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Corporate research & development investments International comparisons

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Abstract

This paper explores the determinants of corporate R&D for U.S., Canadian, British, European, and Japanese firms. We find last year's debt ratio is significantly negatively correlated with current R&D expenditures for U.S. firms, and positively for Japanese firms. Second, we document a significant positive relation between two-year lagged stock return and current R&D expenditures for U.S., European, Japanese, and large-size British firms. Finally, we find a significant positive relation between last year's tax payments and current R&D expenditures for Japanese firms, and a significant negative relation for medium-size and small-size U.S. firms.

Key words: Capital markets; R&D; Taxes; International comparisons

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1. Introduction

This paper empirically explores the determinants of corporate research and development (R&D) expenditures in five OECD regions: the United States,

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Canada, Great Britain, other European countries (Germany, France, Netherlands), and Japan. Studying corporate R&D investment is relevant for several, though not mutually exclusive, reasons. First, there is a long tradition in the economic growth and business cycle literature that gives a central role to inventive activity (Schumpeter, 1939; Kuznets, 1966). Because corporate R&D expenditure is a central component of inventive activity, its study could help us understand the determinants of economic growth and business cycles. Second, private R&D activity is commonly regarded as having significant positive public externalities (Griliches, 1991; Benhabib and Jovanovic, 1991; Romer, 1990), suggesting that R&D expenditures are typically too low from an economy-wide perspective. Third, both the press and influential policy-makers often argue publicly that the United States is losing its technological competitive edge due to under-investment in R&D. Myopic capital markets and/or myopic managers are among the frequently cited causes for this R&D deficit (Hall, 1990).

In this study we analyze 6,549 firm-years of R&D data for U.S., Canadian, British, European, and Japanese firms for the period 1985–1990. Specifically, we investigate in cross-section if a firm's stock returns, operating cash flows, debt structure, and the tax environment influence future R&D expenditure innovations, and contrast these effects across these countries. We find that while debt ratios tend to be negatively correlated with R&D expenditure innovations in the U.S., they are positive predictors of innovations in R&D expenditures in Japan. We interpret this as evidence that U.S. firms either have more of a need to 'safeguard' their R&D expenditures from possible financial distress by not assuming large amounts of debt, or alternatively that U.S. lenders are less willing to finance R&D projects. Stock returns, mostly with a two-year lag, positively predict R&D expenditures in all countries save Canada in a variety of specifications. Yet, the relationship was most consistently positive for European and perhaps Japanese firms. This is not consistent with the popular notion that U.S. managers reduce R&D more than their European and Japanese counterparts when their stock price decreases. Operating cash flow is not a strong predictor of future R&D innovations in any country. This rejects the notion that R&D occurs mostly when firms have more operating cash flow on hand, and thus can avoid the costs of external capital markets. Finally, we find that the income tax coefficients are mostly negative in the U.S., but positive in Japan. This suggests that in contrast to the U.S. tax code, the Japanese tax code manages to encourage R&D.

The remainder of the paper is organized as follows. The next section describes theories of corporate investment and justifies our choice of variables in predicting R&D. Section 3 characterizes our sample and the data. Section 4 presents and discusses our empirical findings, and Section 5 summarizes our results.

2. Theories of corporate investment, and variable selection

2.1. The Q theory

Research and development can be considered a component of the corporate investment strategy, more risky than capital expenditures. The Q theory, as in, for example, Tobin (1969), Poterba and Summers (1983), and Hayashi (1985), is the foremost theory used to explain cross-sectional investment behavior.[1] The intuition behind the Q theory is that a company should invest when the marginal benefit of investing exceeds the marginal cost. Variables commonly suggested to influence (or correlate with) the costs of investing are the cost of equity capital (stock price), access to other external capital sources (debt), access to internal capital sources (operating cash flow), corporate taxes and their influence on intertemporal payouts, and the price of investment goods themselves. Variables influencing the benefits of investing are future market opportunities, again measured by such items as the firm's stock return and tax tradeoffs. Q itself is a summary measure defined as the difference between the total firm-value per unit of capital and the price of investment goods. Empirically, because the price of investment goods is difficult to measure, and because the value of debt for most firms changes only slowly, stock returns are the best measure of variation in Q. Our study follows the general implications of the Q theory, in that we hypothesize the following variables to be important predictors of R&D activity:

Stock returns

A firm's past stock returns might correlate with future R&D expenditures for at least three reasons. First, Lach and Schankerman (1989) argue both theoretically and empirically that positive stock returns signal that the firm has strong growth opportunities. An increase in R&D might help take advantage of growth opportunities. Second, Barro (1990) points out that stock returns, perhaps because they are the most variable component of Q, are better predictors of

[1] Another popular investment model is the accelerator model. Traditional accelerator models posit a relation between corporate demand for capital goods and the level or change in a firm's output or sales. Neoclassical accelerator models assume Cobb–Douglas production functions, and posit that a firm's desired capital stock is proportional to the ratio of sales to the tax-adjusted relative price of capital; see Jorgenson (1971). This theory has also considerably influenced the investment literature. However, a literal implementation of this model in the context of our paper raises some concerns. For example, sales and operating cash flow are likely to be highly correlated; and we use cash flow as a determinant of R&D for reasons discussed below. Second, unless we have data covering a few business cycles, variation in the price of credit would not be sufficient for this variable to be a significant determinant, empirically, of R&D. Our sample period covers 1985–1990; during this period we doubt there was significant variation in the price of credit.

investment than empirical proxies of Q. Third, higher equity prices directly lower the cost of equity capital.[2]

Debt ratio

Myers (1977) has noted that R&D activity is an intangible and often firm-specific asset, producing future growth opportunities. When there are costs of financial distress, firm-specific assets quickly lose value and cannot be easily used to satisfy debtor claims. Thus, when firms face possible financial distress, it is suboptimal for firms that are involved in R&D activities to also carry a high debt ratio, because such debt would carry prohibitive costs and/or covenants; see Smith and Warner (1979).

Operating cash flow

Leland and Pyle (1977) have argued that when investors find it difficult to evaluate the quality of a project, they are likely to treat low-risk, short-term projects more favorably than high-risk, long-term projects. Furthermore, Bhattacharya and Ritter (1983) suggest that for competitive and strategic reasons, firms may not be willing to share their R&D plans or progress with outsiders. Therefore, any signal about the future payoffs of R&D that the firm can send is unlikely to be very informative.

Myers and Majluf (1984) have argued that when investors cannot distinguish between high-quality and low-quality future opportunities, managers with good information are more likely to finance projects internally, less likely to raise outside debt, and least likely to raise outside equity. The resulting adverse selection raises the cost of external equity compared with internal finance. Stiglitz and Weiss (1981) show that a similar lemons problem in the debt market may rationally lead to credit rationing. Thus, given these asymmetric information considerations, internally generated operating cash flow is the most likely source of R&D capital.[3]

Mayer (1990) compares the sources of corporate financing for Canada, Finland, France, Germany, Italy, Japan, UK, and USA, for the period 1970–1985. He considers industry-aggregate data of the nonfinancial sector

[2]There are, however, limits to the role of equity as a source of funds when there are capital market imperfections. In particular, when firms face financial distress costs (Myers, 1977), when managers possess inside information (Myers and Majluf, 1984; Leland and Pyle, 1977), or when the market does not rationally value R&D projects (Morck, Shleifer, and Vishny, 1990), firms might eschew raising equity capital to fund even worthy projects. Mayer (1990) and Mackie-Mason (1990), among others, document that firms rarely use equity or debt as sources of financing; retained earnings are the dominant source of financing.

