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# Empirical Determinants and Patterns of Research and Development Investment in Asia

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## ABSTRACT

This paper investigates the financial determinants of research and development (R&D) investment in Asia, where innovation is naturally seen as the key driver of future (high) economic growth. We sample listed nonfinancial firms from eight economies in region (the People's Republic of China; Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; the Philippines; and Singapore) for the period 2002–2011 using the Oriana database. Panel data regressions show sensitivity of R&D investment to changes in cash flow, indicating reliance on internal financing of R&D and financially constrained firms, and a greater role of debt, rather than equity, as a source of external financing. In terms of alternative uses of funds, dividend payments by firms seem to divert from their spending on R&D, but investments in financial assets do not. In terms of ownership structure, empirical results show that both higher domestic ownership concentration and higher foreign ownership tend to lower cash flow sensitivity of R&D investment, suggesting more stable funding of innovation. Overall, there does not seem to be an extreme preference of firm shareholders for short-term returns at the expense of long-term productivity. However, there is clearly a gain for firms as well as economies they are in with better access to external financing of R&D.



Keywords: R&D investment, financing innovation, cash flow, R&D financing constraints, Asia

JEL classification: G30, O30, O40, D92

## I. INTRODUCTION

Especially since Krugman's (1994) commentary on the nature of Asia's high growth in the 1980s, much emphasis has been placed on the role of technological progress in sustaining economic growth in the region. Research and development (R&D) investment, the vital force behind innovation, was naturally cast as the main driver of future (high) Asian growth.

A number of Asian economies appear to have done quite well in approaching this goal. Japan and the Republic of Korea, for instance, have among the highest R&D-spending-to-gross domesdic product (GDP) ratios in the world (World Bank Database, accessed July 2013). The People's Republic of China (PRC) now invests nearly 1.7% of GDP in R&D, up from an average of less than 1% in the 1990s. The East Asian ratio (2.4% of GDP) already exceeds the European Union (EU) ratio (2%) but remains below the United States (US) ratio of about 2.9%. Asia now reportedly has a 37% share of global R&D, accounted for mainly by the PRC (with 15%), Japan (11%), and India (3%).1

However, some economies in the region have not been as successful in pushing the envelope on innovation. The R&D-spending-to-GDP ratio averages at 1.5% for developing economies of East Asia and about 0.1% for countries such as Indonesia and the Philippines. Hong Kong, China and Malaysia, despite their advanced financial status, and India, notwithstanding known advantages in science and technology, actually spend less than 1% of GDP on R&D. Worrisome trends have also been observed in Asian economies known to have focused heavily on innovation to sustain growth, particularly in the Republic of Korea, where there has been a observed decline in R&D investment growth during the global financial crisis (Seo, Kim, and Kim 2012).

Despite the importance of innovation for Asia, there have not been very many studies on the determinants of R&D investment across the region, with research tending to focus instead on physical investment. The few papers that do exist center their analysis on individual countries such as the Republic of Korea and Japan. They have also tended, presumably by design, to focus on a few handpicked factors.

In helping fill the gap, we attempt to do so at a more micro level, using information on listed nonfinancial firms in Asia. This provides us with rich data on the possible factors behind innovation spending in the region. We also try to present a fuller view of the different factors that may impact investment in innovation.

Considering how R&D can be difficult to finance even in advanced economies because of its unique characteristics (basically, lack of collateral and problems associated with asymmetric information), we presume that financing considerations play a huge role when investment decisions are being made. Hence, central to our empirical model are corporate finance variables that represent access to internal as well as external funds.

The study tries to empirically determine which among the external sources of financing (i.e., debt or equity) is dominant. With regard to internal financing, it additionally tries to assess whether the observed sensitivity of R&D investment to fluctuations in cash flow can indeed be attributed to binding financial constraints on Asian nonfinancial firms.

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[1] Available online: http://www.rdmag.com/articles/2012/12/asia-drives-growth-2013-global-r-d

The paper also investigates how alternative uses of corporate funds such as for dividends and investment in financial assets, which allow quick monetary returns, might serve to divert funds from longer-term real investment. This seems important in light of new findings where, for instance, during the observed recent slowdown of Korean R&D growth mentioned above, a decline in real investment by top corporations had been matched by a tremendous increase in their financial investment.

