R&D, Agency Costs and Capital Structure: International Evidence

Abstract

We examine the impact of R&D intensity and agency costs on the value of firms across 13 economies. We find that R&D adds value while high agency costs reduce value. R&D adds value, however, even when agency costs are high. We show that in those firms where agency costs are high and R&D intensity is high the debt control hypothesis is at work. In contrast to the stylized fact of high R&D firms having low levels of debt, these firms have higher levels of debt.

JEL: D80, G32, O30, O57

The field of corporate governance has arisen to explain how, why and when asymmetric information, and the associated agency problems, are managed in the modern firm (Shleifer and Vishny 1997). The major agency problem is that managers and directors may adopt corporate objectives inconsistent with long term maximisation of firm value. For example, they may retain excess free cash flow and/or undertake inefficient investments (Jensen 1986, 1989). Of course, managers may directly expropriate the firms' assets and defraud the shareholders (Johnson et al. 2001). R&D becomes particularly interesting when considered in an agency theory framework. Holmstrom (1989) indicates that innovation, and by extension R&D, has five unique characteristics, it is long term in nature, high risk in terms of the probability of failure, unpredictable in outcome, labor intensive and idiosyncratic. These characteristics combine to a net effect where R&D contributes to higher levels of asymmetric information *and* the mechanisms[1] to control that asymmetry are less potent.

Shareholders are often able to observe the extent of R&D expenditure in the firm but cannot know what the product being developed is, nor the value of that product, nor the productivity of the firms' R&D investment (see, however, Deng, Lev and Narin 1999). Aboody and Lev (2000) argue that most firms do not participate in "innovation races", i.e. R&D can be described as being "unique" and firm specific, consequently the behavior and performance of direct competitors is not a guide to firm performance. Further firms are likely to be secretive in the early stages of R&D activity and all the shareholders observe is a number in the financial statements. The empirical literature supports the notion that R&D is associated with asymmetric information. Kelm, Narayanan and Pinches (1995), for example, investigate capital

market responses to R&D over three stages of the R&D process. They report that the market responds favorably at the continuation and new–product stages of the process. Under conditions of symmetric information we would anticipate that the entire market reaction would be captured at the initiation announcement. Similarly, Aboody and Lev (2000) demonstrate that R&D characteristics greatly enhance asymmetric information by showing that (legal) insider trading gains in R&D firms are higher than non-R&D firms, and that the market reacts strongly to the announcement of insider trading.

Debt policy and dividend policy are less likely to constrain R&D induced agency problems. If we follow Jensen (1986, 1989) by defining the agency problem as a dispute over free cash flow then these mechanisms are particularly ill suited to manage R&D induced agency problems. Dittmar, Mahrt-Smith and Serveas (2003), who use R&D as a measure of asymmetric information, find that agency problems are a prime cause of increased cash holdings and that high levels of R&D are associated with higher cash levels. It is plausible to believe, however, that R&D firms keep higher cash levels to finance the R&D activity itself. Certainly, firms cannot, or do not, pay out cash when they undertake high R&D activity. Higher dividends, then, are not the solution. In any event it is expected that firms with high growth options would have a lower dividend payout ratio (La Porta et al. 2000). A priori, the typical R&D firm would likely have many growth options.

The issues relating to debt policy are more complex. Following the Myers-Majluf (1984) pecking order theory we might expect R&D to be financed by retained earnings (consistent with having higher cash balances) and then by debt. Titman and

Wessels (1988), however, report that having "unique" assets is associated with *lower* debt levels. The logic being, first, that consumers will only buy unique products if they are confident that the firm will survive to provide after-sales service. Second, the lack of a secondary market for R&D and the non-collaterability of R&D activity mitigates against debt-financed R&D activity. Further, Shi (2003) indicates that R&D activity, which increases the market value of equity, also increases bond default risk and debt risk premia. Bond holders, ceteris paribus, may be unwilling to hold the risks associated with greater R&D activity. In contrast, however, Zantout (1997) reports that shareholder gains from R&D announcements are not associated with bondholder losses. This would seem to indicate that debt can be valuable to R&D intensive firms. Despite this type of result, Bah and Dumontier (2001) report that R&D intensive firms have significantly lower levels of debt than do non-R&D intensive firms. Generally, it is accepted as a stylized fact that R&D is associated with less debt in the firm's capital structure.

In this paper we investigate the interaction of R&D activity and agency costs on the value of publicly listed firms. Our data set employs over 24,000 firm years from thirteen high income economies. We make two contributions to the literature. First we investigate the impact of agency problems on R&D valuation. Our measure of agency problems is the asset to sales ratio. Ang, Cole and Lin (2000) show this variable to be highly related to agency problems. We are able to show that firms with low agency problems are more valuable *ceteris paribus* than firms with high agency problems. It appears that the act of undertaking R&D increases the value of the firm irrespective of agency costs. We also document country specific and industry specific versions of our model. Our second contribution is related to the first. We would anticipate that high

agency cost firms would not undertake R&D activity or, if they did, that R&D activity would have a negative valuation effect. Investors might consider R&D expenditure under those circumstances as asset diversion. We report, however, a positive valuation effect. Furthermore, for those (high agency cost) firms, we also report higher levels of debt. It appears that high R&D – high agency cost firms employ more debt in their capital structures apparently as a corporate governance mechanism. This result is consistent with the debt control hypothesis (Jensen 1986). It is also consistent with Zantout (1997) who reports that the stock market reaction to R&D expenditure announcements is positively related to the firms' debt ratio.

To the best of our knowledge there is little research into the relationship between agency problems and R&D activity. Jensen (1993) uses R&D expenditure to demonstrate that internal corporate governance control mechanisms are ineffective. Francis and Smith (1995), using US data, report that diffusely–held firms are less innovative than closely held firms. Lee and O'Neill (2003) compare ownership concentration and R&D activity in Japan and the US. They confirm that ownership concentration is positively related to R&D in the US, but find no such relationship for Japan. Cui and Mak (2002) use the Morck, Shleifer and Vishny (1988) approach to investigate the relationship between insider ownership and Tobin Q for high R&D firms. They report a W–shaped relationship and interpret the results as indicating that higher levels of ownership are required to substitute for poor board governance in these types of firms. Chung, Wright and Kedia (2003) report the relationship between firm value (measured by Tobin Q) and R&D depends on corporate governance.

R&D can be, and is, used to smooth earnings (Bange and De Bondt 1998). To the extent that smoothed earnings signal high quality firms (Dye 1988, Chaney and Lewis 1995) R&D activity may assist in reducing asymmetric information problems and the associated agency problems leading to higher share prices (Lev and Kunitzky 1974). Earnings management may be valuable in the US, however, the international evidence is less sanguine. Bhattacharya, Daouk and Welker (2001) find, in an international comparison of 40 economies, that earnings management is associated with a higher cost of equity capital. Leuz, Nanda and Wysochi (2001) report that earnings management is associated with weaker protection of investor rights and consequently greater levels of agency cost.

Some studies approach the issue of R&D and agency costs indirectly when investigating investment myopia. R&D is often used as a proxy for long term investment that is particularly subject to myopia. For example, Knoeber (1986) and Pugh, Page and Jahera (1992) report that R&D rises after firms adopt anti-takeover measures. Meulbroek et al. (1990), however, report opposite result. Bushee (1998) indicates that firms with "passive" investors, following buy and hold strategies, are less likely to cut R&D after declines in earnings. Lundstrum (2002) provides an argument where myopia is the solution to an agency problem. He reports a negative relationship between R&D and CEO age and argues this is induced by shareholders in order to reduce the costs of future hold-up (i.e. shareholders prefer firms to underinvest rather than pay hold-up costs in future). Barket and Mueller (2002) also find a negative relationship between CEO age and R&D activity. They also find, however, that R&D increases with CEO tenure implying, to their minds, that CEOs "mold" R&D expenditure to their own preferences. R&D also features in the

managerial compensation literature. For example, DeFusco, Zorn and Johnson (1991) report that managers tend to increase debt and reduce R&D expenditure after stock option plans are adopted. Nam, Ottoo and Thornton (2003) investigate the impact of stock option plans on debt ratios and R&D. They differentiate between price effects and volatility effects of option plans. The greater the price effect from a stock option plan the lower the investment in R&D. The less risk averse managers are (greater volatility effects) the higher the R&D investment. Of particular interest to us is that Nam et al. (2003) report stronger relationships between managerial incentives and R&D in those firms with lower levels of external monitoring. Inefficient incentive structures and low monitoring would lead to inefficient R&D decisions. Their results seem to suggest that firms with low levels of monitoring may overinvest in R&D and firms with high levels of monitoring may underinvest in R&D. Nam et al. (2003), however, are unable to directly test this view.

The remainder of the paper is set out as follows. Section I sets out the basic model that we employ. Section II contains a discussion of our data and section III contains results. In section IV we discuss whether debt constrains agency problems in high R&D firms. Section V contains a discussion and conclusion.