[3]Jacobson and Aaker (1993) argue that the extent of information asymmetry might be different in the U.S., Japan, and perhaps Germany. This suggests a reason for intercountry differences in the effect of internally generated cash flow on R&D.

from the OECD Financial Statistics.[4] He finds that capital markets are not significant net contributors of corporate capital in any of these countries. Retentions from earnings are the dominant source of financing for these countries. Among external sources, banks are the primary source followed by the bond markets. Equity is a small, and often a negligible, source. Fazzari, Hubbard, and Petersen (1990) and Whited (1992) provide empirical evidence that a firm's internally generated operating cash flow has a significant effect on corporate capital expenditures. To the extent that capital investments and R&D expenditures have similar determinants, operating cash flow would correlate positively with future R&D.

Taxes

Unlike stock return, debt ratio, and operating cash flow, the role of taxes is more complex. Clearly, a firm's tax environment will also influence its investment decisions including R&D investments. In the countries in our sample, firms typically expense R&D in the year they are incurred, and tax credits are available to offset R&D expenditures (Hall, 1992). Because the value of R&D-related tax subsidies increases with a firm's marginal tax rate, we expect a positive relation between a firm's tax rate and R&D expenditures. However, higher corporate tax rates in the future (correlated with current tax rates) may provide a disincentive to invest. Different countries have tried to use tax incentives to foster private R&D to varying degrees. The most complicated and activist tax treatment of R&D is in Japan. If R&D expenses exceed the largest R&D expense since 1966, 20 percent of the excess may be credited against the corporate tax, up to 10 percent thereof; see Wright (1987–1992).[5] In contrast, other countries either directly subsidize R&D activities with government grants (because grants are equally likely to be captured by firms with low income taxes, grants should not influence the tax coefficient) or tend not to emphasize R&D expenses over other investment activities.[6] Hence,

[4]In contrast to Mayer (1990), we focus primarily on firm-level R&D expenditures, not on aggregated capital structure. The advantage of using industry-aggregate data is the coverage of companies is comprehensive. The advantage of using firm-level data is the more detailed coverage flowing into the statistical estimation, as well as data quality and internal consistency. Of course, as noted below, for some countries, the coverage of companies using firm-level data is rather limited.

[5]Wright (1985) mentions that, in addition, if so designated by MITI, high-technology facilities can credit against tax the lower of (1) 20 percent of the increment in R&D expenses plus 7 percent of acquisitions costs, or (2) 15 percent of corporate taxes.

[6]The U.S. and Canada tax codes did try to influence R&D activities. Having repealed its investment tax credit in 1985, the U.S. allowed firms to deduct R&D expenses currently or ratably over five years beginning with the year in which benefits are first realized. An additional credit was applicable for certain incremental research expenditures for activities conducted in the U.S. In Canada, a corporation was allowed to deduct an allowance of 50 percent of the excess of its current and capital research expenditures in Canada over its average research expenditures for the previous three-year period from 1981 to 1988. The U.K., France, and Germany offer no or few systematic special R&D incentives; offering incentives mostly by the firm's region rather than by its activities.

Japanese firms with high taxes are more likely to increase their R&D expenditure compared to firms with high taxes in other countries.

Although our variable selection closely follows the Q literature, we do not theoretically derive and econometrically estimate a specific Q model. Our preference is to use Q theory as a guide in selecting variables, instead of using a Q model's functional relations literally.[7] Instead, we use *prediction* of future R&D innovations as our criterion, allowing reasonable hypotheses to be investigated even without a formal model.[8]

2.2. Limitations in comparing international data

Before we introduce our variable definitions, it is important to describe national differences in the economic meaning of the accounting data used in this study. Accounting systems can be broadly classified into those that have developed from the Anglo–British tradition, specifically the U.S., Canada, and U.K., and those that have developed from the (more heterogeneous) Franco–European tradition, which also includes Japan (see Choi and Mueller, 1984).

[7]First, we are not comfortable estimating a nonlinear relation derived from some assumed production function. Second, we can measure the market value of the equity accurately, but not the market value of the firm. Third, as documented by Barro (1990) in aggregate data, stock returns (probably the most variable component of Q) can better predict investment than various empirical definitions of Q. Fourth, our intention is to predict one component of investment, not total investment. Fifth, theory requires that we use marginal Q whereas, empirically, we can only measure average Q (Hayashi, 1982).

[8]Below, we discuss two additional variables that are likely to influence R&D expenditures. However, due to data limitations we are unable to include these variables in our empirical analysis.

Managerial incentives: If managers are compensated only through salary, their incentives are similar to that of bondholders, that is, favor low-risk, short-term projects over high-risk, long-term projects such as R&D. However, equity-sensitive claims and long-term compensation contracts can help align manager incentives with that of shareholders. Bizjak, Brickley, and Coles (1993) provide evidence consistent with this argument for a sample of 430 U.S. firms. Also, monitoring by blockholders, and the discipline imposed by the managerial labor market and the corporate control market will align management incentives. Hence, management compensation contracts and firm ownership contracts have the potential to influence R&D expenditures.

Industry membership and market structure: A firm's economic R&D opportunities are a function of its line of business and 'market conditions'. For example, today computer software companies and medical drug companies are likely to encounter many more economically viable R&D opportunities than, say, tobacco companies or companies that manufacture missiles and nuclear arms. For tobacco companies, market conditions refer to the social stigma attached to smoking. For missile and nuclear arms manufacturers, the market conditions refer to the international political environment that makes use of such weapons unlikely. Market conditions can also refer to the organization of a particular industry; firms in intense competition with each other are more likely to innovate (Katz and Ordover, 1990).

The former is based more on a 'micro-approach' that emphasizes the firm's need to report numbers to its owners. The latter is based more on a desire to report uniform, comparable numbers within a country. Although recent efforts have made progress in converging accounting rules in OECD countries, a reader of any international comparative research must be aware of a number of problems. We shall discuss potential pitfalls from the perspective of an American reader. Because the British and Canadian accounting philosophies and systems are very similar to the U.S. system, we shall make a special effort to outline relevant differences of European and Japanese data.

2.2.1. Accounting incentives

There are at least two important accounting incentives that are different in other countries. First, different countries impose different degrees of legal liability. Second, differences in tax systems and tax rules can change accounting incentives. Specifically, European and Japanese firms have more incentives to present only one set of accounting figures instead of one for financial reporting purposes and one for tax purposes. French firms have no choice. Germany has a long set of regulations governing proper rules of book-keeping, supplemented by the *Stock Corporation Rule of 1965* that governs basic accounting principles. If a company does not keep in accord with these principles, the tax accounting regulators can reject the accounting records and assess taxable income themselves. Thus, to avoid the costs and risks of keeping two sets of accounting statements, German companies tend to rigidly follow inflexible and conservative tax requirements in their internal accounting systems. However, not all European countries' companies unify tax accounting and financial accounting. The Dutch separate the two, with linkage only through tax allocation procedures. The large Japanese firms in our sample are subject to the Ministry of Finance *Securities and Exchange Law*, established by the *Business Accounting Deliberating Council*, and published as a 'code'. As in Germany, companies adhere to tax accounting, but they do so because companies are forced to use similar methods in both their financial and tax statements. For example, companies cannot take allowances under accelerated depreciation in their tax statement and under straight-line depreciation in their financial statement. In contrast, U.S., Canadian, and British firms can present separate public financial and private tax statements. Consequently, published financial statements are less likely to underestimate performance.[9]

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[9]Because such accounting involves intertemporal allocations, over time many of these differences wash out.

