D intensity by its competitors may turn out to be beneficial. Overall, R&D efforts by competitors play a significant role that could be positive or negative depending on the industry characteristics. Researchers have also questioned whether patents really measure R&D efforts. Megna and Klock [1] note that "Patents are commonly thought of as the output of a process in which R&D is the input." "We argue that patents and R&D are distinct measures of intangible assets since patents are marketable commodities, whereas R&D is inchoate." "R&D stocks and patents stocks appear to measure different elements of intangible capital". Cohen et al. [15] find that firms protect their R&D in a number of ways including patents, secrecy, lead time advantages etc and patents tend to be the least emphasized in a majority of industries and secrecy and lead time are the favored options to protect R&D. They also find that patents are registered for other purposes such as blocking a rival or to force rivals into negotiations. Hall and Ziedonis [9] observe that the reasons for the recent surge in patenting have to do with a patent portfolio race rather than a surge in R&D activity. They point out that patents per million dollars of R&D had gone up from 0.3 to 0.6 between 1982 and 1992. They find that "pro patent shift in many industries seems to be an increase in patenting rather than an increase in R&D activity per se"[6]. Based on their extensive study of one million patents issued over a 30 year period, Hall et al. [8] conclude that "patent related measures cannot win a "horse race" with R&D as a determinant of market value, but this is hardly surprising: even if citations are a reasonably informative signal of success, this does not mean that they will be more correlated with value than R&D, because optimizing firms will increase their R&D in response to success." It is fair to infer from the above literature that previous measures for R&D have not found wide acceptance in the literature and there is a need for new measures of R&D which incorporate competition. In the next section, we examine such measures for R&D closely following previous literature.

Hypotheses

We develop various measures for R&D and assess their impact on firm value and stock returns following the cited literature. Not all measures may be significant across all industries and industry-specific empirical testing may be needed. This follows previous literature that each industry is different depending on its technology cycle. Measures derived from R&D expenditure have several advantages over the measures for patents. First, annual R&D expenditure is based on audited financial information and is universally available. Second, they are useful in industries where every successful R&D is not patented. Third, patents measure past R&D. Fourth, some literature suggests that patents and R&D measure different intangible capital Megna and Klock [1] and R&D expenditure is superior to patents in measuring market value Hall et al. [8].

R&D capital is the most researched measure of R&D Hausman et al. [16], Megna and Klock [1], Lev and Sougiannis [3], Chan et al. [4], and Blundell et al. [17]. However, Hall and Ziedonis [9] report that when many lags are included in the model, the sum of the coefficients is roughly the same as the estimated coefficient of current R&D expenditure without lags. They therefore recommend using current R&D expenditure especially in industries with short history or technological cycles. We examine as a robustness check whether R&D capital provides more information as compared to current R&D expenditure as a measure for evaluating stock market returns.

Researchers have held that the impact of R&D efforts have to be studied in the context of competition forces in the industry. Megna and Klock [1], Sundaram et al. [18], Garlappi [19], and Asthana and Zhang [14]. The impact of competitors' R&D could be either positive or negative. Megna and Klock [1] suggest that if the intangible capital cannot be appropriated perfectly and the technological advance is cumulative, then the innovation stock of rivals should positively impact the R&D efforts of the firm and be negative otherwise. Overall literature suggests that to ascertain the impact on firm value, R&D expenditure has to be analyzed with the competition. Our measures evaluate R&D interacted with firm level competition. Based on previous literature, firm-level competition can be calculated in four different ways, based on sales, total assets, physical plant and equipment, and operating profit margin. These methods are discussed in the next section.

The impact of competition on innovation can be positive or negative depending on the industry as noted by Megna and Klock [1]. Even within an industry at a given time, competition can either hinder or enhance R&D for different firms. The intuition for this is supplied by Gilbert [20]. He suggests that "There is an intuitive argument that moderate levels of competition should be most effective in promoting innovation." "To the extent that market concentration is a reasonable proxy for the degree of competition, this suggests that intermediate levels of market concentration are the most fertile environments for innovative activity". Aghion et al. [21] postulate that competition and R&D have an inverted-U shaped relationship by assuming a sequential structure of innovation. That is to say, if the competition increases, R&D should increase, but beyond a point increased competition reduces R&D. They suggest an exponential quadratic function of competition to model R&D. Following this, we suggest that, in every case, the squared term of the competition measure is also correlated with R&D and hence the return. The correlation of the squared term is expected to have a sign opposite to that of the competition term. Klock and Megna [22], and Hall and Ziedonis [9] also suggest that R&D and its valuation depend the number of employees and the per capita R&D effort. Following this, we also calculate R&D expenditure per employee. Lanjouw and Schankerman [23] examine the value of patents with respect to the size of the firm. They find that smaller firms are less capable of tackling the litigations arising out of patents and protecting the intellectual know-how generated by R&D. They conclude that patents are more valuable to larger firms rather than smaller firms. Following this analogy, we suggest that a measure of R&D to impact shareholder returns is the number of employees of the firm. Thomas [24] suggests that, in industries where R&D itself is regulated, such as in pharmaceutical industry, complying with regulatory environment calls for establishing an infrastructure of qualified personnel that the smaller firms with few R&D projects are ill equipped to do. This further emphasizes the employee factor in measuring R&D.

We hypothesize that firm value and stock returns are positively impacted by R&D capital and significantly affected by the interaction of R&D with competition based on sales, total assets, physical plant and equipment, and operating profit margin. The impact may be positive or negative depending on the industry characteristics. We further suggest that the impact of R&D interaction with the squared R&D capital and competition are significant and bear an opposite sign. R&D value is also affected by the number of employees. We also suggest that these measures will have to be individually tested and identified for each industry.