I. The Valuation Effects of R&D Expenditure

There is a broad consensus in the literature that R&D activity adds value. Many of the studies that confirm this view are event–study orientated. For example, the classic Chan, Martin and Kensinger (1990) examined the stock market response of 95 announcements, over a six year period, of increased R&D expenditure. More recently,

Eberhart, Maxwell and Siddique (forthcoming) examined 8,313 instances, over a fifty year period, of increased R&D expenditure. Other studies, such as Chan, Lakonishok and Sougiannis (2001), evaluate whether R&D is related to stock returns using asset–pricing theory. Finally some studies, such as Chung, Wright and Kedia (2003) and Hall and Orani (2003), employ cross section techniques relating R&D to various measures of market value. The most used measure of market value is some proxy for Tobin Q. We follow the latter approach by relating R&D and our measure of agency costs to Q.

The basic version of our model is set out below.

$$Q_{i,t} = \alpha_0 + \alpha_1 \text{Log}(\text{Assets}_{i,t}) + \alpha_2 \text{DY}_{i,t} + \alpha_3 \text{Debt-Assets}_{i,t} + \alpha_4 \text{RoA}_{i,t} + \alpha_5 \text{RD-Sales}_{i,t} + \alpha_6 \text{Agency}_{i,t} + \text{Industry} + \text{Country} + \text{Annual} + \varepsilon_{i,t} \quad (1)$$

Where $Q_{i,t}$ is our proxy for Tobin Q (market value of equity plus book value of assets less book value of shareholder equity all divided by book value of assets). $\text{Log}(\text{Assets}_{i,t})$ is the natural logarithm of book value of assets and is a proxy for size. $\text{DY}_{i,t}$ is the firm's dividend yield and $\text{Debt-Assets}_{i,t}$ is book value of total debt to book value of total assets[2], $\text{RoA}_{i,t}$ is accounting return on assets, $\text{RD-Sales}_{i,t}$ is reported R&D expense to net sales and $\text{Agency}_{i,t}$ is the assets to sales ratio. The basic model includes dummy variables indicating country of origin and industry.

We expand our basic model, using dummy variables, to differentiate between firms that have high and low levels of R&D and high and low levels of agency costs. In this respect our analysis is similar to that in Chan et al. (1990) who differentiate between high tech and low tech firms and Szewczyk, Tsetsekos and Zantout (1996) and

Eberhart et al. (forthcoming) who differentiate between high growth and low growth firms.

Size, dividend yield, debt-asset ratios and return on assets are all control variables. We are interested primarily in the R&D intensity variable, in the agency variable and particularly the interactions between those variables. The agency variable we employ in equation (1) is from Ang, Cole and Lin (2000). They investigate two measures of agency cost in a sample of small unlisted firms in the US. Their first measure is operating expense to sales and their second measure is the sales to assets ratio. This latter variable is the proxy we employ. Ang et al. indicate that this variable measures the loss in revenue due to inefficient or inappropriate asset usage (p.82). Cole et al. indicate that low sales to asset ratios indicate higher agency costs. In order to simplify the discussion we have taken the inverse (assets to sales) as our measure of agency costs and higher measures of the ratio would be related to having higher agency costs.

We hypothesize that R&D intensive firms with low agency costs will be more valuable than R&D intensive firms with high agency costs. In general we would anticipate that firms with high levels of agency cost will not undertake R&D as the market will not value that R&D as an investment, but rather as asset diversion and tunneling. To the extent that high agency cost firms do undertake R&D there may well be a negative relationship between R&D intensity and firm value. Similarly, we expect R&D intensive firms to be more valuable in economies that better "manage" asymmetric information problems, e.g. common law economies. Similarly, market–based financial systems are more likely to encourage R&D activity and consequently will value R&D more highly than bank–based economies. Allen and Gale (2000)

summarize the literature in this regard. In short, market–based financial systems have well developed information distribution mechanisms and are able to allocate capital to activities even when investors hold diverse views on the value of the investment. Conversely, bank–based systems operate with a high degree of consensus. Investors are less willing to provide finance to new and high risk investments. Bank–based financial systems do well in routinized "traditional" industries. Carlin and Mayer (2003) provide empirical evidence consistent with this view. Conversely, Beck and Levine (2002) argue that given the legal system, the basis of the financial system (bank–based or market–based) is not too important.

Our model is close, in spirit, to that of Hall and Oriani (2003). The purpose of their paper is to compare European (France, Germany and Italy) R&D firm valuation to Anglo-Saxon (UK and US) R&D firm valuation. They employ panel data techniques and a production function approach determines their valuation model. In essence, however, Hall and Oriani (2003) are using a Tobin Q approach similar to ours. They are able to report R&D valuation effects that are three time larger for the UK than for France and Germany. In particular, they report that the coefficient on R&D is less than unity (one). This implies, assuming efficient markets, that some firms overinvest in R&D (i.e. the assets created by the "investment" are less valuable than the amount paid for them). While our model specification is not exactly equivalent to that in Hall and Oriani (2003) we interpret our results for low agency cost firms as making an "optimal" investment in R&D and for high agency cost firms as an overinvestment in R&D. Our paper differs from Hall and Oriani (2003) in that they do not include agency costs in their model.

II. Data

A. Sample Construction

Data are collected from the Osiris Database (December 2002 file) for thirteen high income economies where firms report R&D expenditure and that data are included in the database. Osiris is one of a suite of databases owned by Bureau van Dijk.[3] Bureau van Dijk standardizes accounting information with the explicit objective of achieving uniformity and allowing international comparison and cross-border analysis. Bureau van Dijk claim that the standardized information have been approved by accounting bodies and practitioners in each economy and the data entry procedures include rigorous checking with many data fields subject to automatic validation. The economies in our sample are, Canada, Denmark, France, Germany, Greece, Ireland, Israel, Japan, Netherlands, Sweden, Switzerland, UK and the US.[4] All data are recorded in US dollars. Most research into R&D activity is undertaken using US or UK data. The data for these economies are easily available and, in particular, R&D activity is reported in the annual financial statements. R&D coverage for other economies is less comprehensive with voluntary disclosure being the norm. Those papers that do employ international data have to rely on voluntary disclosure which may introduce selectivity bias into the results. Hall and Oriani (2003), however, report that many (and even most) European R&D firms report their R&D activity. A second source of "international" bias is the difference in accounting conventions across economies. In the US and UK firms have long been required to report R&D activity (1974 and 1989) which must (generally) be expensed in the income statement. Other economies allow for expensing or, in some specific instances, capitalization (Lev 1999). We follow Bhagat and Welch (1995) in arguing that differences in accounting

convention have to be tolerated. Unlike Bhagat and Welch (1995) we do pool the data in addition to running country specific models. As in the Bhagat and Welch (1995) paper the accounting differences should not affect the individual country analysis. In the pooled equations we include individual country dummies and also estimate equations where we group economies by whether they have a common law or civil law legal system and by whether they are market–based or bank–based. It is well known and documented that accounting conventions are systematically related to variables such as these.[5] Finally, tax incentives for R&D vary across economies. Despite the potential for accounting and policy induced bias, international comparisons are worthwhile. The scope for agency problems and the mechanisms to deal with them, the mechanisms for mobilizing resources and the efficiency of capital markets all vary across economies. The ability of markets to value physical and non-physical capital will vary too. These differences are likely to be more important when considering R&D valuation, and public policy toward R&D, than the sources of empirical bias.

B. Descriptive Statistics

Data are collected for industrial firms only (not banks or insurance firms). Our sample period is 1999 – 2001. We obtain data for 15,531 firms. This results in 46,593 firm years. There are 21,539 firm years with at least one missing observation which we then exclude from the analysis. This results in 25,054 firm years. Finally we exclude 364 observations in the regression analysis which we identify as outliers. Summary statistics (25,054 firm years) are shown in table I.

TABLE ONE ABOUT HERE

Table I shows the total number of firm years per economy in the sample and also the number of firm years that have reported R&D expenditure. We assume that all firms that undertake R&D also report R&D expenditure. Consequently firms that do not have any reported R&D are assumed to not undertake any R&D and are recorded as zero. The first row of the table shows the average Q, RD-Sales % and Asset-Sales % for all observations across all economies. The next 13 rows show the equivalent data for each economy. The overall average level of R&D expenditure is very high at 91.83 percent. This, however, is a US effect. The US data indicate a very high level of R&D expenditure at 211.66 percent of net sales with US firms making up forty percent of all observations and 56.40 percent of all R&D firms.[6]

Economies are also grouped together on the basis of their financial structure (either market–based or bank–based) following Demirguc-Kunt and Maksimovic's (2002) classification and on their legal origin, based on the LaPorta et al. (1997) classification. Average values for Q, RD-Sales % and Asset-Sales % are also reported in table I. With respect to RD-Sales% both Market–based and Common Law economies (which include the US) have extremely high averages relative to Bank–based and Civil Law economies. Immediately below the Market and Common Law rows, however, the same statistics are calculated excluding the US data. It is still the case that Common Law and Market–based economies undertake, on average, higher levels of R&D activity relative to sales than do Bank–based and Civil Law economies. Our proxy for agency costs also captures important variation in the sample. When the US is included, Common Law and Market–based economies have a lower agency costs score, on average, than do Civil Law and Bank–based economies.