2.2.2. *Accounting methodologies*

Although the U.S. has more detailed accounting regulations and disclosed items than the rest of the world together, the remaining discretion is enough to have allowed accounting researchers to produce an empirical comparative literature. There is considerably more heterogeneity across sample countries. For example, France is the only country in which firms fail to make provisions for uncollectible accounts. Germany is the only country in which firms do not routinely consolidate both domestic and foreign subsidiaries. German firms compute net income by excluding profit (loss) carry-forward from prior periods and transferring it to various equity reserves. The Dutch have historically been leading in using replacement (market-value) based valuation concepts. In Japan, book-value adjustments are uncommon, whereas in Germany they are banned by law. And the U.S. is unusual in that LIFO is very common, in that interest and foreign exchange translation are pooled, and in that financial leases and measurable pension obligations are now comprehensively capitalized.

By ignoring firm-specific heterogeneity, we are assuming that other firm-specific factors (such as their accounting choices) are not correlated with the phenomenon under investigation. Despite the differences listed above, one can argue that, even in our international study, one can tolerate the differences in accounting procedures. First, basic accounting principles and intents are similar in all OECD countries considered. Consequently, differences produced by accounting variations among the rather basic set of variables and (OECD) countries considered in this study are unlikely to be a first-order effect. (We have deliberately excluded countries that are not typically expensing R&D.) Second, the Global Vantage data base is unique in that it is collected according to *standardized* definitions researched and written jointly by S&P's Compustat Services, Inc. and Extel Financial Ltd. to ensure consistency across different industries and among different countries. Data is not presented *as reported* when known differences in definition exist, nor is it made comparable on an international basis by adjusting for differences in accounting principles among different countries. Third, we do not mix countries in our regressions, allowing the reader to consider each country evidence on its own. (The exception is Europe, where we mix France, Germany, and the Netherlands, simply because we do not have enough observations in any single country on the continent.) To the extent that accounting differences remain, it is unclear *ex ante* whether the U.S. figures are closer to or further from the underlying economic principles they purport to measure than figures produced in other countries. Fourth, to the extent that national philosophies or other factors shift *all* firms in one direction, our cross-sectional tests are not affected. And to the extent that we typically control for lagged variables, our regressions are not sensitive even to those variations in firm-specific levels permissible in some but not in other countries, as long as different accounting practices result in firm-specific adjustments that remain constant during our sample period.

2.2.3. Data reporting requirements

The U.S. offers perhaps the most detailed regulations as to the information that must be disclosed. Other countries impose disclosure regulation by industry, or allow firms to omit reporting certain items. In our sample, R&D spending itself is most subject to limited availability. Towards the end of our sample period, in Canada, France, and Germany about 20 percent of firms reported R&D, in Japan and Great Britain about 30–40 percent, and in the U.S. about 50 percent (prior to 1990). Unfortunately, the consequent economic effects of nonreporting are less obvious. In our study, we clearly have self-selected (voluntary reporting) or standards-selected (industry- or size-based requirements) firms, a limitation a reader must be aware of.

2.2.4. Industrial organization

Countries differ in their industrial organization. For example, Japanese companies are linked more closely than U.S. companies and thus may have different incentives to smooth earnings. Further, about three quarters of Japan's sample firms are in the manufacturing sector, while only one third of Canada's sample are in the manufacturing sector. Finally, the U.S. has many more large publicly listed firms than other countries. A filter to limit the minimum acceptable size of U.S. companies has the effect of reducing the number of U.S. firms to cover an equivalent percentage of the most important firms in all countries (thus making the U.S. sample more comparable to other countries) but increasing the average U.S. firm size (thus making the U.S. sample less comparable to other countries). Section 4.3 investigates the effects of such a filter.

3. The data

3.1. The Global Vantage tape

In 1982 COMPUSTAT assembled a comprehensive list of all firms in the *Morgan Stanley Capital International Index and Prospective* and the *Financial Times World Index* to track its *Global Vantage Tapes,* further supplemented with firms that were firmly represented in their respective local market indices. The countries for which COMPUSTAT supplemented its data set were Austria, France, Italy, New Zealand, Sweden, Canada, Hong Kong, Malaysia, South Africa, Switzerland, Finland, Ireland, Netherlands, Spain, and Germany. Firms that disappeared after 1982, for example, through acquisition or bankruptcy, are kept on the tapes to eliminate survivorship bias.

3.2. The variables

Our focus is on the cross-sectional determinants of R&D. We consider the following variables:[10]

Research and development expense (Global Vantage data item 52 on the I/C tape): This supplementary Income Statement item represents all costs incurred relating to development of new products and services. It specifically includes (amortized) software costs and software expenses. To the best of our knowledge, in our sample countries, firms overwhelmingly expense (rather than capitalize) R&D in all sample countries.[11]

Debt (Data items #94 + #106 + #109): The sum of debt in current liabilities, long-term debt, and other liabilities.[12]

Stock returns (Computed from the Issue Tape): Returns (incl. dividends) are computed over the fiscal year of the company. This involves a fairly complex procedure using the *Global Vantage Issue Tape.*

Operating cash flow (Data items #32 + #11): We measure operating cash flow as the sum of net income plus depreciation. Net income is the sum of income before income taxes and appropriations (IBIA) plus net items, minus appropriations to untaxed reserves, income taxes and minority interest. In Germany, this item excludes profit (loss) carried forward from prior periods and

[10]We deflate these variables to adjust for firm size either by assets (data item #89) or by sales (data item #1). Because the results are similar using assets or sales, we only report the results where assets is used as the denominator. Because we divide both dependent and independent variables (except return), they could also be considered as heterogeneity adjustments.

Also, we specifically exclude firms whose overall period footnotes signal wide-ranging accounting changes and/or merger and acquisition activity in the three years leading up to each predicted R&D expenditure. We also ran our analysis separately for firms by excluding firms whose data item footnotes signalled accounting changes, and found the results to be similar enough not to warrant special treatment.

[11]In contrast to almost universal expensing in the U.S., international recommendations allow amortization in exceptional situations: [1] the product is clearly defined and its costs are separable; [2] the product is technically feasible; [3] the management plans to produce or use the product; [4] there is a clear market or internal usefulness; [5] completion is reasonably certain. As a practical rule, however, almost all companies seem to expense R&D. When amortizable, strict limits apply (in Germany and the EEC, there is a five-year amortization schedule; in France, exceptions are permitted in specified circumstances in the case of development costs only, as outlined by International Accounting and Reporting Issues: 1990 Review, United Nations Center on Transnational Corporations).

[12]When the three components were not individually available, we tried subtracting from total liabilities (#118) the sum of accounts payable (#97), deferred taxes (#105), minority interest (#107), and untaxed reserves (#108). This allowed us to compute an additional 72 debt values. In 23 further cases, we had to rely on long-term debt and other liabilities, because debt in current liabilities was unavailable. In addition, we considered other definitions of debt; for example, the sum of long-term debt and debt in current liabilities. The results were qualitatively similar to the ones reported.

transfers or allocations to various equity reserves, but not transfers to secret reserves. IBIA in turn consists of nonoperating income plus operating income net of interest expense. Depreciation and amortization is the sum of intangible amortization and fixed depreciation. Specifically, it includes amortization of intangible assets (such as goodwill and patents), and depletion charges depreciation of tangible fixed assets.[13]

Income tax (Data item #23): This data item contains all charges in lieu of income taxes, deferred income taxes, income taxes on dividends or earnings of unconsolidated subsidiaries, other income taxes, and territorial income taxes, but not franchise taxes, other taxes, and tax carrybacks and carryforwards reported after net income. Note that this data item includes not only current, but also deferred and other taxes.[14]

3.3. Data description

Table 1 provides the sample mean and median for 1990 for our variables for the various countries.[15] The country categorization is inflexible, in that

[13]In 132 cases in which depreciation was unavailable (all in Japan), we constructed a close substitute using an accounting identity: operating income [#14] is defined as sales [#1] plus other operating revenues [#2] minus depreciation and amortization minus operating expenses [#3].