Following the literature, we explore the impact of ownership structure, particularly the level of domestic ownership concentration, the extent of foreign control, and the category of owners. In all cases, a longer investment horizon and greater weight place on a firm's long-term growth rather than on short-term gains would make abovementioned shareholders positive influences on R&D.

The paper is organized as follows. Section II provides the background literature for the empirical model. Section III introduces the econometric specification. Section IV gives a quick view of the data and sample trends. Section V presents the statistical results. Lastly, Section VI summarizes the key points of the study.

## II. THEORETICAL BACKGROUND

The importance of R&D is by now well-recognized. Endogenous growth theory emerged in the late 1980s emphasizing the role of innovation in pushing development (e.g., the works of Lucas and Romer), ideas that are now well embedded in the macro literature.

However, there are also known obstacles to R&D investment (Brown, Martinsson, and Petersen 2012). One is the very nature of knowledge capital, where large external returns and spillovers suggest underprovision in the economy (Hall and Lerner 2009). Another relates to the known difficulties of financing innovation. The hurdles are recognized to be higher for R&D than for physical investment because of its unique features—e.g., greater problems associated with information asymmetry (adverse selection and moral hazard), limited collateral value, and greater uncertainty of outcomes.

In the literature, the determinants of R&D fall into two not very distinct categories (Chen 2010). The first highlights financial factors and focuses on the interplay of internal and external financing, while the second features the influence of ownership structure on innovation spending, based on varying preferences for risk and investment or planning horizons.

The Modigliani-Miller theorem (1958) asserts the irrelevance of a firm's financial structure in investment decisions, but this only holds when capital markets are perfect and there are no financing constraints. The latter may drive a wedge between the cost of internal and external funds (e.g., Fazzari, Hubbard, and Petersen 1988), influencing investment spending. Firms experiencing financing frictions, which are presumably higher for R&D because of its unique characteristics, would logically prefer to first fund their investments internally, using self-generated funds.

Analytically, the order in which firms would tap the debt and equity markets depends on the relative costs. On one hand, pecking order theory hypothesizes a preference of debt over equity because of information asymmetry. Myers and Maljuf (1984) for instance argue along this line, as managers know more about the true conditions of the firm and have the incentive to overvalue the share price, leading investors to lower their valuation of new equity (i.e., raise the

financing cost). On the other hand, agency theory reserves a greater role for equity than debt, as debt exerts greater discipline on managers and limits their discretion on the use of funds (e.g., Jensen 1986).

For R&D, in particular, Brown, Fazzari, and Petersen (2009) postulate that equity finance may be preferred by young technology-oriented firms, again because of R&D's unique features including: limited collateral value, uncertain and volatile outcomes lessening the attractiveness of debt contract (Stiglitz 1985), severe adverse selection problems due to the inherent riskiness of the investments (Stiglitz and Weiss 1981), and greater moral hazard problems associated with debt financing. Hence, not including equity issuance as an explanatory term in an investment model may be an important source of omitted variable problems.

Related to this, there is a rich empirical literature on how binding financing constraints (i.e., limited access to or high cost of external financing) leads to sensitivity of investment to cash flow, which reflects the availability of internal funds, in estimated investment functions. Starting with Fazzari, Hubbard, and Petersen (1988), these studies argue that firms with limited access to external financing or which face high external financing costs need to rely more heavily on internal funds for their investment needs.This makes cash flow an important determinant of investment, including on R&D.

While these studies have been criticized for not being well-grounded in theory (beginning with Kaplan and Zingales 1997), many subsequent papers have confirmed the original hypothesis about financially constrained firms. Moreover, some authors argue that conflicting evidence (e.g., provided by Kaplan and Zingales 1997 and Cleary 1999) can be explained by negative cash flow observations and a few influential sample points (Allayanis and Mozumdar 2004, from Khramov 2012).

One could also look to the alternative uses of corporate funds, apart from physical investment and working capital, to explain R&D investment decisions of firms. Studies have emerged that look at the effect of a change in firm behavior called "financialization," characterized by an increased role of financial motives and financial markets and greater emphasis on shareholder value. Increased preference for short-term gains, as reflected for instance by a rise in dividend payments, and a shortening of investment horizons are hypothesized to crowd out funds for real investment, including R&D, and slow down capital accumulation.[2]

The impact of ownership structure, comprising the other major strand of the literature on determinants of R&D investment, is primarily based on agency theory, where problems arise in firms with dispersed ownership because of misaligned incentives and asymmetric information. The issue with regard to innovation spending is the observed myopic behavior of managers, who tend to be reluctant investors in R&D (e.g., Froot, Perold, and Stein 1992; Jensen and Meckling 1976).