When the US is excluded, however, that figure rises above that of the Civil Law and Bank–based economies. The relative valuation of firms, given by Q, indicates that firms in Common Law and Market – based economies are, on average, more valuable than those in Civil Law and Bank–based economies. This is consistent with results in LaPorta et al. (1999).

Finally the table shows the break down of data by industry. Osiris records four digit SIC data for firms. We use that data to allocate firms to one of ten industry groupings following the SIC classification as per Appendix 1. The results in table one show variation in R&D intensity. We have three industries with very high R&D intensity, Industry 2 (Primary, Chemical and Petroleum Industries), Industry 7 (Personal and Business Services) and Industry 8 (Service (Other) Industries). Later in the analysis these three industries will be combined together to form a "high" R&D intensity grouping. In contrast, five of the industries have R&D to Sales ratios of less than ten percent. These five groupings will be used later as a "low" R&D intensity group. Our sample clearly captures a range of R&D behavior. The two industries with the highest R&D intensity (Industry 2 and Industry 8) also show the highest average measures of agency costs. Low R&D intensity industries, however, also show high average agency costs.

Table II shows a comparison between firms that undertake R&D and those that do not. Firms that undertake R&D tend to be more valuable, larger but less profitable than those that do not undertake R&D. The debt-assets ratio for R&D firms is lower than that of non-R&D firms. There is no statistical difference between agency costs in the two types of firm and no statistical difference in dividend yield.

TABLE TWO ABOUT HERE

Table III contains the summary statistics for the data used to estimate equation (1). As a first approximation equation (1) was estimated and outliers were identified and removed.[7] The summary statistics reported in table three exclude those outliers and reflect the data that are actually used in the regression analysis. Panel A indicates the mean, median, maximum, minimum and standard deviations of the data, while panel B indicates correlation coefficients and panel C reports variance inflation factors. The summary statistics in panel A indicate that the sample has captured a wide degree of variability in the variables given the range between the minimum and maximum values. A comparison of the mean and median values shows that most of the variables have a skewed distribution. The correlation coefficients in panel B show low correlations amongst the independent variables. Together with the low variance inflation factors reported in panel C this indicates that multicollinearity is unlikely to be an issue in the regression analysis.

TABLE THREE HERE

III. Results

A. Regression Results for Pooled Data

Table IV contains the basic regression analysis. Column one shows the base case version of equation (1).[8] In terms of the very basic model it appears that undertaking R&D activity has a statistically significant positive impact on the value of the firm.

While the RD-Sales coefficient is significantly different from zero, it is much smaller than unity. Hall and Oriani (2003) also find R&D coefficients to be less than unity – indicating that firms are overinvesting in R&D. In column two we include our measure of agency costs. It, however, is not statistically significant. In column three we create two dummy variables, HighRD-Sales and LowRD-Sales. These variables take on a value of one when the ratio of R&D to sales is above the 75th percentile or below the 25th percentile.[9] Firms with high levels of R&D are relatively more valuable and firms with low levels of R&D are relatively less valuable. In column four we perform a similar exercise when we create a HighAsset-Sales and a LowAsset-Sales variable. Again each of these variables indicates firms above and below the 75th and 25th percentiles for the Asset-Sales ratio. Unsurprisingly, those firms with low agency costs are more valuable compared to those with high agency costs. The final column (5) includes interaction effects.[10] Consistent with the results in column three, firms that undertake high levels of R&D are more valuable than those that undertake less R&D. Similarly, for a given level of R&D low agency cost firms are more valuable than high agency cost firms. It is worth noting that high R&D – high agency costs firms are relatively more valuable than are low R&D – low agency cost firms. Undertaking R&D is a valuable activity despite agency costs. It does suggest, however, that high agency costs in R&D intensive firms are constrained or managed in some way.[11] The other observation is the size of the coefficient on high R&D – low agency costs firms. It has a standard error of 0.071417 (not reported here) indicating that the coefficient (0.934727) is not statistically significantly different from one. While the interaction variable is not equivalent to the test in Hall and Oriani (2003), to our minds, this indicates that these firms are making an appropriate investment in R&D. On this logic high agency cost firms that do undertake R&D overinvest.

Nonetheless undertaking R&D is valued by the market, as low R&D firms – irrespective of agency costs – are less valuable.

TABLE FOUR HERE

B. Regression Results for Country Data

Table V shows the results of equation (1), as specified in column one of table four, on a country by country basis. It also shows the results for market-based and bank–based economies and common law and civil law economies. In seven of the thirteen economies the RD-Sales coefficient is positive and statistically significantly different from zero. (In the case of France, the coefficient is negative and significant at the 10 percent level). In no instance is it anywhere near unity. Indicating, on average, that the valuation effect of R&D is less than the investment in R&D (i.e. over-investment). It is not obvious what Greece, Israel, the Netherlands, Sweden and the UK have in common – apart from the RD-Sales coefficient not being statistically significantly different from zero. In order to explore the issue further, equation (1) is re-estimated for Market–based and Bank–based economies and then for Common Law and Civil Law economies. Finally the Market–based and Common Law equations are re-estimated without the US data to determine if a US effect is at work. The RD-Sales coefficient is positive and statistically significant in Market–based and Common Law economies, but not Bank–based and Civil Law economies. As can be seen from the final row in the table this result is not a US effect. The result for Bank–based economies is consistent with the financial structure literature indicating that R&D activity is likely to be less valuable in Bank–based economies (Carlin and Mayer

2003). Similarly the law and finance literature indicates that Civil Law economies would be less efficient in managing the asymmetric information problems associated with R&D and so it would be less valuable in those economies, on average.

TABLE FIVE HERE

Table VI shows the extended version of equation (1) from column Five of table four (i.e. the equation with interactions between the R&D and agency variables) on a country by country basis. Just as in table V the equation is estimated for bank–based and market–based economies and for Common Law and Civil Law economies (with and without the US). High R&D – high agency cost firms are less valuable in Greece and Switzerland and more valuable in Japan and the US. For low agency cost firms a high level of R&D adds value in Canada, Germany, Japan, the UK and the US. Low levels of R&D in a high agency cost firm add value in Ireland and in Switzerland. Otherwise in Canada, Germany, the UK and the US low R&D in a high agency cost firm reduces value. Finally, low R&D – low agency cost firms are less valuable in France, Greece, the UK and the US, but more valuable in Denmark. When re-estimating the equations by financial structure and legal family, however, the results indicate that R&D activity creates value overall. The greatest contribution to value appears to occur when agency costs are low and the firm is in either a Market–based or Common Law economy. In those economies the HighRD*LowAsset-Sales coefficient is not statistically significantly different from one. These results do not appear to be a US effect. In bank–based and civil law economies, however, the HighRD*LowAsset-Sales coefficient is statistically significantly different from one.

TABLE SIX HERE

C. Regression Results for Industry Data

In tables VII and VIII the analysis is repeated with industries instead of economies. In general, the results are qualitatively similar to those reported earlier. In table VII we show that undertaking R&D reduces value in Industries one (Mineral Industries) and nine (Public Administration), while it adds value in industries three (Manufacturing and Equipment), five (Wholesale and Retail Trade), six (Finance, Insurance and Real Estate) and seven (Personal and Business Services). There does not, however, appear to be any pattern between the average Q for the industry (shown in table one) and the extent to which the RD-Sales coefficient is positive or statistically significant. In table VIII we do not show results for industry nine (Public Administration) as there are only 16 firm years in that industry. In one of the low R&D intensity industries (industry four) the interaction variables are not statistically significant at all while in the others they exhibit similar patterns to before. While some of the HighRD*LowAsset-Sales coefficients appear to be quite large they are not statistically different from one.[12]

TABLES SEVEN and EIGHT HERE

We then investigate whether there are any differences between high and low R&D intensity industries and whether those differences vary by legal system and/or financial system. We combine industries two (Primary, Chemical and Petroleum Industries), seven (Personal and Business Services) and eight (Service (Other)

Industries) into a single High R&D intensity category and the other industries are combined into a Low R&D intensity category.[13] Results are shown in tables IX and X. We also show results for High and Low R&D intensity across Market–based, Bank–based, Common Law and Civil Law economies. The first striking difference between table IX and table VII is the coefficients on Dividend Yield. Previously, that coefficient was generally negative or statistically insignificant. For high intensity R&D industries it is positive and statistically significant. A second feature of table IX worth highlighting relates to the coefficient RD-Sales. It is not statistically significant for high intensity R&D industries in Bank–based economies and similarly is not significant in Civil law economies for either high or low R&D intensive industries. Results in table X are qualitatively similar.