[14]Income taxes are perhaps the data item that is both farthest from the economic meaning we want to impute to it, and the least internationally comparable data item in our study. While we want to measure the effect of taxes on R&D, it is unclear how deferred taxes should be discounted. Moreover, different countries have different tax systems. Total income taxes in the U.S. and Canada include a charge equivalent to the income tax credit (and any applicable state income taxes). In the U.K., it excludes petroleum revenue taxes. In France, it excludes a profit sharing tax. And in Japan, this item include enterprise tax but only when no breakout is available. Current income taxes in the U.S. include DISC (domestic international sales corporation) taxes. In both the U.S. and Canada, it includes flow-through investment tax credit, income taxes on dividends or unconsolidated subsidiaries earnings, investment tax credit recapture (when available) and territorial income taxes. In the U.K., this excludes advance corporation tax recoverable or written off, double-taxation relief, and related companies taxation. In Germany, this item includes taxes on income, earnings, and assets.

When we tried a regression with current taxes (data item #24) instead of tax liability, the results were of the same sign as those reported. However, because this data item was unavailable for many sample firms, especially in Europe, the results were mostly statistically insignificant.

[15]We windsorized values of various variables (R&D, net income, stock returns, taxes) that were less than 50 percent of total asset size (50 percent for stock returns) and greater than 200 percent of total asset size (200 percent for stock returns). About 5 percent of observations were affected by this procedure.

Data on net income, total assets, income taxes, depreciation, and total debt are available for all (100 percent) firms that are included in the Global Vantage tape. However, data on R&D expenditures, and annual stock return are missing from the Global Vantage tape for many firms (50 to 80 percent for R&D and 0 to 20 percent for stock returns). The former data restriction reflects the voluntary nature of R&D reporting, while the latter reflects both a lack of easy access to data and the private (or subsidiary) nature of many large foreign companies in the data set.

Table 1

Sample mean/median of selected variables for 1990; the sample is drawn from COMPUSTAT's Global Vantage tape

R&D(0) = current-year firm expenditure on R&D as a percentage of total assets.
ΔR&D(0) = change in current-year firm expenditure on R&D as a percentage of total assets.
DEBTX(*t* − 1) = ratio of firm's long-term debt and debt in current liabilities to total assets, lagged one year.
LIABOT(*t* − 1) = ratio of firm's other liabilities to total assets, lagged one year.
RET(*t* − 1) = annual stock return in own currency, lagged one year.
RET(*t* − 2) = annual stock return in own currency, lagged two years.
OCF = operating cash flow.
OCF(*t* − 1) = net income plus depreciation as a percentage of total assets, lagged one year.
OCF(*t* − 2) = net income plus depreciation as a percentage of total assets, lagged two years.
ASSETS = total assets in millions of dollars.
TAX(*t* − 1) = tax owed as a percentage of total assets, lagged one year.
TAXP(*t* − 1) = tax payment as a percentage of total assets, lagged one year.

	U.S.	Canada	U.K.	Europe	Japan
Sample size	1080	50	199	45	112
R&D(0)	4.676/1.916	2.766/0.721	1.523/0.555	6.037/5.264	2.637/2.011
R&D(0)	0.196/0.000	0.044/0.000	0.087/0.000	0.385/0.008	0.017/0.000
DEBTX(*t* − 1)	0.254/0.228	0.307/0.331	0.184/0.178	0.186/0.154	0.298/0.283
LIABOT(*t* − 1)	0.031/0.000	0.020/0.000	0.031/0.019	0.221/0.134	0.056/0.048
RET(*t* − 1)	8.557/9.662	6.096/7.830	16.134/18.193	31.158/37.729	16.352/12.726
RET(*t* − 2)	3.441/4.705	9.245/6.634	2.555/4.982	32.021/31.020	32.321/30.685
OCF(*t* − 1)	8.041/9.589	7.513/8.278	12.037/11.701	9.038/9.444	6.151/5.847
OCF(*t* − 2)	8.621/10.000	9.215/8.952	12.612/12.349	8.724/8.711	6.171/6.037
ASSETS	1963.0/193.5	2217.7/435.9	1946.3/311.0	7810.1/1838.7	5280.3/2198.3
TAX(*t* − 1)	3.061/2.695	2.631/2.640	4.191/3.929	2.810/2.373	3.463/2.912
TAXP(*t* − 1)	3.220/2.721	2.074/1.730	4.033/3.754	2.164/1.651	3.579/3.241

multinational companies are classified only within their country of origin. Without asset composition data of holdings in foreign countries, we were unable to improve on the *Global Vantage* classification. Europe includes France, Germany, and the Netherlands.[16] An analysis of the R&D expenditures as a fraction of assets by country (region) over the period 1985–1990 (not included in Table 1) suggested the following: Generally, British and Japanese R&D expenditures were stable in this period. European R&D expenditures show a pronounced drop around 1987, U.S. R&D expenditures rose slowly, and Canadian R&D expenditures showed a pronounced increase in 1990. European firms invested most in R&D, followed by the U.S., Japan, Canada, and U.K. In fact, European firms tend to invest almost three times as their British counterparts.

Debt is defined as the sum of long-term debt, debt in current assets, and other liabilities. Europe and Japan have the highest debt ratios. The higher debt ratios in Japan and Europe (particularly, Germany) have been noted by various authors (for example, Prowse, 1990). Some of these differences in debt ratios can perhaps be attributed to the less severe conflicts of interest between the stockholders and bondholders in these countries, compared to U.S.[17] In Germany, large banks often own significant blocks of debt and equity in the same firm, and often serve on the board. These ownership and governance structures perhaps help mitigate stockholder–bondholder conflicts of interest. Similarly, in Japan, a *keiretsu's* interlocking equity and debt position among firms and their bank, and product and factor market interactions help mitigate indirect financial distress costs for group firms; see Hoshi, Kashyap, and Scharfstein (1990a). These considerations could lead to higher debt ratios for group firms in Japan.

Stock returns were higher in Europe and Japan (and perhaps the U.K.) than in the U.S. and Canada. Operating cash flow was highest in U.K. (a median 11

[16] Firms in the following countries are excluded from this analysis for the stated reasons.

Sweden: The Swedish system is very different from most other systems in that its economy is heavily directed by its government. Anyone wishing to take advantage of government subsidies and incentives must follow standard accounting principles. Furthermore, the most odd feature of the Swedish system is that companies may take charges for tax purposes, even when they do not represent 'ordinary and necessary business events' (such as future investments). Furthermore, even though few companies capitalize R&D (for tax reasons), companies are allowed to do so.

Switzerland: Although Switzerland has paid much attention to recent international efforts to unify accounting statements, their mandated accounting standards are rather unsophisticated. Consequently, Swiss reports differ in their voluntary inclusion of many items not mandated by official Swiss rules. When consolidated, statements are typically unaudited. Independent audits are typically not published.

Belgium, Italy, Spain: Firms in these countries did not overwhelmingly expense R&D throughout the sample period.

[17] Smith and Warner (1979) discuss various sources of conflict of interest between shareholders and bondholders. They argue that debt ratio will be higher for firms where such conflict of interest is less severe.

percent of assets), smaller in Europe, Canada, and the U.S. (a median 8–9 percent), and lowest in Japan (6 percent). Liquidity was declining in all countries. Effective taxes were highest in Britain, mostly due to the high income of British companies in the sample period, followed by Japan, the U.S., Europe, and Canada.