In the following section, we operationalize the measures for R&D interaction with competition and squared competition so that they can be empirically tested.

Data and Methodology

Our data set includes all pharmaceutical (SIC code 2834) and computer software (SIC code 7372) firms for which accounting and share prices data are available from Compustat data base. We collect data for the 21 years period from 1985 to 2005. After discarding observations with missing data, we have 492 firm-years of data for the pharmaceutical firms and 957 firm-years of data for the computer software firms. We also need additional information to calculate Tobin's q and Lerner index. For the extra variables needed for these computations, we are left with 466 firm-years of data for pharmaceutical firms and 918 firm-years of data for computer software firms. Real Tobin's q is unobserved and there are several methods to calculate its proxies. Erickson and Whited [25] find that the average q explains less than two-thirds of the variation in its best proxy. They suggest using instrumental variables but also concede that finding such instruments is not easy. They also find that when Tobin's q is used as a dependant variable as in our case the measurement error does not bias any slope coefficient but renders the R^2 smaller. They recommend adopting the "book" method of computing Tobin's q. Our calculations are based on the book method, while noting its limitation. Summary statistics for all firms in the pharmaceutical industry are provided in Table 1. Panel A provides the summary statistics for pharmaceutical industry and Panel B the summary statistics for the computer software industry. Sales of pharmaceutical firms displayed in Panel A range all the way from no sales to $52 billion. Similarly we have firms with negligible ($630) to nearly $17 billion of annual R&D. There are both profitable firms and loss-generating firms. The sample includes firms with losses ($5 million), all the way to a net income of $11 billion. The total assets vary from $3 million to $123 billion and the plant and equipment from negligible to $18 billion. The number of employees ranges from 100 to 122,000. Thus, the sample of pharmaceutical firms has a wide cross section of firms to study the stock returns for R&D. We observe a similar situation with regard to the computer software firms displayed in Panel B. We have 957 firm-years of data for most variables and 918 firm-years of data for tests involving Tobin's q and cost competition measures. The sales vary from $10 million to $39 billion and the research and development expenditure varies from nil to $7.8 billion. The firms include both highly profitable and loss-generating firms. The net income varies from a loss of $1 billion to profits of $12 billion. The sample includes firms whose total assets range from $4 million to $ 92 billion and possess plant and equipment from negligible to $23 billion. Thus for both industries, we have a wide range of firms to test our measures.

We develop measures for R&D that have an impact on firm value and stock returns based on the existing literature and in particular, measures developed in the patent literature on R&D. The summary statistics of the measures are provided in Table 2 and the details of various measures are provided in Appendix. Capitalized value of R&D, known as R&D capital is widely used in the literature. The commonly accepted measure uses R&D expenditure for the past five years with an annual depreciation rate of 20% as suggested by Chan et al. [4]. We adopt that measure. To our knowledge, no other calculated measure of R&D at the firm level is available in the literature. The other measures proposed by us as are discussed below.

R&D and Competition

Megna and Klock [1], Sundaram et al. [18], and Asthana and Zhang [14] find that value of R&D is moderated by a firm's competitive position in the industry. We develop measures for the firms' competitive position in the industry and interact them with R&D. There are two widely used measures for industry concentration or competition. One set of measures is derived from industry concentration namely, the Herfindahl-Hirschman Index (HHI) [14,26,27]. We use a firm level scaled version of HHI to capture the competitive position of the firm. Another measure is the cost-competitive position of the firm based on Lerner index(LI), calculated as (1- Lerner index) [21,28-31]. We evaluate measures for R&D both with respect to HHI and LI. Further, concentration with respect to HHI can be measured in three ways. Computing HHI for sales is more common and is employed among others by Tingvall and Poldahl [26] and Asthana and Zhang [14]. Danzon et al. [32] note the significant presence and growth of contract research organizations (CROs) which carry out R&D for other firms on contract and sometimes on their own. These firms have assets in place and carry on research but have very little sales. Asset based HHI better incorporates the role of such firms. Hall and Ziedonis [9] advocate using physical plant and machinery (PPE) and the interaction of R&D with PPE to evaluate patents. Following this, we also calculate a measure of competition based on a scaled HHI of PPE. We thus have four measures of R&D interacted with competition namely, R&D Capital, R&D Asset Dominance, R&D Sales Dominance, R&D Plant Dominance, R&D operating Margin Dominance. Appendix provides the definitions of measures.

R&D and competition, second-order interaction

Aghion et al. [21] and Gilbert [20] suggest an optimum level of R&D for a given level of competition. We argue that if firms decide an optimum level of R&D based on competition in the industry, then market should also reward or penalize R&D efforts that are above or below these levels. Following Aghion et al., we use squared measures of interaction term with competition Aghion et al. [21] use squared measure of the competition]. We investigate if the impact of the R&D interaction with the squared measures of competition has the opposite sign from those of the interaction terms with competition measures.

We thus generate four measures of R&D based on the second-order interaction of competition with R&D. These measures are Sq. R&D Asset Dominance, Sq. R&D Sales Dominance, Sq. R&D Plant Dominance, and Sq. R&D operating Margin Dominance. Following the same reasoning, we define Sq. R&D capital. The definitions are provided in Appendix. These measures will have an opposite sign to the competition measures and will be significant [21].