TABLES NINE and TEN HERE

IV. Does debt constrain agency problems in high R&D firms?

We now turn our attention to the fact that we find a value additive effect to R&D in high agency cost firms. In table XI we segment our data by high and low R&D and high and low agency costs and calculate summary statistics for the interactions of these variables. We then examine whether the segmented data is statistically different from the unsegmented data. Importantly, for our purposes, HighRD*LowAsset-Sales firms have lower debt than do other firms. This is a stylized fact in the R&D literature, consistent with results from Bah and Dumontier (2001) – firms that undertake R&D have less debt.

HighRD*HighAsset-Sales firms have more debt compared to all other firms. This result is inconsistent with the previous literature into R&D activity, but is consistent with the debt control hypothesis (Jensen 1986). High levels of debt constrain managerial opportunism forcing decision makers to undertake economically viable investments and exit unprofitable activity. Those firms that are likely to have economically viable R&D activity but are also likely to have high levels of agency costs may well use debt levels to signify their bona fides.

TABLE ELEVEN HERE

In table XII we identify these firms by economy and industry. It would be easy to argue that our result in table XI is simply an artifact or is particular to a specific industry. A glance at table XII, however, indicates that these high R&D – high agency cost firms are not confined to a particular economy or particular industry. There are no such firms in Ireland or Industry Nine (Public Administration). On the other hand, most such firms are located in the US. Within the US, almost half (43.7 percent) are in Industry 3 (Manufacturing and Equipment). In short, high R&D – high agency cost firms are not confined to a single industry or economy. While about half of the firms are located in the US, the remaining firms are spread across the world.

TABLE TWELVE HERE

In table XIII we segment the data into high R&D and high and low agency cost groups and re-estimate the basic version of equation (1). As can be seen in the HighRD*HighAsset-Sales sample firms with high higher debt-equity ratios are more

valuable whereas in the HighRD*LowAsset-Sales sample they are not. This we ascribe to debt being used as a control mechanism in these firms.

TABLE THIRTEEN HERE

V. Discussion and Conclusion

To the best of our knowledge this is the first paper to investigate the relationship between R&D intensity and agency costs in a large cross-section of economies. Consistent with the literature, we have found that R&D activity is value relevant and that investors view R&D activity as a wealth enhancing investment. Similarly, we find that high agency costs are value destroying. We report that undertaking R&D dominates agency costs in a valuation sense. This is unexpected as we would have anticipated that firms with high agency costs would not normally undertake R&D activity. Given high agency costs and the inherent uncertainty of the R&D process we did not anticipate that investors would view R&D in high agency cost firms as an investment.

It appears that there is a sub-set of firms that have high agency problems, yet undertake R&D activity. These firms have a credibility problem. How are they able to convince the market that any R&D expenditure is an investment and not the manifestation of an agency problem? A priori we believe that the usual mechanisms to constrain agency problems would be less effective when dealing with R&D induced asymmetric information. It is a stylized fact in the literature that high growth firms and those that undertake high levels of R&D would have low debt levels and low, if

not zero, dividend payouts. For the bulk of firms this appears to be the case. For those firms with high agency costs, however, that is not the case. From the analysis shown here it appears that firms in high R&D intensity industries are more valuable if they have a higher dividend yield. At the individual firm level it appears that those firms with high R&D and high agency costs are more valuable if they have a higher debt ratio. We also compared our results across legal systems and financial systems. R&D appears to be more valuable in those economies that better manage asymmetric information i.e. market–based and common law economies.

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Table I: Country and Industry Statistics. Total Firms indicates the number of firms in the data base. R&D firms are those firms that have reported R&D activity and are captured in the Osiris Database. RD-Sales is the percentage of R&D expense to Net Sales, Q is a proxy for Tobin Q. Market indicates a group of market-orientated economies and Bank indicates a group of bank-orientated economies. Economies are allocated as being market or bank orientated based on Demirguc-Kunt and Maksimovic (2002). Common and Civil indicate the legal origin of the economy and is taken from LaPorta et al. (1997). SIC codes for all firms are collected and firms are allocated to one of 10 industries numbered 0 through 9. Data shown are averages.

	Q	RDSales %	Asset-Sales %	Total Firm Years	R&D Firm Years	R&D Firm %
All	2.19	91.83	205.50	25054	6704	26.76
Canada	1.64	48.87	328.47	1281	308	24.04
Denmark	2.03	5.88	126.01	249	43	17.27
France	2.07	5.89	523.85	1533	139	9.07
Germany	1.97	2.15	440.31	1062	224	21.09
Greece	3.32	0.30	123.10	171	49	28.66
Ireland	1.96	1.90	125.48	119	28	23.53
Israel	1.56	15.46	141.36	44	30	68.18
Japan	1.50	0.55	116.41	6615	1122	16.96
Netherlands	2.03	2.42	142.58	419	55	13.13
Sweden	2.28	28.70	174.23	548	138	25.18
Switzerland	1.61	2.03	180.14	449	152	33.85
UK	2.25	30.85	229.74	2523	635	25.17
US	2.76	211.66	179.05	10041	3781	37.66
Market	2.53	154.09	199.40	14812	4917	33.20
Bank	1.69	1.78	214.33	10242	1787	17.45
Common	2.55	161.81	201.27	14008	4782	34.14
Civil	1.73	3.09	210.87	11046	1922	17.40
Market (ex-US)	2.07	32.94	242.22	4771	1136	23.81
Common (ex-US)	2.04	35.63	257.51	3967	1001	25.23
Industry0	1.56	0.53	244.54	93	24	25.81
Industry1	1.40	11.36	242.11	1793	318	17.74
Industry2	2.15	263.14	319.53	4189	1324	31.61
Industry3	2.07	41.62	123.75	7468	3101	41.52
Industry4	1.81	6.94	258.76	2095	222	10.60
Industry5	1.82	2.47	165.40	3671	209	5.69
Industry6	1.86	1.74	233.56	1464	46	3.14
Industry7	3.67	193.43	143.02	3412	1278	37.46
Industry8	2.38	213.01	526.99	850	179	21.06
Industry9	1.75	0.77	114.65	16	3	18.75

Table II: Comparison for firms with and without R&D. The row marked F contains p-values from a F-test for equality of variances and the row marked t contains p-values from a two-sided t-test for equality of means (unequal variances).

Panel A: R&D Firms	Q	Asset-Sales	Debt-Assets	DY	Log(Assets)	RoA
Mean	2.5773	199.8413	49.4216	0.8906	12.4676	-14.6014
Median	1.6300	88.0400	45.5849	0.0000	12.3801	1.3500
Std. Dev.	2.4377	2515.8230	39.4557	2.9798	2.2905	52.3312
N	6474	6474	6474	6474	6474	6474
Panel B: Non R&D Firms	Q	Asset-Sales	Debt-Assets	DY	Log(Assets)	RoA
Mean	1.4730	213.6600	58.2298	9.1365	12.3633	0.3345
Median	1.0900	100.2450	58.1945	0.8185	12.1770	3.4300
Std. Dev.	1.2894	3891.1430	30.9689	729.4479	1.8746	26.4637
N	18216	18216	18216	18216	18216	18216
F	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
t	0.0000	0.7453	0.0000	0.1271	0.0010	0.0000

Table III: Summary Statistics for Equation (1). Panel A contains mean, median, maximum, minimum and standard deviation data, while panel B contains correlation statistics and panel C contains variance inflation factors (VIF = $(1 - R^2)^{-1}$).

Panel A Summary	Q	Debt-Assets	DY	RD-Sales	Asset-Sales	RoA	Log(Assets)
Mean	1.7626	55.9202	6.9744	88.4725	210.0366	-3.5818	12.3907
Median	1.1700	55.5237	0.2961	0.0000	96.5300	3.0400	12.2151
Max	26.23	1848.95	96589.22	486500.00	336346.70	277.45	20.02
Min	0.0200	0.0649	0.0000	0.0000	0.0000	-780.7700	3.0445
Std. Dev.	1.7379	33.6290	626.5643	4352.3080	3581.9230	35.7470	1.9925
N	24690	24690	24690	24690	24690	24690	24690
Panel B: Correlations	Q	Debt-Equity	DY	RDSales	Asset-Sales	RoA	Log(Assets)
Debt-Assets	0.0536						
DY	-0.0084	-0.0083					
RD-Sales	0.0494	-0.0137	-0.0002				
Asset-Sales	0.0068	-0.0166	-0.0002	0.0144			
RoA	-0.4004	-0.2545	0.0351	-0.0394	-0.0010		
Log(Assets)	-0.1755	0.0976	0.0109	-0.0221	-0.0132	0.2783	
Panel C: VIF		1.1064	1.0012	1.0024	1.0006	1.1900	1.1210

Table IV: Results of Regression (1). Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of total assets (%) (Debt-Assets), the return on Assets (%), R&D to Sales (%) and Asset-Sales. The numbers in parentheses are White (1980) adjusted p-values.