4. Empirical results

The main focus of our study is a cross-sectional exploration of the predictors of R&D. We present results from cross-sectional vector autoregressions (VARs), both in levels and in differences.[18] Note that because our regressions are cross-sectional, we primarily explain heterogeneity in R&D. Insofar as our regressions include own lagged R&D, we investigate what other variables produce innovations in R&D.[19]

All regressions analyze the determinants of corporate R&D by regressing R&D expenditure on the firm's own past R&D, debt ratio, stock return, operating cash flow and tax liability. Our regression specification is essentially cross-sectional because our panel data set contains several hundred cross-sectional observations for each country. To a lesser extent, our regression specification can be considered time-series because our data set contains five time-series observations per firm. Since R&D expenditures are highly correlated, the time-series observation will bias our coefficients downwards. Yet this bias is small because the cross-sectional number of observations dominates the time-series specification.

There are other caveats. First, the regression specification does not arise from a specific theoretical model. Therefore, although we can rely on prediction as an objective criterion, our study should be considered exploratory. Indeed, we feel that the theories discussed above are so broad that no satisfactory comprehensive model may ever be developed. Second, the examined theories are long-horizon, while the estimated regressions measure only immediate effects. For example, it might be possible for firms with high income taxes to delay investing

[18]An earlier draft of this paper included the Koenker and Bassett (1978) robust regression technique and fixed effects regressions. With some minor exceptions, our results were generally consistent with those in Table 2. (Table 5 includes some reference to the exceptions.)

[19]It can be shown that VARs are asymptotically equivalent to Granger–Simms regressions, in which lagged unexpected components in one variable are regressed on unexpected components in another variable. Of course, Granger–Simms causality does not measure real causality. Note also that lagged R&D first and foremost adjusts for firms' cross-sectional differences, and only secondarily for time variation. That is, firms with high R&D levels have high lagged R&D levels too. (See also our discussion in the results.)

if they believe that tax code changes can increase investment tax credits in later years. Or, managers with low operating cash flows could invest in R&D with the expectation that high future operating cash flows can pay for the incurring R&D expenditures. Third, we are examining theories as if they applied equally to all companies, although different theories may apply to different firms in varying degrees. The presumption that every firm must be affected by the same underlying economic factor to the same degree is certainly false. At best, we can hope to measure dominant factors.

4.1. Levels regressions

Table 2a presents regression results for the determinants of corporate R&D expenditures for the major industrialized countries. The dependent variable is R&D expenditure (as a percentage of total assets) in the current year. We find the following relationships:

Autocoefficients

One-year lagged R&D expenditure, $R\&D(t-1)$, is significant for all countries, and the two-year lagged R&D is significant for U.S., Canada, and Europe. It is important to note that the autocoefficients in this context do not necessarily reflect individual firm autocorrelations in R&D, but primarily control for interfirm ongoing heterogeneity.[20]

Debt ratio

For U.S. firms, last year's debt ratio, $DEBT(t-1)$, is significantly negatively correlated with current R&D expenditures.[21] This evidence is consistent with the implication of Myers' (1977) – because of financial distress costs, firms with considerable growth opportunities (and, correspondingly, firms that have significant R&D opportunities) are unlikely to issue much debt. There is no significant relation between current R&D expenditures and last year's debt ratio for Canadian, British, and European firms. Surprisingly, for Japanese firms, last year's debt ratio is *positively* correlated with this year's R&D expenditures. The fact that firms with larger debt ratios are likely to increase their R&D expenditures suggests that financial distress costs are not a major determinant for Japanese companies.

[20] For example, if one firm has R&D fluctuating about 1 percent and another fluctuating about 10 percent, with other variables influencing the deviations and with no intrafirm autocorrelations, the autocoefficient in these regressions will be very high.

[21] We include only one lag of debt, because it is highly autocorrelated.

Table 2a

Regression results for determinants of R&D expenditure

The sample is drawn from the period 1985–1990 from COMPUSTAT's Global Vantage tape. The dependent variable is firm annual R&D expenditure as a percentage of total assets. The independent variables are: *R&D*$(t-1)$ = one-year lagged firm annual R&D expenditure as a percentage of total assets. *R&D*$(t-2)$ = two-year lagged firm annual R&D expenditure as a percentage of total assets. $DEBT(t-1)$ = one-year lagged debt over total assets; debt is defined as the sum of debt in current liabilities, long-term debt, and other liabilities. $RET(t-1)$ = one-year lagged annual stock return in own currency. $RET(t-2)$ = two-year lagged annual stock return in own currency. OCF = operating cash flow. $OCF(t-1)$ = one-year lagged net income plus depreciation as a percentage of total assets. $OCF(t-2)$ = two-year lagged net income plus depreciation as a percentage of total assets. $TAX(t-1)$ = one-year lagged tax payment as a percentage of total assets. 1986 through 1990 are annual dummy variables. White (1980) heteroscedasticity-consistent standard errors are used to construct the t-statistics.

	U.S.		Canada		U.K.		Europe		Japan	
	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t
R&D$(t-1)$	0.58	7.52	0.29	2.87	0.91	7.13	0.68	8.44	0.94	10.63
R&D$(t-2)$	0.13	2.00	0.74	6.87	0.13	1.18	0.33	4.19	0.05	0.61
$DEBT(t-1)$	−4.71	−2.68	−0.51	−1.01	0.25	1.37	−0.45	−0.76	0.35	1.64
$RET(t-1)$	−0.09	−0.21	−0.30	−0.90	0.15	1.03	−0.05	−0.15	0.00	0.04
$RET(t-2)$	0.71	2.27	−0.12	−0.33	−0.03	−0.32	0.66	2.22	0.16	1.94
$OCF(t-1)$	−5.08	−1.52	6.23	1.27	1.97	0.78	−1.04	−0.22	−0.29	−0.17
$OCF(t-2)$	−1.94	−0.82	−7.31	−2.08	−1.39	−0.85	−2.12	−0.45	−0.93	−0.51
$TAX(t-1)$	−3.14	−1.02	−11.63	−0.02	−0.80	−0.44	5.96	1.29	2.47	1.35
1986	0.39	1.33	0.15	0.73	−0.07	−0.52	0.24	0.75	0.08	0.54
1987	−0.01	−0.02	−0.10	−0.67	−0.16	−1.27	−0.22	−0.77	−0.07	−0.50
1988	0.51	1.59	−0.33	−1.93	−0.09	−0.84	0.09	0.20	−0.11	−0.78
1989	0.67	1.90	−0.19	−1.08	−0.08	−0.69	−0.02	−0.06	−0.12	−0.85
1990	0.89	2.26	0.29	1.22	−0.08	−0.65	0.17	0.52	−0.03	−0.19
Constant	2.59	3.41	0.33	1.20	−0.02	−0.14	0.08	0.19	−0.08	−0.41
Sample size	5270		221		502		179		377	
Adjusted R^2	0.6398		0.9250		0.9311		0.9598		0.9704	

Stock returns

We find no significant relation between one-year lagged stock return, $RET(t-1)$, and current R&D expenditures for any country. We find a significant positive relation between two-year lagged stock return, $RET(t-2)$, and current R&D expenditures for U.S., European, and Japanese firms; these coefficients are not statistically different from each other for these countries. This suggests a significant lag between increases in a firm's value and R&D expenditures.[22] Our finding is consistent with the joint hypothesis that stock returns provide market signals to firms regarding their future growth opportunities, and that these firms increase their investment in R&D to take advantage of such growth opportunities (Lach and Schankerman, 1989).

