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Abstract

We investigate whether measures of intangible capital based on advertising and R&D can explain variation in Tobin's Q ratio for the pharmaceutical & chemical industry using data from 1982 to 2001. The study is motivated by prior literature studying this relation in other industries, recent literature investigating intangible capital in this industry, and the larger controversy about whether stock valuations have been high due to irrational investors or large investment in intangible capital. We find that our measures of intangible capital are statistically significant determinants of Tobin's Q and explain twenty percent of the variation in our sample.

Keywords: Intangibles, R&D, advertising, chemicals, pharmaceuticals

JEL Classification: G10

Intangible Capital in the Pharmaceutical & Chemical Industry

Abstract

We investigate whether measures of intangible capital based on advertising and R&D can explain variation in Tobin's Q ratio for the pharmaceutical & chemical industry using data from 1982 to 2001. The study is motivated by prior literature studying this relation in other industries, recent literature investigating intangible capital in this industry, and the larger controversy about whether stock valuations have been high due to irrational investors or large investment in intangible capital. We find that our measures of intangible capital are statistically significant determinants of Tobin's Q and explain twenty percent of the variation in our sample.

1. Introduction

Valuation of intangible capital is a widespread topic of interest in the new millennia. Shiller (2000) argues that the stock market was irrationally exuberant in the 1990s. This hypothesis is supported, in part, by behavioral theory developed by Kahneman (2003) and others. Shiller supports his view with statistical evidence that stock prices are more volatile than certain specifications of the efficient market model would allow. Regulators such as Arthur Levitt argue that accounting and financial fraud became a more serious problem in the 1990s, in part, due to the manipulation of financial statements and the lack of standards for valuation.[1] Academic lawyers such as Robert Prentice (2000) also developed an intense interest in the policy implications for the regulation of financial markets and securities fraud litigation in the presence of irrational market participants.[2] These issues took on obvious importance for accounting

[1] See Arthur Levitt (2000).

[2] Two good overviews of the legal literature related to irrational exuberance and accounting fraud can be found in Klock (2002a) and Klock (2002b).

academics who are interested in the relevance of financial statements and methods for valuing intangibles.

On the other hand, Hall (2001) persuasively argues that there are perfectly rational explanations for high P/E ratios in innovative industries. Since professional managers cannot systematically generate abnormal profits, it is more plausible to believe that Shiller's rejection of market efficiency is the result of model misspecification due to a failure to account for nonstationarity. Hall asserts that large changes in market value are the result of revisions in estimates of future probabilities rather than shifts in utility functions. His view is supported by Roll's (1994) casual empirical observations as well as Rubinstein's (2001) model demonstrating that even markets with irrational investors aggregate into rational valuations.

Hall's alternative to Shiller's irrational exuberance hypothesis is deeply rooted in the empirical observation that the capital underlying the U.S. economy has become dominated by intangibles. Intangible capital is associated with high cash flow growth and valuable embedded real options. Amram and Kulatilaka (1999) argue that failure to account for option value leads to significant undervaluation of R&D programs. Shapiro and Varian (1999) argue that brand loyalty and customer base are major sources of value in an information-driven economy. Baily and Lawrence (2002) build an empirical case for the conclusion that there has been a structural shift in the acceleration of productivity due to information capital.

The widespread interest and debate about whether securities are valued rationally is linked to questions of whether capital is measured correctly and omission of intangibles is important. Future cash flows accruing to intangible capital are more difficult to predict and value than cash flows accruing to tangible capital. As the economy becomes more dependent on intangible capital, it is increasingly important to investigate the linkage between firm value and the use of intangible capital.

This research investigates the measurement and valuation of intangible capital in the chemical industry, including pharmaceuticals. Several previous studies demonstrate the merit of investigating this issue at the industry level since sources of intangible capital vary by industry. Megna and Mueller (1991) show that advertising is an important source of intangible capital in the distilled beverage and cosmetic industries. Trajtenberg (1991) demonstrates that patents are important for optical scanners. Megna and Klock (1993) demonstrate that R&D expenditures measure intangible capital in the semiconductor industry. Shane and Klock (1997) show that patent citation-weighted metrics are also important in the semiconductor industry. Klock and Megna (2000) show that spectrum license data can be used as a metric of intangible capital of cell phone companies. These are just some examples of industries and intangible capital metrics which have been investigated in the literature.