	(1)	(2)	(3)	(4)	(5)
C	2.465236	2.464355	2.509944	2.453821	2.458774
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log(Assets)	-0.035462	-0.035398	-0.058061	-0.038320	-0.045806
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
DY	0.000009	0.000009	0.000010	0.000009	0.000006
	(0.1510)	(0.1512)	(0.0628)	(0.1322)	(0.2792)
Debt-Assets	-0.001257	-0.001251	0.000362	-0.000873	0.000390
	(0.3218)	(0.3240)	(0.7489)	(0.4840)	(0.7367)
RoA	-0.017544	-0.017542	-0.015340	-0.017209	-0.015400
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
RD-Sales	0.000012	0.000012	0.000010	0.000011	0.000009
	(0.0123)	(0.0123)	(0.0257)	(0.0150)	(0.0456)
Asset-Sales		0.000003			
		(0.3981)			
HighRD-Sales			0.691788		
			(0.00000		
Low-RD-Sales			-0.133762		
			(0.0294)		
HighAsset-Sales				-0.055592	
				(0.0229)	
LowAsset-Sales				0.170352	
				(0.0000)	
HighRD*HighAsset-Sales					0.478635
					(0.0000)
HighRD*LowAsset-Sales					0.934727
					(0.0000)
LowRD*HighAsset-Sales					-0.203781
					(0.0000)
LowRD*LowAsset-Sales					-0.146419
					(0.0000)
Adj-R^2	0.2254	0.2254	0.2585	0.2274	0.2480
Country Dummy	Yes	Yes	Yes	Yes	Yes
Industry Dummy	Yes	Yes	Yes	Yes	Yes
Annual Dummy	Yes	Yes	Yes	Yes	Yes
N	24690	24690	24690	24690	24690

Table V: Country Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. Industry dummies are included in all regressions. The numbers in parentheses are White (1980) adjusted p-values.

	C	Log(Assets)	DY	Debt-Assets	RoA	RDSales	Adj-R^2	N
Canada	2.184254	-0.067126	0.000011	0.002826	-0.013074	0.000213	0.2387	1266
	(0.0000)	(0.0000)	(0.1083)	(0.0741)	(0.0000)	(0.0289)		
Denmark	2.447615	0.091147	-0.004563	-0.029842	-0.001993	0.006578	0.1605	245
	(0.00170	(0.0625)	(0.1543)	(0.0029)	(0.8547)	(0.0002)		
France	2.360729	-0.030691	-0.002461	-0.006751	-0.019779	-0.000335	0.2262	1527
	(0.0000)	(0.0504)	(0.1560)	(0.0008)	(0.0000)	(0.0812)		
Germany	3.356944	-0.080424	-0.029913	-0.009247	-0.004175	0.027552	0.2160	1050
	(0.0000)	(0.0106)	(0.0007)	(0.1135)	(0.1549)	(0.0226)		
Greece	6.744885	-0.404159	-0.090186	0.005264	0.083216	0.093240	0.3089	170
	(0.0000)	(0.0000)	(0.0085)	(0.3123)	(0.0002)	(0.1767)		
Ireland	8.049833	-0.425303	-0.045149	-0.004832	-0.027477	0.051139	0.5251	118
	(0.0001)	(0.0070)	(0.3778)	(0.6826)	(0.0905)	(0.0447)		
Israel	2.442922	0.052242	-0.017246	-0.027214	-0.004359	-0.000150	-0.0203	44
	(0.4001)	(0.8357)	(0.4699)	(0.2860)	(0.7571)	(0.9861)		
Japan	1.115496	0.008129	-0.001013	-0.000949	0.005069	0.057541	0.0588	6590
	(0.0000)	(0.2892)	(0.0037)	(0.2098)	(0.0309)	(0.0000)		
Netherlands	3.074044	-0.119836	-0.006372	0.002301	-0.019247	-0.000933	0.3120	417
	(0.0000)	(0.0221)	(0.0029)	(0.7870)	(0.0005)	(0.8941)		
Sweden	4.164318	-0.091159	-0.015245	-0.016903	-0.018813	-0.000021	0.3770	538
	(0.0000)	(0.0278)	(0.0297)	(0.0000)	(0.0000)	(0.9269)		
Switzerland	2.666084	-0.053663	-0.016739	-0.009590	-0.004189	0.114392	0.1916	448
	(0.0000)	(0.2587)	(0.0162)	(0.0291)	(0.5020)	(0.0025)		
UK	3.009224	-0.102395	-0.057504	0.004385	-0.017141	0.000197	0.2510	2490
	(0.0000)	(0.0000)	(0.0005)	(0.0141)	(0.0000)	(0.1779)		
US	2.535999	-0.011656	-0.012255	-0.000493	-0.018364	0.000011	0.2146	9787
	(0.0000)	(0.3379)	(0.1811)	(0.7827)	(0.0000)	(0.0204)		
Market	2.659395	-0.037719	0.000005	-0.000204	-0.018077	0.000011	0.2156	14498
	(0.0000)	(0.0000)	(0.4504)	(0.8850)	(0.0000)	(0.0131)		
Bank	1.922571	-0.025430	-0.001640	-0.003334	-0.008278	0.000562	0.0841	10192
	(0.0000)	(0.0003)	(0.0047)	(0.0000)	(0.0012)	(0.1862)		
Common	2.623238	-0.033927	0.000006	-0.000058	-0.018092	0.000011	0.2124	13705
	(0.0000)	(0.0004)	(0.3919)	(0.9673)	(0.0000)	(0.0135)		
Civil	2.086149	-0.031135	-0.001721	-0.004248	-0.012925	0.000308	0.1261	10985
	(0.0000)	(0.0000)	(0.0050)	(0.0000)	(0.0000)	(0.3281)		
Market (ex-US)	2.863370	-0.098265	0.000007	0.001823	-0.016947	0.000191	0.2426	4711
	(0.0000)	(0.0000)	(0.2887)	(0.1389)	(0.0000)	(0.0175)		
Common (ex-US)	2.823759	-0.100638	0.000009	0.002577	-0.016675	0.000195	0.2265	3918
	(0.0000)	(0.0000)	(0.1951)	(0.0405)	(0.0000)	(0.0196)		

Table VI: Country Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. High RD is a dummy variable = 1 if the firm's RD-Sales ratio is > 75th percentile for all firms and = 0 otherwise. Low RD is a dummy variable = 1 for firms with Assets-Sales ratios < 25th percentile for all firms and = 0 otherwise. High Asset-Sales is a dummy variable = 1 for firms with Assets-Sales > 75th percentile of all firms and = 0 otherwise. Low Asset-Sales is a dummy variable =1 for firms with Assets-Sales < 25th percentile for all firms and = 0 otherwise. Industry dummies are included in all regressions. The numbers in parentheses are White (1980) adjusted p-values.