Operating cash flow

In Section 2.1, we argued that a firm's internally generated operating cash flows are the most likely source of R&D capital. However, the evidence for U.S. firms is inconsistent with our hypothesis. (It is opposite to that predicted.) There is a significant negative correlation between last year's internally generated operating cash flow, $OCF(t-1)$, and current R&D expenditures. There is no significant relation between past operating cash flows and current R&D expenditures for British, European, and Japanese firms.[23] A similar inference of no relation can be drawn for Canadian firms if one adds the coefficients for $OCF(t-1)$ and $OCF(t-2)$.[24]

Taxes

We find no significant relation between last year's tax payments, $TAX(t-1)$, and current R&D expenditures for U.S., Canadian, and British firms. For European and Japanese firms we find a marginally significant positive

[22]This suggests that the average (across all industries) application lag for U.S., Europe, and Japan is about two years. Pakes and Schankerman (1984) define application lag as the lag between the time when a new technological opportunity for the firm arrives and the time when this new opportunity results in the firm spending R&D dollars on applying it.

[23]Hoshi, Kashyap, and Scharfstein (1990b) also find no relation between past cash flows and current investment for a sample of 109 Japanese firms for the period 1978–1986. They also find that 69 of these firms loosened ties to their *keiretsu* bank during the later period of their analysis, and document that these firms showed a significant positive relation between cash flow and investment. Unfortunately, we do not have such data on the Japanese firms in our sample to conduct a similar test.

[24]It is possible that some anomalous findings are a result of the way we empirically define and measure internally generated operating cash flow. As noted earlier, we measure cash flow as net income plus depreciation. Our definition of cash flow is similar to that used in the literature: see Hall (1992), Whited (1992), Hoshi, Kashyap, and Scharfstein (1990b), Morck, Shleifer, and Vishny (1990), Lehn and Poulsen (1989), and Fazzari, Hubbard, and Petersen (1988). Worthington (1993) uses value of all shipments minus noncapital input costs as a measure of cash flow; we do not have such data for our sample.

relation between last year's tax payments and current R&D expenditures. This finding gives some credence to the arguments noted in the U.S. media that U.S. firms are at a disadvantage with respect to R&D investment, because, unlike Japanese firms, their U.S. counterparts do not receive effective tax incentives.

Yearly dummy variables

The yearly dummy variables suggest a secular increase in R&D expenditure by U.S. firms during the late 1980s. This evidence runs counter to the U.S. media myth that U.S. firms (or, at least, U.S. firms included in COMPUSTAT) are cutting back on R&D investment. Interestingly, the dummy variable for 1987 for USA is negative (but, insignificant), perhaps suggesting that the Tax Reform Act of 1986 encouraged U.S. firms to hasten the realization of their R&D expenditures in 1986 (rather than to realize it in 1987). With the exception of 1988 for Canada, there are no significant yearly effects for the non-U.S. firms.

4.2. First-differences regressions

Because firms could anchor their current R&D decisions to their most recent R&D expenditures, Table 2b investigates if our variables can forecast changes in R&D. Except for lagged R&D, which we now also measure in changes, our independent variables remain the same. Predicting changes, we find a negative relation between one-year and two-year lagged changes in R&D and the current year's change in R&D for U.S. and Canadian firms, and a positive correlation at lag 2 for European firms.[25]

Similar to Table 2a, the relationship between last year's debt ratio and R&D expenditures is negative (though, only marginally) for U.S. firms and positive for Japanese firms. This relationship is insignificant for Canadian firms, marginally positive for British firms, and marginally negative for European firms.

Correlations of lagged past stock returns and current changes in R&D expenditures are similar to those in Table 2a. The only exception is the correlation of U.S. firms for the lag-2 returns, which in Table 2a was significantly positive but is now insignificantly positive. These results are surprising because they reject the 'common wisdom' in the press that it is stock returns that are inducing U.S. firms to neglect R&D. In Europe and Japan, the coefficient on stock returns remains significantly positive.

The correlations with respect to one-year and two-year lagged operating cash flows are similar to those in Table 2a. The exception is the formerly negative U.S. coefficient which appears (insignificantly) positive here.

[25]This evidence is in contrast to the positive correlation documented by Hall (1992) between one-year lagged and current year's changes in R&D expenditures for manufacturing U.S. firms for the period 1976–1987.

Table 2b

Regression results for determinants of annual changes in R&D expenditure

The sample is drawn from the period 1985–1990 from COMPUSTAT's Global Vantage tape. The dependent variable is change in firm annual R&D expenditure as a percentage of total assets. The independent variables are: $\Delta R\&D(t-1)$ = one-year lagged change in firm annual R&D expenditure as a percentage of total assets. $\Delta R\&D(t-2)$ = two-year lagged change in firm annual R&D expenditure as a percentage of total assets. $DEBT(t-1)$ = one-year lagged debt over total assets; debt is defined as the sum of debt in current liabilities, long-term debt, and other liabilities. $RET(t-1)$ = one-year lagged annual stock return in own currency. $RET(t-2)$ = two-year lagged annual stock return in own currency. OCF = operating cash flow. $OCF(t-1)$ = one-year lagged net income plus depreciation as a percentage of total assets. $OCF(t-2)$ = two-year lagged net income plus depreciation as a percentage of total assets. $TAX(t-1)$ = one-year lagged tax payment as a percentage of total assets. 1986 through 1990 are annual dummy variables. White (1980) heteroscedasticity-consistent standard errors are used to construct the t-statistics.

	U.S.		Canada		U.K.		Europe		Japan	
	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t
$\Delta R\&D(t-1)$	−0.30	−3.10	−0.82	−6.81	−0.12	−0.78	−0.31	−3.67	0.85	0.12
$\Delta R\&D(t-2)$	−0.24	−2.24	−0.38	−1.66	−0.07	−0.64	0.02	4.42	0.68	0.15
$DEBT(t-1)$	−2.43	−1.47	−0.61	−1.03	0.29	1.49	−0.85	−1.42	0.45	2.30
$RET(t-1)$	0.00	0.01	−0.23	−0.73	0.08	0.61	−0.15	−0.38	−0.01	−0.11
$RET(t-2)$	0.35	1.02	−0.18	−0.51	−0.14	−0.92	0.66	1.99	0.17	2.03
$OCF(t-1)$	2.14	0.57	3.95	1.10	2.37	0.99	−2.67	−0.52	−1.04	−0.61
$OCF(t-2)$	4.14	1.32	−5.00	−2.12	−1.79	−1.09	−0.52	−0.10	−0.16	−0.08
$TAX(t-1)$	−11.34	−2.08	−0.12	−0.02	−0.35	−0.19	7.93	1.52	3.17	1.79
1986	0.29	0.89	0.04	0.16	−0.07	−0.54	0.16	0.45	0.13	0.80
1987	−0.09	−0.27	−0.06	−0.36	−0.15	−1.14	−0.29	−0.86	−0.02	−0.12
1988	0.39	1.09	−0.38	−2.01	−0.05	−0.46	−0.01	−0.02	−0.06	−0.44
1989	0.22	0.62	−0.28	−1.33	−0.06	−0.48	−0.06	−0.15	−0.06	−0.40
1990	0.56	1.38	0.13	0.68	−0.07	−0.56	0.08	0.23	0.03	0.17
Constant	0.19	0.41	0.47	1.63	0.02	0.13	0.34	0.76	−0.22	−0.17
Sample size	5164		217		449		161		356	
Adjusted R^2	0.1372		0.6366		0.0213		0.1097		0.0461	

Table 3
Summary statistics on asset size in millions of dollars of sample firms; the sample is drawn from the period 1985–1990 from COMPUSTAT's Global Vantage tape