R&D Measure	Expected Impact on Stock Return	Expected Impact on Tobin's q
R&D Capital	+	+
R&D Asset Dominance	- In some industries	- In some industries
R&D Sales Dominance	+/-	+/-
R&D Plant Dominance	+/-	+/-
R&D operating Margin Dominance	+/-	+/-
R&D per Employee	-	-
Squared. R&D Capital	opposite sign as the first order measure in some industries	opposite sign as the first order measure in some industries
Sq. R&D Asset Dominance		
Sq. R&D Sales Dominance		
Sq. R&D Plant Dominance		
Sq. R&D operating Margin Dominance		

Variable	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Sales	4596.42	9242.89	0	52516
R&D	668.08	1550.89	0.06	16923.85
Net Income(NI)	703.67	1745.36	-4887.22	11332
Total Assets	7034.9	15944.98	3.48	123684
Physical Plant & Equipment (PPE)	1618.07	3155.13	0.02	18385
Book Equity	1911.01	4207.8	16131.17	28178
Employees	16.01	27.72	0.01	122
Share Price Fiscal Year	31.9	24.51	5.06	122.03
Operating Profit	1411.26	3085	-220.23	22181
Depreciation	251.16	627.23	0.01	5661.66
Current Liability	500.2	1389.95	0	11589
Inventory	583.33	1082.01	0	6660
Panel B: Computer Software Firms under SIC Code 2834. Number of Firms 957				
Sales	659.66	2641.77	10.01	39788
R&D	104.04	446.47	0	7779
Net Income(NI)	114.83	790.56	-1102	12254
Total Assets	1078.2	5479	4.7	92389
Physical Plant & Equipment (PPE)	78.39	241.83	0.03	2346
Book Equity	566.37	3941.85	-7168	71141
Employees	2.31	5.98	0.03	61
Share Price Fiscal Year	19.58	22.33	1	198.75
Operating Profit	181.17	1027.04	-490	13584
Depreciation	31.07	99.73	0.02	1536
Current Liability	12.55	107.66	0	2693
Inventory	7.06	32.1	0	673

Note: 1.The number of observations for Operating Profit, Depreciation, Cost Competition, Current Liability, and Inventory is 466 in case of pharmaceutical firms and 918 for the Computer Software firms.
2. Share Price is in $, and Employees are in thousands. All other figures are in $ million

Table 1: Profile and Summary Information of Firms used in the Study.

Variable	Mean	Standard Deviation	Min	Maximum
Panel A: Summary statistics of R&D Measures for Pharma industry. Number of observations 492				
R&D Capital	39.32	43.65	1.65	383.25
R&D Asset Dominance	73.13	394.96	0.00	5858.20
R&D Sales Dominance	59.72	228.57	0.00	2764.32
R&D Plant Dominance	60.08	234.40	0.00	3360.44
R&D operating Margin Dominance	18.25	187.49	0.05	3983.71
R&D per Employee	106.26	256.39	0.75	4748.20
Sq. R&D Capital	3446.91	10295.14	2.72	146880.70
Sq. R&D Asset Dominance	17.15	152.07	0.00	2820.00
Sq. R&D Sales Dominance	55.70	456.00	0.00	7640.00
Sq. R&D Plant Dominance	58.40	581.00	0.00	11300.00
Sq. R&D operating Margin Dominance	5.67	10.40	0.05	222.00
Variable	**Mean**	**Standard Deviation**	**Min**	**Maximum**
Panel A: Summary statistics of R&D Measures for Pharma industry. Number of observations 492				
R&D Capital	261.54	1089.44	0.14	17801.20
R&D Asset Dominance	33.17	358.77	0.00	6759.36
R&D Sales Dominance	31.06	334.65	0.00	6194.21
R&D Plant Dominance	23.521	216.46	0.00	3451.61
R&D operating Margin Dominance	91.38	356.43	0.00	7484.14
R&D per Employee	36.71	23.00	0.00	181.78
Sq. R&D Capital	1254.04	15100.00	0.02	317000.00
Sq. R&D Asset Dominance	130.00	1900.00	0.00	45700.00
Sq. R&D Sales Dominance	113.00	1690.00	0.00	38400.00
Sq. R&D Plant Dominance	47.40	611.00	0.00	11900.00
Sq. R&D operating Margin Dominance	93.32	331.50	0.00	7200.46

Note: 1.The number of observations for R&D operating Margin Dominance and Sq. R&D operating Margin Dominance is 466 in case of pharmaceutical firms and 918 for the Computer Software firms.
2. Share Price is in $, and Employees are in thousands. All other figures are in $ million. Squared R&D dominance measures are in $ billion.

Table 2: Summary Information of R&D Measures used in the Study

Size factor

Following Thomas [24], Hall and Ziedonis [9] and Lanjouw and Schankerman [23], we suggest that R&D expenditure interacted with a size factor (R&D per employee) have a significant negative impact on market value and stock returns.

The R&D measures, the signs of the coefficients and the expected significance are summarized in Table 1.

Table 3 Panel A presents the summary statistics for the eleven measures proposed by us calculated for all firms in the pharmaceutical industry and Table 2 Panel B presents the same data for the computer software industry. For the firms in the pharmaceutical industry, R&D capital varies from 1.65% to 383.25%. The R&D asset dominance varies from near zero $5.85 million, the R&D sales dominance varies from zero $276 million, and R&D plant dominance varies from near zero to $336 million. The R&D per employee varies from near zero to $4.75 million. The squared R&D dominance measures are expressed in $ billions and have a corresponding range. Thus the measures have a wide range for measuring the impact of R&D on stock returns. Similarly for the firms in the computer software industry, R&D capital varies from near zero to $17.81 million, R&D dominance for assets varies from zero $675.93 million, R&D dominance for Sales varies from zero to $619.42 million, and R&D dominance for Plant and equipment varies from zero $345 million. The R&D intensity for employee varies from near zero to $0.18 million. The values for the second order interaction terms expressed in $ billions show a similar variation. Thus for both industries, our measures cover a wide range to test for the impact of stock value and stock returns on R&D.