	C	Log(Assets)	DY	Debt-Assets	RoA	RDSales	HighRD *HighAsset-Sales	HighRD *LowAsset-Sales	LowRD* *HighAsset-Sales	LowRD *LowAsset-Sales	Adj-R^2	N
Canada	2.178306	-0.074488	0.000009	0.003596	-0.011313	0.000155	0.314253	0.924141	-0.239414	-0.076461	0.2781	1266
	(0.0000)	(0.0000)	(0.1295)	(0.0180)	(0.0000)	(0.1117)	(0.1498)	(0.0000)	(0.0001)	(0.3318)		
Denmark	2.370984	0.074894	-0.004368	-0.028051	-0.001324	0.005215	1.111937	0.073296	0.322244	0.734448	0.1785	245
	(0.0036)	(0.1470)	(0.1785)	(0.0061)	(0.8900)	(0.0027)	(0.2260)	(0.9240)	(0.1974)	(0.0516)		
France	2.425022	-0.028594	-0.002232	-0.007332	-0.020441	-0.000368	-0.269732	0.223755	-0.004065	-0.304442	0.2310	1527
	(0.0000)	(0.0801)	(0.2079)	(0.0003)	(0.0000)	(0.1463)	(0.2248)	(0.5933)	(0.9608)	(0.0019)		
Germany	3.504519	-0.093921	-0.029625	-0.008252	-0.003085	0.018733	0.186026	0.866602	-0.229864	-0.180309	0.2269	1050
	(0.0000)	(0.0029)	(0.0005)	(0.1502)	(0.2885)	(0.0932)	(0.4948)	(0.0724)	(0.0057)	(0.1205)		
Greece	6.950863	-0.383841	-0.080923	0.001790	0.075739	0.158355	-0.657173	-0.635578	-0.369532	-0.632370	0.3256	170
	(0.0000)	(0.0000)	(0.0110)	(0.7259)	(0.0005)	(0.1842)	(0.0088)	(0.3561)	(0.1472)	(0.0117)		
Ireland	7.315305	-0.392817	-0.023091	-0.003407	-0.025396	0.071019	1.160194	-1.072851	0.496072	0.541397	0.5402	118
	(0.0002)	(0.0086)	(0.6534)	(0.8072)	(0.1377)	(0.0026)	(0.3008)	(0.2237)	(0.0984)	(0.3207)		
Israel	1.711923	0.156549	-0.009935	-0.033506	-0.003571	0.001449	-0.583715	-0.460995	-0.663306	-0.809038	-0.1099	44
	(0.6639)	(0.6656)	(0.7102)	(0.2341)	(0.8372)	(0.8986)	(0.3827)	(0.4158)	(0.3844)	(0.2844)		
Japan	1.134455	0.006439	-0.001014	-0.000981	0.004916	0.050438	0.143211	0.208228	0.042328	-0.032955	0.0605	6590
	(0.0000)	(0.4070)	(0.0040)	(0.1921)	(0.0347)	(0.0000)	(0.0471)	(0.0844)	(0.1787)	(0.3689)		
Netherlands	3.164776	-0.128608	-0.006154	0.003046	-0.019044	-0.005913	0.296996	0.577433	-0.161602	-0.099181	0.3092	417
	(0.0000)	(0.0159)	(0.0031)	(0.7224)	(0.0007)	(0.4540)	(0.4859)	(0.2308)	(0.3475)	(0.6758)		
Sweden	4.113939	-0.089038	-0.015305	-0.016658	-0.018749	-0.000034	-0.134860	0.101322	0.006433	0.073829	0.3728	538
	(0.0000)	(0.0461)	(0.0334)	(0.0000)	(0.0000)	(0.8746)	(0.5746)	(0.7794)	(0.9700)	(0.7378)		
Switzerland	2.517672	-0.044875	-0.017241	-0.009469	-0.003666	0.123500	-0.410300	0.008011	0.313210	0.129226	0.1938	448
	(0.0000)	(0.3414)	(0.0053)	(0.0349)	(0.5410)	(0.0006)	(0.0976)	(0.9870)	(0.0562)	(0.5329)		

Cont.	C	Log(Assets)	DY	Debt-Assets	RoA	RDSales	HighRD *HighAsset-Sales	HighRD *LowAsset-Sales	LowRD* *HighAsset-Sales	LowRD *LowAsset-Sales	Adj-R^2	N
UK	3.067332	-0.116170	-0.053584	0.005883	-0.016154	0.000127	0.134637	0.981737	-0.221683	-0.203774	0.2661	2490
	(0.0000)	(0.0000)	(0.0006)	(0.0010)	(0.0000)	(0.2905)	(0.4904)	(0.0001)	(0.0055)	(0.0287)		
US	2.353494	-0.014695	-0.010329	0.001602	-0.015744	0.000008	0.551874	0.964178	-0.407735	-0.227392	0.2454	9787
	(0.0000)	(0.2147)	(0.1651)	(0.3079)	(0.0000)	(0.0708)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Market	2.565179	-0.046219	0.000003	0.001721	-0.015727	0.000008	0.445177	0.968544	-0.312040	-0.163068	0.2424	14498
	(0.0000)	(0.0000)	(0.6830)	(0.1645)	(0.0000)	(0.0525)	(0.0000)	(0.0000)	(0.0000)	(0.0001)		
Bank	2.029346	-0.038773	-0.001621	-0.002726	-0.007573	0.000261	0.408452	0.739777	0.018315	-0.092042	0.0963	10192
	(0.0000)	(0.0000)	(0.0040)	(0.0004)	(0.0034)	(0.4607)	(0.0000)	(0.0000)	(0.5245)	(0.01000		
Common	2.519282	-0.042229	0.000003	0.001904	-0.015624	0.000008	0.487874	0.987695	-0.332564	-0.183536	0.2414	13705
	(0.0000)	(0.0000)	(0.6195)	(0.1241)	(0.0000)	(0.0542)	(0.0000)	(0.0000)	(0.0000)	(0.0000)		
Civil	2.163956	-0.042587	-0.001689	-0.003618	-0.012145	0.000111	0.326977	0.755579	0.025214	-0.068630	0.1363	10985
	(0.0000)	(0.0000)	(0.0044)	(0.0000)	(0.0000)	(0.6671)	(0.0000)	(0.0000)	(0.3716)	(0.0571)		
Market (ex-US)	2.869653	-0.106821	0.000006	0.002978	-0.015847	0.000130	0.148488	0.816839	-0.168534	-0.090867	0.2554	4711
	(0.0000)	(0.0000)	(0.3602	(0.0146)	(0.0000)	(0.0686)	(0.2533)	(0.0000)	(0.0018)	(0.1473)		
Common (ex-US)	2.839062	-0.111000	0.000008	0.003781	-0.015395	0.000134	0.259058	0.894510	-0.184262	-0.109611	0.2436	3918
	(0.0000)	(0.0000)	(0.2444)	(0.0027)	(0.0000)	(0.0737)	(0.0941)	(0.0000)	(0.0019)	(0.1008)		

Table VII: Industry Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. Industry dummies are included in all regressions. The column marked "Low" shows results for those industries with low R&D intensity and the Column marked "High" shows results for high R&D intensity industries. The numbers in parentheses are White (1980) adjusted p-values. Country and Annual dummies included. (Zero and Six do not include all country dummies and Nine has no country dummies).

	Zero	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
C	-1.181049	2.029931	1.826631	2.558863	2.710230	1.791870	2.935609	4.133055	2.483130	-1.372606
	(0.7514)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.2939)
Log(Assets)	0.251598	-0.077187	0.049676	-0.005469	-0.064405	0.008019	-0.120064	-0.098666	-0.009224	0.292943
	(0.4307)	(0.0005)	(0.00050	(0.6373)	(0.0000)	(0.5979)	(0.0000)	(0.0000)	(0.8504)	(0.0296)
DY	-0.362720	-0.000684	-0.015859	-0.004604	-0.000231	-0.001088	-0.001057	0.000008	-0.032702	-0.180705
	(0.3844)	(0.0765)	(0.0649)	(0.2429)	(0.2238)	(0.1555)	(0.0424)	(0.0782)	(0.0000)	(0.3440)
Debt-Assets	0.007131	0.006798	-0.003607	-0.005183	-0.000946	-0.002846	0.000793	-0.000162	-0.001330	-0.005180
	(0.7325)	(0.0000)	(0.0107)	(0.0012)	(0.6645)	(0.1255)	(0.6437)	(0.9091)	(0.7691)	(0.6667)
RoA	0.083149	-0.011454	-0.023860	-0.020843	-0.019969	-0.009899	-0.013308	-0.015145	-0.020320	0.069100
	(0.0613)	(0.1024)	(0.0000)	(0.0000)	(0.0000)	(0.0018)	(0.0000)	(0.0000)	(0.0000)	(0.0316)
RD-Sales	-0.294105	-0.000122	0.000003	0.000083	0.000634	0.004485	0.001734	0.000013	-0.000007	-0.179869
	(0.4829)	(0.0812)	(0.4814)	(0.0462)	(0.1719)	(0.0510)	(0.0001)	(0.0000)	(0.8909)	(0.0524)
Adj-R^2	0.1276	0.3065	0.2700	0.2229	0.2644	0.1015	0.2161	0.1869	0.1955	0.3202
N	92	1786	4144	7366	2078	3644	1451	3267	843	16

Table VIII: Industry and Agency Cost Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. High RD is a dummy variable = 1 if the firm's RD-Sales ratio is > 75th percentile for all firms and = 0 otherwise. Low RD is a dummy variable = 1 for firms with Assets-Sales ratios < 25th percentile for all firms and = 0 otherwise. High Asset-Sales is a dummy variable = 1 for firms with Assets-Sales > 75th percentile of all firms and = 0 otherwise. Low Asset-Sales is a dummy variable =1 for firms with Assets-Sales < 25th percentile for all firms and = 0 otherwise. The numbers in parentheses are White (1980) adjusted p-values. Country and Annual dummies included. (Zero and Six do not include all country dummies).