	U.S.	Canada	U.K.	Europe	Japan
Sample size	5559	239	697	221	589
Mean	1605.41	1820.73	1956.77	5683.65	3690.23
Median	177.85	656.23	248.89	1323.54	1557.77
Minimum	0.64	22.65	0.92	7.27	108.36
Maximum	180236.0	35987.9	54519.1	59256.7	85114.7
Percentile					
10	26.84	108.72	40.59	130.07	398.78
20	52.62	177.58	65.80	281.50	630.25
30	84.92	264.03	110.05	472.66	886.84
40	122.78	367.94	155.54	887.38	1156.47
50	177.85	656.23	248.89	1323.54	1557.77
60	263.89	1222.32	421.35	2278.02	2040.79
70	451.88	1699.24	815.23	3821.10	2834.62
80	1042.88	2257.98	1588.21	8594.57	4198.83
90	3013.00	4247.01	4412.86	18681.66	9038.15

Finally, the correlations of the non-U.S. firms for the $TAX(t-1)$ variable are similar to those in Table 2a. The U.S. firms now exhibit a significant negative correlation. This pattern might be consistent with the argument that the Japanese tax code encourages firms to invest in R&D, while the U.S. system discourages R&D.

4.3. Firm size differences

We now investigate if our findings are driven by the heterogeneity in firm size among Global Vantage companies. Summary statistics on asset size for sample firms categorized by country are provided in Table 3. *For our sample*, on average, U.S. firms are smallest. After including a selection of large firms in all countries that it covers, COMPUSTAT essentially fills up the remainder of their Global Vantage tapes with U.S. firms. It is possible that intercountry differences in the cross-sectional determinants of R&D might be attributed to differences in average firm size for different countries. To address this concern, we constructed a subsample (for each country) where we included only those firms whose total asset sizes were greater than \$500 million.[26] Regression results for the determinants of R&D expenditures among these firms are summarized in Table 4a,

[26]The cutoff of \$500 million was selected to provide as large a sample as possible for countries other than U.S., while ensuring comparability of firm size.

otherwise analogous to Tables 2. Our results in Table 4a are generally similar to those in Tables 2, with the following exceptions: For large U.S. firms we find no relation between debt and R&D expenditures (we noted a significant negative relation for all U.S. firms). For large British firms we find a positive relation between past stock returns and R&D (earlier, we found no relation for all British firms). Similar to European and Japanese firms, we find a positive correlation (though only marginally significant) between taxes and R&D for large U.S. firms (we found this relation to be negative but insignificant for all U.S. firms).

By leaving out firms smaller than $500 million, regression estimates in Table 4a ignore a considerable amount of information. Table 4b reports regression results for small (less than $100 million), medium (between $100 and $500 million), and large (greater than $500 million) U.S. firms.[27] Following are the major differences in the determinants of R&D among small, medium, and large U.S. firms: There is a significant negative relation between debt ratio and R&D for small U.S. firms. This relation is negative and marginally significant for medium-size U.S. firms. There is no relation between debt ratio and R&D for large U.S. firms. This implies, as the theory would suggest, that debt is detrimental for R&D only to firms most likely to be subject to severe financial distress costs (that is, liquidation): small firms. Because large firms tend not to be liquidated in financial distress, such firms are less sensitive to their debt level when they increase R&D. The relation between stock returns (at lag 2) and R&D is positive and gets progressively stronger as one moves from large to medium-size to small firms. While we find a positive (though marginally significant) relation between R&D and taxes for large U.S. firms, this relation is negative for medium-size and small U.S. firms. In sum, the ability to deduct R&D expenditures from current taxes seems to be most valuable to large firms paying more tax. Small firms paying more tax seem to be less likely to increase R&D to avoid taxes. This last finding on taxes perhaps has significant implications for policy-makers who wish to use U.S. tax-policy to stimulate innovation and growth in the economy.

5. Summary

This paper empirically explores the determinants of corporate R&D. We analyze 6,549 firm-years of R&D data for U.S., Canadian, British, European, and Japanese firms for the period 1985–1990. Specifically, we investigate if a firm's past stock returns, cash flows, debt structure, and the tax environment affect its R&D expenditures. Table 5 summarizes our findings. The following highlights our main findings.

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[27]With the possible exception of U.K., a similar firm-size classification would lead to rather small sample sizes for other countries.

Table 4a

Regression results for determinants of R&D expenditure for large-size firms

The sample is drawn from the period 1985–1990 from COMPUSTAT's Global Vantage tape; the sample is restricted to firms whose total asset size is greater than $500 million – this ensures that sample firms are of comparable size. The dependent variable in panel A is firm annual R&D expenditure as a percentage of total assets. The dependent variable in panel B is change in firm annual R&D expenditure as a percentage of total assets. The independent variables are: $R\&D(t-1)$ = one-year lagged firm annual R&D expenditure as a percentage of total assets. $R\&D(t-2)$ = two-year lagged firm annual R&D expenditure as a percentage of total assets. $\Delta R\&D(t-1)$ = one-year lagged change in firm annual R&D expenditure as a percentage of total assets. $\Delta R\&D(t-2)$ = two-year lagged change in firm annual R&D expenditure as a percentage of total assets. $DEBT(t-1)$ = one-year lagged debt over total assets; debt is defined as the sum of debt in current liabilities, long-term debt, and other liabilities. $RET(t-1)$ = one-year lagged annual stock return in own currency. $RET(t-2)$ = two-year lagged annual stock return in own currency. OCF = operating cash flow. $OCF(t-1)$ = one-year lagged net income plus depreciation as a percentage of total assets. $OCF(t-2)$ = two-year lagged net income plus depreciation as a percentage of total assets. $TAX(t-1)$ = one-year lagged tax payment as a percentage of total assets. Dummy variables for years 1986 through 1990, and an intercept term are included but not reported here. White (1980) heteroscedasticity-consistent standard errors are used to construct the t-statistics.

Panel A: Levels regressions

	U.S.		Canada		U.K.		Europe		Japan	
	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t
$R\&D(t-1)$	0.90	20.76	0.65	3.89	0.87	10.38	0.70	6.70	0.99	10.78
$R\&D(t-2)$	0.10	2.44	0.37	2.13	0.11	1.48	0.32	2.92	0.04	0.04
$DEBT(t-1)$	0.10	0.72	0.21	1.76	−0.60	−1.09	0.60	0.83	0.29	1.32
$RET(t-1)$	−0.08	−0.84	0.06	0.85	0.30	1.65	−0.39	−0.70	0.02	0.21
$RET(t-2)$	0.12	1.31	−0.02	−0.32	0.48	2.45	0.41	1.51	0.15	1.86
$OCF(t-1)$	0.65	0.65	1.38	1.20	9.19	2.03	2.04	0.33	−1.60	−0.84
$OCF(t-2)$	−0.89	−1.52	−0.83	−0.97	−4.63	−1.62	−4.89	−0.77	0.57	0.29
$TAX(t-1)$	1.90	1.47	1.33	1.14	−4.38	−0.91	5.98	1.16	2.25	1.13
Sample size	1544		120		179		130		344	
Adjusted R^2	0.9617		0.9919		0.9278		0.9587		0.9711	

Panel B: First-differences regressions

	U.S.		Canada		U.K.		Europe		Japan	
	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t	Coef.	White-t
$\Delta R\&D(t-1)$	−0.10	−2.43	−0.38	−1.61	−0.25	−2.40	−0.29	−2.60	0.06	0.82
$\Delta R\&D(t-2)$	−0.02	−0.61	0.10	0.69	−0.20	−1.34	0.02	6.05	−0.01	−0.23
$DEBT(t-1)$	0.10	0.73	0.13	1.06	−0.78	−1.27	0.21	0.30	0.43	2.19
$RET(t-1)$	−0.08	−0.77	0.06	0.86	0.14	0.79	−0.44	−0.79	−0.01	−0.17
$RET(t-2)$	0.12	1.25	−0.02	−0.20	0.48	2.40	0.47	1.32	0.16	1.95
$OCF(t-1)$	0.62	0.62	1.82	1.52	9.14	2.08	1.21	0.14	−2.39	−1.22
$OCF(t-2)$	−0.93	−1.47	−0.76	−0.97	−4.18	−1.47	−2.49	−0.37	1.40	0.71
$TAX(t-1)$	2.04	1.56	0.46	0.32	−3.77	−0.72	5.80	0.88	3.05	1.56
Sample size	1522		119		152		119		325	
Adjusted R^2	0.0241		0.2076		0.3644		0.0735		0.0672	

Table 4b
Regression results for determinants of R&D expenditure for small, medium, and large-size U.S. firms.