Table 4 presents the correlation matrix of R&D measures for both pharmaceutical and computer software industries. As expected, R&D

measures for assets, sales, and plant dominance (HHI based) show close correlation in both the industries. Their correlation with operating margin dominance (LI based) is strong in the computer software industry but weak in the pharmaceutical industry. This emphasizes the industry specific nature of these dominance measures. Further, Tingvall and Poldahl [26] observed an inverted-U relationship for R&D based on HHI measure but not for the LI measure. Our findings also suggest that HHI and LI competition measures are distinct and their correlation depends on the industry. R&D capital is not significantly correlated with other measures. Appropriate measures should be identified for each industry from our wide range of measures. Choosing appropriate measures for specific industries is in line with patent literature.

Findings and implications

We evaluate the impact of each of our measures individually on stock values and annual share returns by univariate regressions for each industry. Our data is a panel data set for firms in the industry over several years. We anticipate that time series correlation of error terms across the years will affect the consistency of the results and therefore avoid regressions on the pooled data set. To ensure consistent results across the years and to avoid time series correlation of error terms, we use separate regressions for each year and calculate Fama-Macbeth coefficients and t statistics across the years [Fama and Macbeth [33]. Our analysis and presentation of the results closely follows Fama and French [34] and Asthana and Zhang [14]. R&D capital uses four lag variables and therefore we have seventeen years of data from 1989 to 2005. We carry out, for each industry for each year, separate univariate regressions for each of the eleven measures

With Tobin's q and annual return as the dependant variables. Thus, we carry out in all a series of 748 regressions (eleven regressions over seventeen years for two dependant variables over two industries). For regressions involving annual return as the dependant variable, the return for the previous year is included as a control variable. In addition, we also wish to assess the combined effect of each pair of the dominance and squared dominance measures on annual returns and Tobin's q. This requires an additional 340 regressions, making it, in all, and 1088 OLS regressions [9]. Due to the bulkiness of these results, we report only the results for the 64 Fama–Macbeth combined coefficients and t statistics. Table 5 Panel A presents the univariate regression results for the pharmaceutical industry. Column 1 presents the results for annual returns and column 2 presents the corresponding results for Tobin's q. None of the coefficients for the univariate regressions against annual returns are significant. This agrees with the finding by Chan et al. that the historical returns for firms that carry out R&D are not different form firms which do not. Chan et al. [4] suggest that this finding is in conformity with the efficient market hypothesis that when a firm engages in high R&D activity on a regular basis, the market does not re evaluate the return every year. On the other hand such firms may have a higher stock valuation as compared to other firms that carry out minimal R&D. This is indeed borne out by the significance of the coefficients in the regressions against the Tobin's q shown under column 2. For the firms in the pharmaceutical industry this indicates well defined classes of firms which regularly carry out substantial R&D or minimal R&D over the years. In other words, these firms follow a consistent R&D policy over the years. Empirical literature in pharmaceutical industry suggests a three way classification of firms [35], namely, pioneers that carry out high risk research on a new family of products, imitators that research on a known family of products aiming at new products with marginal improvements, and generic firms that aim to produce existing drugs at lower prices through minimal research. Grabowski and Vernon [35] further suggest that R&D strategies of the pharmaceutical firms are based on this role and a pioneering firm will not change into a generic firm for a few products. This characterization of industry by Grabowski and Vernon [35] is in conformity with our findings of low significance for our computed R&D measures in relation to annual returns but a high correlation with firm value, as represented by Tobin's q. Overall we

Variable	R&D Capital	R&D Asset Dominance	R&D Sales Dominance	R&D Plant Dominance	R&D operating margin dominance	R&D per Employee
Correlation Matrix for R&D measures–Pharmaceutical Industry						
R&D Capital 1	1					
R&D Asset Dominance	-0.07 1	1				
R&D Sales Dominance	-0.09	0.82 1	1			
R&D Plant Dominance	-0.09	0.89	0.93	1		
R&D operating Margin Dominance	0.06	0.06	0.05	0.05	1	
R&D per Employee	0.24	-0.02	-0.05	-0.04	0.08	1
Correlation Matrix for R&D measures–Computer Software Industry						
R&D Capital 1	1					
R&D Asset Dominance	-0.06 1	1				
R&D Sales Dominance	-0.06	0.99 1	1			
R&D Plant Dominance	-0.07	0.98	0.98 1	1		
R&D operating Margin Dominance	-0.09	0.91	0.92	0.91	1	
R&D per Employee	0.33	0.24	0.23	0.24	0.33	1

Table 3. Correlation Matrix.

Dependant Variable/ Independent Variables	Return		Tobin Q	
	Slope	Statistics	Slope	Statistics
Fama Macbeth Univariate Regressions				
R&D Capital	2.48	0.78	24.10	0.89
R&D Asset Dominance	-0.01	-0.14	-0.19	-5.82****
R&D Sales Dominance	0.01	0.69	-0.24	-4.0****
R&D Plant Dominance	0.01	0.12	-0.21	-5.94****
R&D operating Margin Dominance	-0.05	-0.27	-2.64	3.68****
R&D per Employee	2.43	0.66	35.31	2.15**
Squared. R&D Capital	0.03	0.51	0.32	1.52
Sq. R&D Asset Dominance	-0.01	-0.65	-0.01	-4.48****
Sq. R&D Sales Dominance	0.01	0.63	-0.01	-2.31**
Sq. R&D Plant Dominance	-0.01	-0.10	-0.01	-4.13****
Sq. R&D operating Margin Dominance	-0.06	-1.29	-0.16	-0.32
Fama Macbeth Bivariate Regressions				
R&D Capital	15.10 1.18	168.84	1.10	15.10 1.18
Squared. R&D Capital	0.03	-0.20	1.16	1.57
Squared. R&D Capital	0.06	0.73	0.88	-3.32****
Sq. R&D Asset Dominance	-0.01	-1.02	0.04	3.74***
R&D Sales Dominance	0.07	0.94	-0.83	3.99****
Sq. R&D Sales Dominance	0.01	-1.05	0.01	3.52****
R&D Plant Dominance	-0.15	-0.67	-0.88	-4.10***
Sq. R&D Plant Dominance	0.01	0.81	0.01	3.89****
R&D operating Margin Dominance	-0.32	-0.46	-2.84	-3.30****
Sq. R&D operating Margin Dominance	0.60	0.94	0.07	0.11