The remainder of the paper is organized as follows. Section 2 provides a description of the industry. Our methodology for measuring intangible capital and evaluating those measurements is set out in Section 3. Section 4 describes the data collection effort and descriptive information on the sample. Section 5 presents the results. Conclusions are given in Section 6.

2. The Chemical Industry

The chemical industry comprises more than ten percent of U.S. industrial manufacturing gross domestic product, more than any other sector.[3] Size alone makes it an interesting candidate for study, but in addition, it is an industry with a great deal of diversity in intangibles. Some firms derive much value from patented products and brand names, while other firms are oriented towards manufacturing commodities. The diversity in reliance on intangible capital spreads out the range of the observations for this variable and increases the likelihood of successfully identifying empirical relationships suggested by a priori theory.

Another motivation for examining this industry is that Aboody and Lev (2001) provide a benchmark for our results. Aboody and Lev provide persuasive and valid reasons for studying intangible capital in the chemical industry. Among these reasons are the simple facts that the industry is large, pervasive, and highly innovative. A priori, we would expect this industry to be one in which there is significant value to measurable intangible assets including both innovation (measured by cumulating and depreciating R&D expenditures) and brand loyalty (measured by cumulating and depreciating advertising expenditures). Our methodology differs from theirs, and the differences are discussed in Section 3. It is worth noting, however, that their methodology is premised on market inefficiency, whereas our methodology assumes that financial markets are efficient.

3. Methodology

We adopt the frequently used approach of constructing measures of intangible capital and

[3] 1998 U.S. Industry & Trade Outlook, section 12-1. See also Aboody and Lev, 2001.

then relating them to Tobin's Q ratio. Examples of this approach can be found in: Griliches (1981), Cockburn and Griliches (1988), Megna and Klock (1993), Klock et al. (1996), Shane and Klock (1997), and Klock and Megna (2000). Tobin 's (1969) Q ratio is defined as the market value of the financial claims on the firm relative to the replacement cost of the firm's capital stock. It is the cost of buying the firm in the financial sector relative to the cost of creating a new firm. Tobin develops the concept as a determinant of investment, but Lindenberg and Ross (1981) and Lustgarten and Thomadakis (1987) utilize it as a measure of monopoly power. In the context of intangible capital, the intuition is that measured variations in Q from its equilibrium value are due to mismeasurement of the capital stock cause by omission of intangible capital. Similar ideas can be found outside the Q literature. For example, Chauvin and Hirschey (1993) observe that high profit rates in some sectors are actually mismeasured due to omission of advertising and R&D capital. Amir and Lev (1996, p. 10) write that innovative industries "are characterized by heavy investment in intangibles …. These investments are largely expensed in financial statements leading to depressed and often irrelevant earnings and book value figures."

The development of our model parallels Megna and Klock (1993) and Klock and Megna (2000). Assuming that firms in the chemical industry operate in perfectly competitive markets and that their capital stocks are at the optimal levels, [4]

$$q_i = \%_i \tag{1}$$

Where q_i is the ith firm's Q ratio, defined as the market value of all financial claims on the firm

[4] Time subscripts are omitted from the following discussion for ease of reading.

relative to the firm's (tangible and intangible) assets, and $\%_i$ is the equilibrium value of Q for the ith firm. Letting MV, K_1, and K_2 represent market value, tangible assets, and intangible assets respectively,

$$\forall_i = q_i \ / \ MV_i/(K_{1i} + K_{2i}) \tag{2}$$

In a simple world, ∀ would equal one in equilibrium since there are incentives to invest when securities can be sold for more than the cost of the underlying assets and incentives to disinvest when securities can be purchased cheaper than the assets. However, ∀ will not generally be one due to complexities introduced by the tax code, and its value can vary both over time and across firms. These variations are readily accommodated by incorporating time fixed effects and firm fixed effects into the model.