	Zero	One	Two	Three	Four	Five	Six	Seven	Eight
C	5.272267	2.106102	1.603729	2.521274	2.731303	1.724897	3.438854	4.082257	2.293706
	(0.0003)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.00000	(0.0000)	(0.0001)
Log(Assets)	-0.37104	-0.082688	0.034866	-0.021121	-0.064139	0.007290	-0.102114	-0.100819	-0.029996
	(0.0039)	(0.0003)	(0.0240)	(0.0663)	(0.0001)	(0.6327)	(0.0000)	(0.0000)	(0.5545)
DY	-0.16258	-0.000710	-0.012250	-0.004170	-0.000228	-0.001083	-0.001324	0.000007	-0.026985
	(0.0570)	(0.0706)	(0.0526)	(0.2363)	(0.2313)	(0.1580)	(0.0002)	(0.1466)	(0.0000)
Debt-Assets	0.012958	0.006860	0.000147	-0.003113	-0.000903	-0.002340	0.000361	0.001583	0.002817
	(0.2151)	(0.0000)	(0.9221)	(0.0340)	(0.6762)	(0.2209)	(0.8332)	(0.2553)	(0.5506)
RoA	0.030342	-0.011298	-0.019291	-0.018096	-0.020056	-0.008978	-0.012905	-0.013773	-0.016161
	(0.3103)	(0.1084)	(0.0000)	(0.0000)	(0.0000)	(0.0074)	(0.0000)	(0.0000)	(0.0003)
RD-Sales	0.081409	-0.000144	0.000000	0.000067	0.000663	0.003915	0.001167	0.000012	-0.000032
	(0.4659)	(0.0345)	(0.9698)	(0.0651)	(0.1732)	(0.0876)	(0.0245)	(0.0000)	(0.4586)
HighRD*HighAsset-Sales	0.103139	0.090859	0.549017	0.494272	-0.282578	0.600925	0.400119	0.249753	1.399128
	(0.8447)	(0.4490)	(0.0002)	(0.0000)	(0.3641)	(0.0369)	(0.5612)	(0.1851)	(0.0227)
HighRD*LowAsset-Sales	0.086236	0.088946	1.184614	0.909631	0.018783	0.922241	-0.276137	0.670066	1.450261
	(0.9368)	(0.2798)	(0.0000)	(0.0000)	(0.9425)	(0.0963)	(0.6188)	(0.0001)	(0.0000)
LowRD*HighAsset-Sales	-0.09503	-0.162970	-0.233568	-0.287350	-0.050657	0.025307	-0.430046	-0.449575	-0.017901
	(0.7404)	(0.0026)	(0.0000)	(0.0000)	(0.5748)	(0.6033)	(0.0283)	(0.0000)	(0.9124)
LowRD*LowAsset-Sales	-0.24935	-0.003146	0.049545	-0.124317	-0.037870	0.127624	-0.833344	-0.547403	0.143177
	(0.4707)	(0.9600)	(0.4956)	(0.0366)	(0.6182)	(0.0687)	(0.0000)	(0.0000)	(0.5113)
Adj-R^2	0.1909	0.3097	0.3127	0.2486	0.2636	0.1076	0.2670	0.2065	0.2341
N	92	1786	4144	7366	2078	3644	1451	3267	843

Table IV: High and Low R&D Industry Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. Country dummies are included in first two regressions. The column marked "Low" shows results for those industries with low R&D intensity and the Column marked "High" shows results for high R&D intensity industries. Market indicates market – based economies, Bank indicates Bank – based economies, Common indicates Common law economies and Civil indicates Civil Law economies. The numbers in parentheses are White (1980) adjusted p-values.

			Market		Bank		Common		Civil	
	Low	High	Low	High	Low	High	Low	High	Low	High
C	2.539768	3.063400	2.521434	3.063356	2.047673	2.556964	2.515434	2.937274	2.030830	2.999959
	(0.0000)	(0.00000	(0.0000)	(0.00000	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log(Assets)	-0.041836	-0.040654	-0.047165	-0.047428	-0.051638	-0.052301	-0.047198	-0.037241	-0.026588	-0.083343
	(0.0000)	(0.0009)	(0.0001)	(0.0029)	(0.0000)	(0.0008)	(0.0002)	(0.0242)	(0.0001)	(0.0000)
DY	-0.000816	0.000016	-0.000795	0.000007	-0.001251	-0.015483	-0.000729	0.000007	-0.001358	-0.015797
	(0.0702)	(0.0003)	(0.1276)	(0.2343)	(0.0017)	(0.0507)	(0.1225)	(0.2349)	(0.0030)	(0.0201)
Debt-Assets	-0.001674	-0.001156	-0.000816	-0.000116	-0.001429	-0.003541	-0.000559	-0.000176	-0.004873	-0.002982
	(0.3919)	(0.3048)	(0.7133)	(0.9258)	(0.0936)	(0.0417)	(0.7995)	(0.8884)	(0.0000)	(0.1158)
RoA	-0.017943	-0.017760	-0.018982	-0.017872	0.000002	-0.015178	-0.018744	-0.018044	-0.010722	-0.016620
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.9993)	(0.0001)	(0.0000)	(0.0000)	(0.0004)	(0.0000)
RD-Sales	0.000103	0.000010	0.000101	0.000010	0.080421	0.000369	0.000102	0.000010	0.000262	0.000371
	(0.0404)	(0.0341)	(0.0387)	(0.0270)	(0.0000)	(0.2563)	(0.0405)	(0.0265)	(0.5234)	(0.2676)
Adj-R^2	0.1846	0.2144	0.1868	0.1814	0.0617	0.0763	0.1813	0.1819	0.0416	0.1100
N	16436	8254	9235	5262	7198	2992	8754	4950	7679	3304

Table X: R&D and Agency cost Industry Regressions. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. Country dummies are included in first two regressions. The column marked "Low" shows results for those industries with low R&D intensity and the Column marked "High" shows results for high R&D intensity industries. Market indicates market–based economies, Bank indicates Bank–based economies, Common indicates Common law economies and Civil indicates Civil Law economies. The numbers in parentheses are White (1980) adjusted p-values.

			Market		Bank		Common		Civil	
	Low	High	Low	High	Low	High	Low	High	Low	High
C	2.519449	2.971091	2.497631	2.967508	2.044830	2.615739	2.467096	2.854751	2.100562	3.009326
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Log(Assets)	-0.046782	-0.054850	-0.045922	-0.058568	-0.054087	-0.063889	-0.043932	-0.050268	-0.038772	-0.091328
	(0.0000)	(0.0000)	(0.0001)	(0.0002)	(0.0000)	(0.0001)	(0.0002)	(0.0024)	(0.0000)	(0.0000)
DY	-0.000724	0.000014	-0.000609	0.000004	-0.001239	-0.015010	-0.000542	0.000004	-0.001329	-0.015186
	(0.0808)	(0.0005)	(0.1473)	(0.4290)	(0.0021)	(0.0508)	(0.1458)	(0.4500)	(0.0031)	(0.0203)
Debt-Assets	-0.000382	0.001321	0.000815	0.002914	-0.001340	-0.002863	0.001126	0.002951	-0.004129	-0.002402
	(0.8342)	(0.2333)	(0.6818)	(0.0182)	(0.1198)	(0.0839)	(0.5649)	(0.0181)	(0.0000)	(0.1918)
RoA	-0.016137	-0.015300	-0.016967	-0.015049	0.000049	-0.014403	-0.016615	-0.015017	-0.009711	-0.015958
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.9854)	(0.0002)	(0.0000)	(0.0000)	(0.0016)	(0.0000)
RD-Sales	0.000081	0.000007	0.000079	0.000007	0.074820	0.000145	0.000080	0.000007	0.000091	0.000105
	(0.0492)	(0.1300)	(0.0480)	(0.1274)	(0.0000)	(0.6280)	(0.0506)	(0.1250)	(0.7966)	(0.7196)
HighRD*HighAsset-Sales	0.444636	0.524057	0.382968	0.501957	0.237621	0.284240	0.435787	0.532829	0.334708	0.260196
	(0.0000)	(0.0000)	(0.0006)	(0.0006)	(0.0472)	(0.0198)	(0.0002)	(0.0004)	(0.0002)	(0.0356)
HighRD*LowAsset-Sales	0.786812	1.030307	0.758703	1.113753	0.302857	0.718225	0.785627	1.126949	0.830453	0.767383
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0390)	(0.0004)	(0.0000)	(0.0000)	(0.0000)	(0.0001)
LowRD*HighAsset-Sales	-0.172538	-0.286241	-0.335300	-0.427335	0.074693	0.098504	-0.348002	-0.472095	0.045221	0.113586
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0150)	(0.1361)	(0.0000)	(0.0000)	(0.1250)	(0.0827)
LowRD*LowAsset-Sales	-0.190302	-0.125851	-0.316762	-0.173584	0.050292	-0.051429	-0.341125	-0.194442	0.023857	-0.017955
	(0.0000)	(0.0286)	(0.0000)	(0.0361)	(0.1486)	(0.4636)	(0.0000)	(0.0226)	(0.4863)	(0.8065)
Adj-R^2	0.2058	0.2410	0.2153	0.2168	0.0640	0.0856	0.2128	0.2203	0.0540	0.1183
N	16436	8254	9235	5262	7198	2992	8754	4950	7679	3304

Table XI: Segmented Summary Statistics. Data are segmented by extent of R&D intensity and also by Agency costs. The final panel shows t-statistics.