Note: *, **, ***, and **** represent 10%, 5%, 1%and 0.1% and more of significance

Table 4: Fama-Macbeth Regressions - Pharmaceutical Industry

find significant support for the use of our computed R&D measure in the pharmaceutical industry.

It is also interesting to note that all the five measures suggested by us [R&D asset dominance, R&D sales dominance, R&D plant dominance, R&D operating margin dominance, and R&D per employee] have high significance and R&D capital, the widely used measure for R&D in the [3,4] is not significant for pharmaceutical industry. Anecdotally, we also observe that the significance for the coefficient of R&D sales dominance is lower than that for asset and plant dominance. This is in conformity with the observation by Danzon et al. [32] on the significance of CROs, although this is not a rigorous empirical finding. Megna and Klock suggest that R&D measures related to competition can have a positive or negative impact but should be significant. For the pharmaceutical industry, three of our measures (all based on HHI) show a negative impact and the measure based on LI shows a positive impact, while all of them are highly significant. The divergence of the results can be compared to that of Tingvall and Poldahl who report that, in their investigation of R&D with respect to competition, that they obtain very different results when they use HHI and LI to measure competition. The difference between these two sets of measures is an interesting area for further study.

Table 4, Panel B presents the regression results for Fama-Macbeth combined coefficients and t statistics for the bivariate regressions for dominance and the corresponding squared dominance measures. Literature [20,21] suggests that there could be an inverted-U shape relationship between R&D and competition resulting in an optimum R&D for a given level of competition. If so, firms whose R&D is higher or lower than this optimum would be penalized by the market. This would suggest opposite signs for the coefficients of the two measures. The regressions for Tobin's q fully bear this out for HHI competition measures while the relationship is insignificant for LI competition measure. Again this finding can be compared with similar findings by Tingvall and Poldahl who find divergent results for HHI and LI measures.

Table 6 Panel A presents Fama-Macbeth combined coefficients and t statistics for the univariate regressions of R&D measures for the computer software industry. Column 1 presents the results for annual return and column 2 presents the results for Tobin's q.

Annual returns are significantly correlated with all the four measures of R&D dominance namely, asset, sales, plant, and operating margin dominance as well as R&D per employee. R&D capital is not significant. For the computer software industry stock returns are significantly correlated with R&D measures, unlike, pharmaceutical industry. Guy [36] points out that R&D in computer software is highly portable in the global market along with availability of free software. Patent protection is not very significant and hence R&D expenditure is volatile. This contrasts with the empirical findings for the pharmaceutical industry. Thus our findings are in broad conformity with the industry characteristics and empirical literature. R&D capital, the commonly used measure is not very significant for stock return but it is significant for Tobin' q. This could imply that in view of the unpredictability of R&D expenditure, annual returns depend on the current R&D, while firms that have a track record of high R&D and have survived the competition have a high firm value. The signs of the coefficient are all negative, the same as in the case of pharmaceutical industry. Table 5, Panel B provides the results for Fama-Macbeth bivariate regressions. As in the pharmaceutical industry, there is a divergence between HHI-based measures and LI-based measures. The impact on Tobin's q shows a high significance for LI measure and marginal significance for HHI measures. The findings in the two industries indicate that all the four R&D competition based measures are important and need to

Dependant Variable/ Independent Variables	Return		Tobin Q	
	Slope	Statistics	Slope	Statistics
R&D Capital	-12.11	-0.29	-75.04	-3.21***
R&D Asset Dominance	-2.60	-2.72***	-1.50	-1.85*
R&D Sales Dominance	-1.64	-2.70***	-0.91	-1.80*
R&D Plant Dominance	-1.20	-2.35**	-0.87	-1.75*
R&D operating Margin Dominance	-22.34	-3.13***	-5.77	-1.74*
R&D per Employee	-10.47	-4.30****	-8.88	-0.57
Squared. R&D Capital	-0.04	-0.09	-0.52	-2.57***
Sq. R&D Asset Dominance	-0.01	-1.27	-0.01	-1.26
Sq. R&D Sales Dominance	-0.01	-1.36	-0.01	-1.33
Sq. R&D Plant Dominance	-0.01	-1.57	-0.01	-1.54
Sq. R&D operating Margin Dominance	-24.69	-3.18***	-6.35	-1.81*
R&D Capital	-437.92	-1.56	-30.77	-2.61***
Squared. R&D	6.12	1.40	2.65	1.81*
R&D Asset Dominance	-13.81	-1.17	-7.50	-1.17
Sq. R&D Asset Dominance	-0.01	-0.65	-0.01	-0.07
R&D Sales Dominance	-10.82	-1.23	-6.28	-1.29
Sq. R&D Sales Dominance	-0.01	-0.20	-0.01	-0.34
R&D Plant Dominance	-10.65	-0.78	-10.68	-1.69*
Sq. R&D Plant Dominance	-0.01	-0.21	-0.01	-1.63*
R&D operating Margin Dominance	-4.70	-0.15	-40.70	-2.73***
Sq. R&D operating Margin Dominance	-25.29	-0.82	-55.52	-3.46****