The Q defined by (2) is unobservable. We observe instead,

$$Q'_i = MV_i / \ K_{1i} \tag{3}$$

Combining (1), (2), and (3), the following equilibrium relation is obtained:

$$Q'_i = \forall_i + \forall_i(K_{2i}/K_{1i}) \tag{4}$$

Having allowed for two different kinds of capital, there is no reason not to generalize to N types of capital where only the first is observed. Thus (4) can be generalized to:

$$Q'_i = \forall_i + (\forall_i/K_{1i})\overset{N+1}{\underset{j=2}{3}}K_{ji} \qquad (4a)$$

This suggests a regression model of the form:

$$Q'_i = \forall_i + \overset{N+1}{\underset{j=2}{3}}\exists_j K_{ji}/K_{1i} + ,_I \qquad (5)$$

The coefficients on the different kinds of capital have been allowed to differ from $\forall$ to reflect the fact that intangible capital stocks are not observed and are measured by proxies. We utilize two sources of intangible capital stocks based on advertising expenses and R&D expenses.

Our methodology for measuring intangibles differs from that of Aboody and Lev (2001). Their approach is to model operating income as a function of intangibles and then attempt to forecast future income. In a related paper, Gu and Lev (2001) make three fascinating claims. One is that measurement of intangibles based on the market's valuation of securities is fundamentally flawed because markets misprice. The second claim is that there is no value to our type of approach because it only provides information already available to investors. The third claim is that their methodology of estimating regressions for the purpose of forecasting future cash flows generated by intangibles is protected by a pending patent.5 The irony is that after criticizing the market valuation approach as circular and providing redundant information, they use regressions with publicly available data, implying a belief that these simple regressions

[5]The claim of patent protection for this methodology is questionable but chilling. To enforce a patent one generally needs to establish a discovery which is not in the prior art and not obvious, both of which appear to be difficult hurdles. Nevertheless the legal costs associated with challenging a claim could certainly have a chilling effect on academic research. Fortunately, our

provide a more accurate estimator that the collective market. This is effectively an argument that one can improve on the market forecast by omitting information contained in the variables they exclude and constraining the effect of their chosen variables to fit their functional form.

4. Data

We collect Compustat data over the twenty year time period covering 1982 to 2001. We collect data for all firms in SIC 28 which provides broad coverage of the chemical industry. There is at least partial data for 805 firms. Since we require four years of lagged data to construct intangible capital stocks, if all firms had complete data for the entire sample period we could potentially have 13,880 observations. We have 725 firms and 7,024 observations in our full sample estimates. Our data requirements include: advertising expenditures; R&D expenditures; market value of equity; long-term debt; current assets; current liabilities; and net property, plant and equipment.

Our construction of advertising and R&D stocks follows the approach of Hall (1990). We cumulate expenditures for 5 years, depreciating them at a rate of fifteen percent per year. Hall provides a statistical argument that the precise choice of the depreciation rate is not important, and our choice of fifteen percent is common.

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methodology is at odds with this alternative approach and therefore not infringing on the claim.

The construction of the Q ratio involves more complicated issues and choices. The standard definition of Q is the market value of all financial claims on the firm divided by the replacement cost of assets. There are practical problems associated with implementing this definition because neither of these variables is observable. A standard approach to constructing the numerator is to use the sum of the market value of equity and the book value of debt. Several studies report that this is a good approximation because the correlations between such a series and an alternative detailed adjustment to the book value of debt is around 98%.[6] Also, a casual survey of the detailed financial statements of the firms in our sample indicates that much of the debt is in the form of short-term, floating-rate bank loans, so the book value of debt should be a better than average approximation to the market value of debt.

The other variable which is not observable is the replacement cost of assets. Again, some researchers have made detailed adjustments to the book value of assets based on some simplifying assumptions. But the arbitrary simplifying assumptions required create new problems. Prior research, notably Chung and Pruitt (1994), has shown that the simple calculation of Q using the book value of assets has a correlation with the alternative of about 98%. This assumption should work even better in our sample because many of the firms are young and all firms are in the same industry. In other words, detailed adjustments would result in little more than proportionate changes across firms. Adjustments which would result over time will be captured by time effects in the estimation process.