	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
Mean	210.04	55.92	6.97	1.76	88.47	-3.58	12.39
Median	96.53	55.52	0.30	1.17	0.00	3.04	12.22
Std. Dev.	3581.92	33.63	626.56	1.74	4352.31	35.75	1.99
SE	22.7958	0.2140	3.9875	0.0111	27.6987	0.2275	0.0127
N	24690	24690	24690	24690	24690	24690	24690
			HighRD*HighAsset-Sales				
	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
Mean	861.15	61.26	0.79	2.64	145.07	-21.17	11.93
Median	188.17	51.70	0.00	1.67	6.37	0.50	11.70
Std. Dev.	6321.05	61.97	2.26	2.48	1042.17	62.75	2.47
SE	198.6024	1.95	0.0710	0.0779	32.7442	1.9716	0.0776
N	1013	1013	1013	1013	1013	1013	1013
			HighRD*LowAsset-Sales				
	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
Mean	31.15	36.63	0.31	3.32	1161.29	-31.76	12.06
Median	33.79	26.29	0.00	2.37	24.75	-12.76	11.87
Std. Dev.	18.14	36.67	1.32	2.83	16403.38	63.16	2.16
SE	0.4365	0.8823	0.0318	0.0681	394.7182	1.5198	0.0520
N	1727	1727	1727	1727	1727	1727	1727
			LowRD*HighAsset-Sales				
	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
Mean	562.78	61.00	2.09	1.49	0.00	0.68	12.24
Median	201.89	60.26	0.49	1.11	0.00	3.96	12.12
Std. Dev.	7323.22	31.40	9.75	1.28	0.00	29.99	1.89
SE	102.2752	0.4385	0.1362	0.0179	0.0000	0.4188	0.0264
N	5127	5127	5127	5127	5127	5127	5127
			LowRD*LowAsset-Sales				
	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
Mean	33.54	56.24	3.47	1.58	0.00	-3.06	12.54
Median	36.04	56.61	0.33	1.11	0.00	2.72	12.41
Std. Dev.	17.24	39.75	52.42	1.56	0.00	31.99	2.10
SE	0.2624	0.6051	0.7978	0.0237	0.0000	0.4869	0.0320
N	4317	4317	4317	4317	4317	4317	4317
	Asset-Sales	Debt-Assets	DY	Q	RD-Sales	RoA	Log(Asset)
HighRD*HighAgency	-2.9409	-2.4686	1.5227	-9.8876	-0.9364	7.9987	5.0941
HighRD*LowAgency	7.7001	17.5918	1.6570	-19.6970	-2.5397	16.1277	5.1005
LowRD*HighAgency	-2.8203	-7.7855	1.1834	9.3103	3.1940	-6.5914	3.8363
LowRD*LowAgency	7.6545	-0.3955	0.7314	5.1724	3.1940	-0.7279	-3.3557

Table XII: Break down of High R&D High Agency Cost Firms. The number of such firm years by economy, Legal Family, Financial Structure and Industry.

	Firm Years	% RD Year	%Total Years
Canada	59	19.16	4.61
Denmark	8	18.60	3.21
France	14	10.07	0.91
Germany	28	12.50	2.64
Greece	5	10.20	2.92
Ireland	0	0.00	0.00
Israel	3	10.00	6.82
Japan	143	12.75	2.16
Netherlands	7	12.73	1.67
Sweden	28	20.29	5.11
Switzerland	16	10.53	3.56
UK	102	16.06	4.04
US	595	15.74	5.93
Market	791	16.09	5.34
Bank	222	12.42	2.17
Common	764	15.98	5.45
Civil	249	12.96	2.25
Market (ex-US)	196	17.25	4.11
Common (ex-US)	169	16.88	4.26
Industry0	7	29.17	7.53
Industry1	63	19.81	3.51
Industry2	202	15.26	4.82
Industry3	430	13.87	5.76
Industry4	35	15.77	1.67
Industry5	52	24.88	1.42
Industry6	9	19.57	0.61
Industry7	188	14.71	5.51
Industry8	27	15.08	3.18
Industry9	0	0.00	0.00

Table XIII: R&D and Agency Cost Regressions. Data are segmented by whether firms have high R&D and High or Low Agency Costs.. Dependant variable is Tobin Q. Independent variables are Log(Assets), the Dividend-Yield (%) (DY), the book value of total debt to book value of assets (%) (Debt-Assets), the Return on Assets (%), R&D to Sales (%) and Asset-Sales. Industry dummies are included in all regressions. High RD is a dummy variable = 1 if the firm's RD-Sales ratio is > 75th percentile for all firms and = 0 otherwise. High Agency is a dummy variable = 1 for firms with Assets-Sales > 75th percentile of all firms and = 0 otherwise. Low Agency is a dummy variable =1 for firms with Assets-Sales < 25th percentile for all firms and = 0 otherwise. The numbers in parentheses are White (1980) adjusted p-values. Country and Annual dummies included.

	HighRD*HighAsset-Sales	HighRD*LowAsset-Sales
C	4.382050	4.756862
	(0.0000)	(0.0000)
Log(Assets)	-0.156364	-0.114940
	(0.0000)	(0.0008)
DY	-0.075911	-0.133238
	(0.0023)	(0.0000)
Debt-Assets	0.005022	0.001914
	(0.0004)	(0.4290)
RoA	-0.011868	-0.015443
	(0.0000)	(0.0000)
RD-Sales	0.000214	0.000007
	(0.0983)	(0.1268)
Adj-R^2	0.2957	0.2214
N	1013	1727

APPENDIX 1: SIC Codes and Groupings.

Industry 0 Agriculture, Forestry, and Fisheries
Industry 1 Mineral Industries
Industry 2 Primary, Chemical and Petroleum Industries
Industry 3 Manufacturing and Equipment
Industry 4 Transportation, Communications, and Utilities
Industry 5 Wholesale and Retail Trade
Industry 6 Finance, Insurance, and Real Estate
Industry 7 Personal and Business Services
Industry 8 Service (Other) Industries
Industry 9 Public Administration

APPENDIX 2: Market – Based and Common Law Classifications

Common Law is an indicator of whether the economy has a common law legal system (or a civil law system) both taken from La Porta et al. (1997). Market-Based is an indicator of whether the economy has a market based or bank based financial structure taken from Demirguc-Kunt and Maksimovic (2002).

	Financial Structure	Legal System
Canada	Market	Common
Denmark	Bank	Civil
France	Bank	Civil
Germany	Bank	Civil
Greece	Bank	Civil
Ireland	Bank	Common
Israel	Bank	Common
Japan	Bank	Civil
Netherlands	Market	Civil
Sweden	Market	Civil
Switzerland	Bank	Civil
UK	Market	Common
US	Market	Common

[1] These mechanisms include, but are not limited to, requiring managers and directors to hold stock in the firm, dividend policy and debt policy.

[2] We have also estimated equation (1) with debt-equity ratios, using the market value of equity. Results are qualitatively similar and tables are available on request.

[3] The database is described in documentation found at www.bvdep.com.

[4] These economies were chosen on the basis that Osiris contained a reasonable number of firms with R&D expenditure. This, of course, introduces some sample bias into the analysis. All international comparison studies suffer from this bias.

[5] See for example Ali and Hwang (2000) who find accounting value relevance to be higher in market – based economies. Similarly, Francis, Khurana and Pereira (2001) report that civil law economies have less timely and transparent accounting than do common law economies. All these differences we believe will be captured by dummy variables in the pooled regressions and/or will be captured when we pool the data into market – based or common law economies and so on. Our data source, described above, also minimizes the differences that might otherwise be expected.

[6] The figure as it stands may strike readers as being excessive. In order to evaluate the veracity of the 211.66 percent figure we examined the firms that generated the largest R&D observations. Many of the firms could plausibly be expected to have high R&D expenditure and many were listed on the NASDAQ. This gives us greater confidence in the very high level of R&D for the US.

[7] We took a radical approach to the identification of outliers. After estimating equation (1) we calculated the absolute value of the Studentized residuals. There were 160 Studentized residuals greater than two. When we examined the absolute value of the residuals themselves there were 364 observations with a value greater than 10. We

eliminated these 364 observations from the sample. If anything, we have over compensated for outliers in the analysis. Given our large sample size, however, we do not believe this approach would bias the results.

[8] Country level versions of column one are shown in table V and industry versions in table VII.

[9] The 75th percentile for R&D to Sales is fairly low as most firms in our sample either do not report R&D or do not undertake R&D. The median for high R&D firms is 7.5 percent while the median for the firms in the 25th percentile is zero.

[10] The country level version of this equation is shown in table VI, while the industry version is shown in table VIII.

[11] We will present evidence in section four indicating that debt operates as a constraint on agency costs for these firms.

[12] Industry 8 (Service (Other) Industries) in particular has a high HighRD*LowAsset-Sales coefficient. The standard error for that coefficient is 0.3313 giving a t–statistic of 1.3588 for hypothesis that the coefficient is not equal to unity.

[13] Readers should note that the high and low R&D intensity industries do not coincide with the high-tech and low-tech dichotomy that Chan et al. (1990) employ.