Table 5: Fama-Macbeth Regressions - Computer Software Industry

be judiciously applied to specific industries. We also wish to ensure that the results of Fama-Macbeth regressions reported in Tables 4 and 5 are robust across individual years and do not show significant variations within the sample. Following the presentation of results in Fama and French [34], we sub-sample the data into three sets for the years 1989 to1994, 1995 to1999, and 2000 to 2005. We compute Fama-Macbeth combined coefficients and t statistics separately for each of the sub-sample for the six R&D measures namely, R&D Capital, R&D asset dominance, R&D sales dominance, R&D plant dominance, R&D operating margin dominance, and R&D per employee. Regressions are carried out against Tobin's q for the pharmaceutical industry and annual return for the computer software industry. The results are shown in Table 6 for the pharmaceutical industry and Table 8 for the computer software industry. We find that the main results shown in Tables 4 and 5 hold true for each of the sub samples. The results are robust across years. We further note that in our analysis, the competition measures suggested by us, namely, R&D asset dominance, R&D sales dominance, R&D plant dominance, R&D operating margin dominance, and R&D per employee are more significant for the two samples and sub-samples than R&D capital, the measure most commonly used in the literature. R&D capital is significant for the computer software industry in predicting Tobin's q as shown in Table 6, Panel A. Hall and Ziedonis [9] observe that including the lag variables of R&D does not capture more significance than current R&D because R&D dollars over the years are highly correlated. They advocate using current R&D. We investigate this possibility for the computer software industry. Table 8 presents the analysis. We regress separately Tobin's q against R&D capital, Squared R&D capital and current R&D and also all three measures together. We find that R&D capital does convey significant information over and above the current R&D. The coefficient for R&D is not significant and R^2 improves marginally from 0.15 to 0.18. We suggest that this may because firm R&D dollars over the years may not be highly correlated in computer software industry. This would also explain why R&D dominance measures based on current R&D are able to significantly predict annual stock return for computer software industry unlike in pharmaceutical industry. The findings by Hall and Ziedonis [9] across their sample of industries on R&D capital and current R&D could be extended to imply that current R&D would score over R&D Capital in industries where firm R&D is predictable and highly correlated over the years. An example could be pharmaceutical industry as characterized by Grabowski and Vernon [35]. In other industries R&D capital may be a useful measure of R&D. Obviously, this requires further research and it may turn out that R&D capital is not a universal measure across industries as currently used , but only appropriate for certain industries. We also wish to explore for the two industries the impact on the regressions by combining multiple measures. We investigate the combination of R&D per employee with the most significant amongst the R&D dominance measures. Table 10 presents the analysis for the pharmaceutical industry. The most significant R&D dominance measure (R&D plant dominance) is combined with R&D per employee. We find that the inclusion of R&D per employee, by itself a significant measure considerably adds to the overall predictability and significance in Fama-Macbeth regression over the entire sample. The coefficients are all significant and the R^2 improves from 0.08 to 0.27. Table 10 shows a similar analysis for computer software industry. We combine R&D operating margin dominance with R&D per employee. Both coefficients are significant and the R^2 improves from 0.08 to 0.11. This again conforms to the patent literature that appropriate measures need to be developed separately for each industry to better understand the impact of R&D and a single measure such as R&D capital may not be appropriate across all industries.

Conclusions

To better explain the stock market valuation of R&D expenditure, patent literature suggests that stock market looks at the R&D output such as patents rather than R&D expenditure. While considerable work has been done in investigating patents and patent related measures, measures based on R&D expenditure have not been investigated. This is

Year	1989/1994		1995/1999		2000/20005	
	Slope	Statistics t	Slope	Statistics t	Slope	Statistics t
Fama Macbeth Univariate Regressions – Dependant Variable Tobin's q						
R&D Capital	74.64	1.46	63.42 1.42	45.54	0.92	R&D Capital 74.64 1.46 63.42 1.42
R&D Asset Dominance	-0.21	4.32****	-0.11	-1.96**	-0.26	-4.81****
R&D Sales Dominance	-0.23	-3.16***	-0.11	-2.41**	-0.41	-2.58***
R&D Plant Dominance	-0.23	-3.78****	-0.1	-2.54**	-0.3	-5.78****
R&D operating Margin Dominance	-0.28	-2.41**	-0.15	-1.60	-0.38	-2.21**
R&D per Employee	41.48	1.43	25.76	2.52**	39.39	0.84

`**Table 6:** Fama-Macbeth Regressions Pharmaceutical Industry – Sub samples

Year/ Dependant Variable	1989/1994		1995/1999		2000/20005	
	Slope	Statistics t	Slope	Statistics t	Slope	Statistics t
Fama Macbeth Univariate Regressions – Dependant Variable Annual stock return						
R&D Capital	-65.48	-0.59	-41.82	-1.51	65.99	65.99 1.74*
R&D Asset Dominance	-5.56	-3.05***	-0.06	-2.02**	-1.77	-1.24
R&D Sales Dominance	-4.07	-3.46****	-0.09	-1.61	-0.51	-1.47
R&D Plant Dominance	-3.19	-2.68***	-0.16	-1.34	-0.24	-1.54
R&D operating Margin Dominance	-49.52	-3.57****	-4.44	-3.1***	-10.08	-1.67*
R&D per Employee	-11.56	-2.08**	-69.01	-2.71***	-121.48	-3.16***

We regress stock returns against various R&D measures. Our data comprise all computer software firms (SIC code 7372) from Compustat data base. We gather data from 1985 to 2005.We have 957 firm years of data in seventeen groups. For regressions involving R&D operating profit dominance we have 918 firm years of data in seventeen groups. We analyze the data separately for the three periods 1989/1994, 1995/1999, and 2000/2005. Appendix provides the definitions of variables and measures.