The final issue in constructing Q, one which is often glossed over, is the fact that firms are

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[6]Chung and Pruitt (1994) find correlations of .97 to .99 depending on the year. Dadalt et al. (2003) actually conclude that the simplistic approach is preferable due to sample selection biases which result from the more intensive data requirements of alternatives.

financed by more than long-term debt and equity. Firms also finance their assets with current liabilities. One standard approach to dealing with this issue is to remove the portion of current assets financed by current liabilities from the denominator of Q. Thus, we construct the Q ratio by summing the market value of equity and the book value of debt, and dividing that by the sum of net property, plant and equipment and net working capital.

[INSERT TABLE 1 HERE]

Table 1 provides descriptive statistics for the full sample of 725 firms. The average value of Q in our full sample is 3.59. There were sixty-five observations for which all necessary data except R&D expenditures was available. If those sixty-five observations were added back to the sample, the average Q would be an indistinguishable 3.57. For the year 2001, the average Q is 4.69, suggesting that Q levels increased for the industry over the time period of investigation. As a point of comparison, Hall (2001) estimates the aggregate Q for the economy to be about 2, from which he infers that about half of aggregate firm value is due to intangible assets. Our descriptive statistics confirm that the chemical industry is indeed an industry with more than average levels of intangible assets. As another point of comparison, Klock and Megna report an average Q of 10.8 in the wireless communications industry, so the level of intangible capital in chemicals is not as great as wireless telecommunications.

Additional information which can be gleaned from the descriptive statistics is that our measure of advertising stock is, on average, about fourteen percent of fixed assets and our measure of R&D stock is, on average, about sixty-five percent of fixed assets. Additionally, it is clear that there are many small firms in the sample, and that the industry uses a moderate amount of leverage. Descriptive statistics are repeated for a subsample of 113 firms with a complete history. These indicate that the subsample firms tend to be larger firms with larger advertising capital, but lower R&D capital and Q ratios.

5. Results

[INSERT TABLE 2 HERE]

Table 2 presents results for the estimation of Equation 6 under two different assumptions. In both cases, the coefficients are estimated using simple regression, but the standard errors and t-statistics are estimated using White's (1980) procedure for an unspecified form of heteroskedasticity. We have 7,024 observations in these regressions. In the first row, all available observations are pooled without any allowance for the possibility of fixed firm effects or time effects. Our measures of intangible capital explain a reasonable seventeen percent of the variation in Tobin's Q for this diverse sample. Both advertising stock and R&D stock are statistically significant at the five percent level using a one-tailed test. The heteroskedastic-consistent t-statistic on R&D is about five in both specifications. The estimated intercept of 2.49 suggests that a firm with neither R&D nor advertising capital would still have substantial alternative sources of intangible assets.

The second row of Table 2 presents results from a fixed-effects model. The r-squared for the model increases to twenty percent, and the fixed effects are statistically significant. However the coefficients on both forms of intangible capital do not change appreciably in either significance or magnitude, and using an F-test we are not able to reject the joint null hypotheses that both coefficients on intangible capital are unchanged when the fixed effects are included at the five percent level of significance.

Utilizing sixteen dummy variables for time effects could generate some concern about colinearity. Analysis of colinearity diagnostics reveals that there is indeed modest colinearity between the dummy variables, but the analysis also indicates that this does not degrade the estimation of the coefficients for intangible capital. This conclusion is also supported by the fact that the estimated coefficients on intangible capital are barely changed when the dummy variables are included. In addition, although we do not report the results in our tables, we also estimated the model capturing time effects as a fifth order polynomial of a time trend and got nearly identical results.

An alternative methodology for capturing fixed effects, including firm fixed effects, is to utilize an error components model. Such a model is difficult to estimate when the length of the time series is not identical for each cross-sectional unit. We therefore employed this methodology to estimate the model for the subsample of 113 firms which had data for the entire twenty year period. Again, since four years of lagged data are required to construct the stocks, each time series used in the estimation contains 113 observations.