The sample is drawn from the period 1985–1990 from COMPUSTAT's Global Vantage tape and includes U.S. firms only. The sample is divided by total asset size: greater than $500 million, between $100 and $500 million, and less than $100 million. The dependent variable in panel A is firm annual R&D expenditure as a percentage of total assets. The dependent variable in panel B is change in firm annual R&D expenditure as a percentage of total assets. The independent variables are: *R&D(t − 1)* = one-year lagged firm annual R&D expenditure as a percentage of total assets. *R&D(t − 2)* = two-year lagged firm annual R&D expenditure as a percentage of total assets. *ΔR&D(t − 1)* = one-year lagged change in firm annual R&D expenditure as a percentage of total assets. *ΔR&D(t − 2)* = two-year lagged change in firm annual R&D expenditure as a percentage of total assets. *DEBT(t − 1)* = one-year lagged debt over total assets; debt is defined as the sum of debt in current liabilities, long-term debt, and other liabilities. *RET(t − 1)* = one-year lagged annual stock return in own currency. *RET(t − 2)* = two-year lagged annual stock return in own currency. *OCF* = operating cash flow. *OCF(t − 1)* = one-year lagged net income plus depreciation as a percentage of total assets. *OCF(t − 2)* = two-year lagged net income plus depreciation as a percentage of total assets. *TAX(t − 1)* = one-year lagged tax payment as a percentage of total assets. Dummy variables for years 1986 through 1990, and an intercept term are included but not reported here. White (1980) heteroscedasticity-consistent standard errors are used to construct the *t*-statistics.

Panel A: Levels regressions

	Size > $500M		Size = ($100M, $500M)		Size < $100M	
	Coef.	White *t*	Coef.	White-*t*	Coef.	White-*t*
R&D(t − 1)	0.90	20.76	0.93	10.00	0.53	6.77
R&D(t − 2)	0.10	2.44	0.03	0.22	0.11	1.69
DEBT(t − 1)	0.10	0.72	− 0.47	− 1.21	− 6.91	− 2.49
RET(t − 1)	− 0.08	− 0.84	− 0.18	− 1.13	0.36	0.40
RET(t − 2)	0.12	1.31	0.23	2.00	1.30	2.19
OCF(t − 1)	0.65	0.65	3.55	1.95	− 10.42	− 2.17
OCF(t − 2)	− 0.89	− 1.52	− 0.69	− 0.55	− 4.67	− 1.27
TAX(t − 1)	1.90	1.47	− 5.04	− 2.43	− 0.50	− 0.11
Sample size	1544		1950		1776	
Adjusted R^2	0.9617		0.8852		0.5942	

Panel B: First differences regressions

	Size > $500M		Size = ($100M, $500M)		Size < $100M	
	Coef.	White *t*	Coef.	White-*t*	Coef.	White-*t*
R&D(t − 1)	− 0.10	− 2.43	− 0.06	− 0.63	− 0.31	− 3.14
R&D(t − 2)	− 0.02	− 0.61	− 0.04	− 0.45	− 0.25	− 2.26
DEBT(t − 1)	0.10	0.73	− 0.14	− 0.29	− 5.14	− 1.52
RET(t − 1)	− 0.08	− 0.77	− 0.13	− 0.97	0.13	0.14
RET(t − 2)	0.12	1.25	0.23	1.70	0.44	0.64
OCF(t − 1)	0.62	0.62	3.42	1.87	0.85	0.17
OCF(t − 2)	− 0.93	− 1.47	− 0.68	− 0.53	6.75	1.45
TAX(t − 1)	2.04	1.56	− 4.23	− 2.45	− 16.52	− 2.14
Sample size	1522		1913		1729	
Adjusted R^2	0.0241		0.0189		0.1509	

Table 5
Summary of findings on correlations between current year's R&D and the following variables

	U.S.	Canada	U.K.	Europe	Japan
Lagged R&D	Positive	Positive	Positive	Positive	Positive
Debt	Negative, especially among small firms	Insignificant	Insignificant	Insignificant	Positive
Stock returns	Mostly positive	Insignificant	Positive for large firms, otherwise insignificant	Positive	Positive, except in robust regressions
Operating cash flow	Negative in level, positive in differences and in robust regressions	Occasionally negative, mostly insignificant	Inconsistent	Insignificant	Insignificant
Tax liability	Negative or insignificant	Positive in robust regressions, otherwise insignificant	Insignificant	Insignificant	Positive

According to theory, we should have found that firms with high stock returns (signaling future opportunities and lower current cost of capital) increase R&D. Although we find no significant relation between one-year lagged stock return and current R&D expenditures for any country, we document a significant positive relation between two-year lagged stock return and current R&D expenditures for U.S., European, Japanese, and large-size British firms. Thus, our evidence backs the theory *in all countries.* Our evidence is not consistent with the popular notion that U.S. managers reduce R&D more than their European and Japanese counterparts when their stock price decreases.

Theory predicts that firms with high cash flow (and thus lower costs of raising funds and a lesser need to access the equity markets, lower free cash flow constraints, and perhaps future growth opportunities) increase R&D. In contrast to the theory, we observe a marginally significant *negative* correlation between last year's internally generated cash flow and current R&D expenditures for U.S. firms. In a robust regression specification that reduces the impact of influential observations, this counter-intuitive correlation reverses. No significant relation is observed between past cash flows and current R&D expenditures for firms in other countries. This rejects the notion that R&D occurs mostly when firms have more cash flow on hand, and thus can avoid the costs of external capital markets *in all countries.*

Theory also predicts that firms with high debt ratios tend to decrease their R&D expenditures, because R&D expenditures can evaporate in financial distress. For U.S. firms, last year's debt ratio is significantly negatively correlated with current R&D expenditures, and this negative relation is largely due to small-size U.S. firms. Surprisingly, for Japanese firms, last year's debt ratio is *positively* correlated with this year's R&D expenditures; this result is robust to alternative specifications. There is no consistent relation between current R&D expenditures and last year's debt ratio for firms in other countries. This suggests that high-debt firms in Japan were not concerned with the intangibility of R&D in bankruptcies, whereas firms especially in the U.S. (and among them, mostly small firms) preferred to safeguard their R&D investments by not assuming large amounts of debt.

Finally, we explored the role of total taxes, even though taxes are complex enough not to permit easy signing on theoretical grounds. We found that there is no significant relation between last year's tax payments and current R&D expenditures for European and British firms. For Japanese firms, as predicted, we find a significant positive relation between last year's tax payments and current R&D expenditures. Also, we find a significant negative relation for medium-size and small-size U.S. firms. This suggests that in contrast to the U.S. tax code, the Japanese tax code manages to encourage R&D.

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