Table 7: Fama-Macbeth Regressions Computer Software Industry – Sub samples

all the more necessary since all R&D is not patented and some literature suggests that patents are distinct from R&D. Literature also discounts the universal use of R&D capital the only R&D measure investigated so far. We suggest ten new measures for R&D closely following the patent literature, along with R&D capital. We investigate these eleven measures on pharmaceutical and computer software firms, industries which are ranked first and second in R&D intensity. We find that our suggested measures are significant and score over R&D capital. The measures also reveal significant insights on R&D expenditure in the two industries. The findings and the significant differences we observe between the industries are in conformity with other empirical literature for the two industries. We also suggest that R&D capital may not be an appropriate measure for all industries and appropriate R&D measures have to be chosen from the eleven measures for specific industries. We readily acknowledge the limitations in this study, namely that we study only two industries and better insights are possible by including other industries as well as further classification of industries. The appropriateness of these measures across other industries may provide useful area for further research in this area (Table 2).

We investigate all pharmaceutical firms (SIC code 2834) and computer software firms (SIC code7372) for which accounting and share prices data is available from Compustat data base. We gather data from 1985 to 2005. After discarding observations with missing data, we have 492 firm years of data for the pharmaceutical firms and 957 firm-years of data for the computer software firms. For calculations involving Tobin's q and Lerner index, we have 466 and 918 firm years of data respectively. Appendix provides the definitions of variables and measures (Table 3).

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We regress stock returns and Tobin's q against various R&D measures. Our data comprise all pharmaceutical firms (SIC code 2834) for which accounting and share prices data is available from Compustat data base. We gather data from 1985 to 2005. After discarding observations with missing data, we have 492 firm years of data in seventeen groups. For regressions involving Tobin's q and R&D operating profit dominance, we have 466 firm years often in seventeen groups. Appendix provides the definitions of variables and measures (Table 6).

Independent variables			
R&D Capital	75.04 (-3.21)**	-30.77 (-2.61)**	-30.8 -(2.67)**
Squared R&D Capital		2.65 (1.81)*	2.67 (1.75)*
R&D			(0.66)
R^2	0.06	0.15	0.18

We regress Tobin's q stepwise against R&D Capital, Sq. R&D Capital and R&D.. We gather data from 1985 to 2005. After discarding observations with missing data, we have 957 firm years of data. Appendix provides the definitions of variables and measures.

Table 8: Fama-Macbeth Regressions Computer Software Industry

Independent variables			
R&D Plant Dominance	-0.21 (-5.94)****	-0.88 (-4.1)****	-0.66 (-2.45)**
Sq. R&D Plant Dominance		-0.01 (3.89)****	-0.01 (3.31)****
R&D per Employee			29.92
R	0.04	0.08	0.27

We regress Tobin's q against R&D Plant Dominance, Sq. R&D Plant Dominance, and R&D per Employee. We gather data from 1985 to 2005. After discarding observations with missing data, we have 492 firm years of data. Appendix provides the definitions of variables and measures.

Table 9: Fama-Macbeth Regressions Pharmaceutical Industry

Independent variables			
Previous Return	-21.57 (-2.11)**	-18.41 (-2.14)**	-19.51 (-2.00)**
R&D operating Margin Dominance	-22.34 (-3.13)***		-20.15 (-2.92)***
R&D per Employee		-103.99 (-4.3)****	-86.42 (-3.56)****
R^2	0.08	0.08	0.11

We regress annual stock return against Previous Return, R&D operating Margin Dominance, and R&D per Employee. The observations comprise of all computer software firms (SIC code 7372) for which accounting and share prices data is available from Compustat data base. We gather data from 1985 to 2005. After discarding observations with missing data, we have 918 firm years of data. Appendix provides the definitions of variables and measures.

Table 10: Fama-Macbeth Regressions Computer Software Industry

We regress stock returns and Tobin's q against various R&D measures. Our data comprise all computer software firms (SIC code 7372) for which accounting and share prices data is available from Compustat data base. We gather data from 1985 to 2005. After discarding observations with missing data, we have 957 firm years of data in seventeen groups. For regressions involving Tobin's q and R&D operating profit (Table 7).

We regress Tobin's q against various R&D measures. Our data comprise all pharmaceutical firms (SIC code data base. from 1985 to 2005. We have 466 firm years of data in seventeen groups. We analyze the data s periods 1989/1994, 1995/1999, and 2000/2005. Appendix provides the definitions of variables and measures (Table 8).

We regress stock returns against various R&D measures. Our data comprise all computer software firms (SIC code 737 base. We gather data from 1985 to 2005.We have 957 firm years of data in seventeen groups. For regressions involving dominance we have 918 firm years of data in seventeen groups. We analyze the data separately for the three periods 198 2000/2005. Appendix provides the definitions of variables and measures (Table 9).

We regress Tobin's q stepwise against R&D Capital, Sq. R&D Capital and R&D. We gather data from 1985 to 2005. After discarding observations with missing data, we have 957 firm years of data. Appendix provides the definitions of variables and measures (Table 10).

We regress Tobin's q against R&D Plant Dominance, Sq. R&D Plant Dominance, and R&D per Employee. We gather data from 1985 to 2005. After discarding observations with missing data, we have 492 firm years of data. Appendix provides the definitions of variables and measures.