[INSERT TABLE 3 HERE]

Table 3 presents our results for the error components model on the subsample. Our qualitative conclusion that intangible capital stocks based on R&D and advertising are statistically significant determinants of Q does not change, but the estimated coefficients are different. In order to provide some light as to whether this is due to a difference in the sample or purely a result of the methodology, we include a third row in Table 3 which estimates one of the previous models on the subsample. It is important to note that the subsample of 113 firms with twenty years of data is markedly different from the larger sample in that the subsample contains larger firms with lower Q ratios. On average, sales for the subsample firms are two and a half times larger than sales in the full sample. Also, the subsample average Q ratio is 2.60, which is noticeably lower than the average 3.59 obtained from all observations.

The first two rows of Table 3 vary the assumption as to whether the autoregressive parameter is constant or varies cross-sectionally. The results between these two assumptions are not markedly different. The third row, which gives the results using simple regression on the subsample, shows that a good part of the differences in the estimates across methodologies is due to differences in the samples, but that there are still substantial differences remaining which are caused by the methodology. Incorporating cross-sectional heteroskedasticity and autoregressive disturbances does make a difference in the point estimates. Nevertheless, the conclusion that these measures of intangible capital are important is robust across a wide range of assumptions.

6. Conclusion

We utilize an efficient markets approach to measuring intangible capital, attributing the value of financial claims in excess of the cost of assets to intangibles. Two sources of intangible assets in the chemical and pharmaceuticals industry are investigated–advertising capital and R&D capital. We find that both of these, but especially R&D, play an important and statistically significant role in firm valuation for this industry. However, the results also suggest that there are additional sources of intangible capital in this industry which are yet to be measured and accounted for.

Table 1

Descriptive statistics

The numbers reported are sample averages using the full sample of 725 firms and 7,024 observations and a subsample of 113 firms with 1,808 observations. Sales, Total Assets, and Long-Term Debt are measured in millions of dollars. The other variables are measured per dollar of physical capital.

Variable	Full Sample	Subsample
Sales	3,180	8,000
Total Assets	3,497	7,827
Long-Term Debt	524	1,020
Advertising Capital	0.1413	0.2210
R&D Capital	0.6545	0.3237
Tobin's Q ratio	3.59	2.60

Table 2

Regressions of Tobin's Q on R&D capital and advertising capital using the full sample

The first row presents estimates from a simple pooled regression. The second row presents estimates from a model that includes year dummy variables to capture time effects. Both models are estimated using the full sample of 725 firms and 7,024 observations. The estimated coefficients on the time effects are not reported, but are statistically significant at the 0.01 level. The numbers in parentheses are heteroskedastic-consistent t-values calculated using White's (1980) methodology.

Model	Intercept	R&D	Advertising	R^2
without time dummies	2.493 (14.52)**	1.544 (5.27)**	0.620 (1.84)*	0.174
with time dummies	--	1.471 (4.98)**	0.632 (1.81)*	0.212

*, ** Indicates statistical significance at the 0.05 and 0.01 levels, respectively. One-tailed test statistics are used based on a presumption of a positive relationship.

Table 3

Generalized least squares estimates of Tobin's Q on R&D capital and advertising capital with error components using subsample of 113 cross-sections and 16 time periods.

The first two rows are estimates of an error components model. This technique gives a cross-sectionally heteroskedastic and timewise autoregressive model. The first row presents estimates that allow the autoregressive parameter to vary across firms. The second row presents estimates for which the autoregressive parameter is constrained to be equal across firms. The R^2 reported with these two rows is a Buse raw-moment R^2. Details of the estimation process are given in White (1993). The third row presents estimates using ordinary least squares with time dummies as in Table 2 in order to show that some of the change in the estimates is the result of changing the sample and some is the result of the change in estimation methodology.

Model	Intercept	R&D	Advertising	R^2
error components with varying rho	1.488 (13.05)**	0.263 (3.52)**	0.637 (4.49)**	0.117
error components with same rho(=.74)	1.188 (23.08)**	0.255 (3.65)**	0.874 (5.76)**	0.281
OLS with time dummies	--	0.544 (2.17)*	1.254 (2.23)*	0.220

*, ** Indicates statistical significance at the 0.05 and 0.01 levels, respectively. One-tailed test statistics are used based on a presumption of a positive relationship.

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