We regress annual stock return against Previous Return, R&D operating Margin Dominance, and R&D per Employee. The observations comprise of all computer software firms (SIC code 7372) for which accounting and share prices data is available from Compustat data base. We gather data from 1985 to 2005. After discarding observations with missing data, we have 918 firm years of data. Appendix provides the definitions of variables and measures.

References

1. Megna P, Klock M (1993) The impact of intangible capital on Tobin's q in the semiconductor industry. The American Economic Review 83: 265.
2. Klette TJ, Griliches Z (2000) Empirical patterns of firm growth and R&D investment: A quality ladder mdoel interpretation. The Economic Journal 110: 363.
3. LevB, Sougiannis T (1996) The capitalization, amortization, and value-relevance of R&D. J Account Eco 21: 107.
4. Chan LK.C, Lakonishok J, Sougiannis T (2001) The stock market valuation of research and development expenditures. J Financ 56: 2431.
5. Al-Horani A, Pope PF, AW Stark (2003) Research and Development Activity and Expected Returns in the United Kingdom. European Finance Review 7: 27.
6. Eberhart AC, Maxwell WF, Siddique AR (2006) Does the Stock Market Under react to R&D Increases? J Investment Manag : JOIM, 1.
7. Hall BH (1993) The stock market's valuation of R&D investment during the 1980's. The American Economic Review 83: 259.
8. Hall BH (2005) Exploring the Patent Explosion. J Technol Transfer 30: 35.
9. Hall BH, Ziedonis RH (2001) The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995. Rand J Eco 32: 101.
10. Eberhart AC, Maxwell WF, Siddique AR (2004) An Examination of Long-Term Abnormal Stock Returns and Operating Performance Following R&D Increases. J Financ 59: 623.
11. Booth GG, Junttila J, Kallunki, JP, Rahiala M, Sahlstrom P (2006) How does the financial environment affect the stock market valuation of R&D spending? J Finance Intermed 15: 197-214.
12. Pakes A (1986) Patents as Options: Some Estimates of the Value of Holding European Patent Stocks. Econometrica 54: 755.
13. McGahan A, Silverman B (2006) Benefiting from Rivals`Breakthroughs. MIT Sloan Management Review 48: 6.
14. Asthana SC, Zhang Y (2006) Effect of R&D investments on persistence of abnormal earnings. Review of Accounting & Finance 5: 124.
15. Cohen W, Nelson R, Walsh J (2000) Protecting Their Intellectual Assets: Appropriability Conditions and Why US Manufacturing Firms Patent (Or Not). National Bureau of Economic Research w7552.
16. Hausman J, Hall BH, Griliches Z (1984) Econometric Models for Count Data with an Application to the Patents-R&D Relationship. Econometrica (pre-1986) 52: 909.
17. Blundell R, Griffith R, Windmeijer F (2002) Individual effects and dynamics in count data models. J Econometrics 108: 113.
18. Sundaram AK, John TA, John K (1996) An empirical analysis of strategic competition and firm values: The case of R&D competition. Journal of Financial Economics 40: 459.
19. Garlappi L (2004) Risk Premia and Preemption in R&D Ventures. J Financ Quant Anal 39: 843.
20. Gilbert R (2006) Competition and Innovation. J Indus Organization Edu.
21. Aghion P, Bloom N, Blundell R, Griffith R, Howitt P (2005) Competition and Innovation: An Inverted-U Relationship. Quarten J Eco 120: 701.

22. Klock M, Megna P (2000) Measuring and valuing intangible capital in the wireless communications industry. Quarterly Review of Economics and Finance 40: 519.

23. Lanjouw JO, Schankerman M (2004) Protecting intellectual property rights: Are small firms handicapped? J Law Econ 47: 45-74.

24. Thomas LG (1990) Regulation and Firm Size: FDA Impacts on Innovation. Rand J Eco 21: 497.

25. Erickson T, Whited TM (2006) On the Accuracy of Different Measures of q. Financial Management 35: 5.

26. Tingvall PG, Poldahl A (2006) Is there really an inverted U-shaped relation between competition and R&D? Economics of Innovation and New Technology 15: 101.

27. Al-Muharrami S, Matthews K, Khabari Y (2006) Market structure and competitive conditions in the Arab GCC banking system. J Bank Financ 30: 3487.

28. Fischer T, Kamerschen DR (2003) Price-cost margins in the US airline industry using a conjectural variation approach. J Transp Econ Policy 37: 227.

29. Maudos J, Guevara JFD (2004) Factors explaining the interest margin in the banking sectors of the European Union. J Bank Financ 28: 2259.

30. Toolsema LA (2004) Monetary Policy and Market Power in Banking. J Econ 83: 71.

31. Matthews K, Murinde V, Zhao T (2007) Competitive conditions among the major British banks. J Bank Financ 31: 2025.

32. Danzon P, Nicholson S, Nuno S (2003) Productivity In Pharmaceutical - Biotechnology R&D: The Role of Experiance and Alliances. National Beaureau of Economic Research.

33. Fama EF, Macbeth JD (1973) risk, return and equilibrium - empirical tests. J Politic Econ 81: 607.

34. Fama EF, French KR (2006) Profitability, investment and average returns. J Financ Econ 82: 491.

35. Grabowski HG, Vernon JM (1987) Pioneers, Imitators, and Generics - A Simulation Model of Schumpeterian Competition. Quartern J Econ 102: 491.

36. Guy F (2000) Strategic bundling: Information products, market power, and the future of globalization. Review of International Political Economy: RIPE 14: 26

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