Greater concentration of ownership could help lessen these problems, as large shareholders may be more effective monitors of management. Because of their large stake, they may also be more interested in the longer-term prospects of the firm and hence more likely to undertake real investment.

[2] See Seo, Kim, and Kim (2012) who provide a short review of the empirical literature prior to their investigation of the effects of financialization on R&D investment in the Republic of Korea since the Asian financial crisis.

However, large shareholders may also exhibit greater risk aversion than small shareholders because their portfolios may not be as diversified. Similar analysis can be made for foreign ownership of firms as well as the various owner types, where greater commitment to the firm's long-term growth rather than reliance on short-term gains would certainly be a positive factor for R&D.

## III. EMPIRICAL SPECIFICATION

### A. R&D Investment Models

Based on the above review of the literature, we initially estimate the following R&D investment model:

$$R\&D_{i,t} = \beta_1 \Delta sales_{i,t} + \beta_2 sales_{i,t-1} + \beta_3 cfo_{i,t} + \beta_4 \Delta cash_{i,t} + \beta_5 size_{i,t} + \gamma_1 time_t + \gamma_2 country_i \times time_t + \alpha_i + \varepsilon_{i,t} \quad (1)$$

where the subscripts refer to firm $i$ and period $t$.

$R\&D_{i,t}$ represents the level of R&D spending of a firm scaled by its beginning-of-period stock of total assets (i.e., R&D intensity); $\Delta sales_{i,t}$ represents growth in net sales; $sales_{i,t-1}$ represents the log of net sales lagged one period ; $cfo_{i,t}$ represents cash flow from operations (net income plus depreciation) scaled by beginning-of-period total assets; $\Delta cash_{i,t}$ represents the change in cash holdings; and $size_{i,t}$ refers to the log of total assets. The model also includes time and country dummies ($time_t$ and $country_i \times time_t$) and firm-specific effects ($\alpha_i$).

We follow earlier studies on R&D that incorporate sales variables instead of measures of Tobin's Q in the investment equation to account for investment opportunity of firms (e.g., Brown, Fazzari, and Petersen 2009, Lee 2012). By doing so, the paper sidesteps problems associated with proxying marginal Q by average Q. Additionally, the sales accelerator may be more suited than the Q-ratio to an investment equation for intangible assets and arguably serve as a better gauge of a firm's growth potential if the firm is operating in an economy where financial markets are not yet fully developed.[3]

Growth in net sales and lagged net sales will have a non-negative impact on R&D investment if they proxy for investment fundamentals.[4] The coefficient on the cash flow term will also be significant if the availability of internal financing influences R&D spending ($\beta_3 > 0$ possibly indicating funding stress).

A build-up of cash reserves similarly indicates greater internal funding capacity for R&D, but drawdowns by firms with limited access to external finance to smoothen R&D spending possibly generate an inverse relationship (Brown, Martinsson, and Petersen 2012). Finally, if Schumpeter's hypothesis is correct, large firms, which are supposedly the main source of innovation, should have higher R&D intensities than smaller firms.

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[3] Lee (2012) argues that is it the applicability of Tobin's Q to R&D investment is "questionable" since Tobin's Q is conceptually the ratio between the market and replacement value of the same physical asset. In estimating a fixed asset investment function, Ogawa (2013) finds the Q-ratio to be a weak indicator of a firm's current and future profitability, especially in financially developing countries (i.e., coefficients not significant in the investment equation).

[4] Strictly positive, when under imperfect competition.

Our model includes firm-specific fixed effects to account for unobserved time-invariant determinants of R&D spending at the firm level. Similarly, we add time-specific effects to control for economic fluctuations over different periods, as well as country-specific effects, which are captured by interaction terms with time dummies, to control for factors unique to an economy, including regulatory, institutional, and industry characteristics.

To investigate the role of external finance, we add measures of debt and equity to our initial R&D investment equation:

$$R\&D_{i,t} = \beta_1 \Delta sales_{i,t} + \beta_2 sales_{i,t-1} + \beta_3 cfo_{i,t} + \beta_4 \Delta cash_{i,t} + \beta_5 debt_{i,t} + \beta_6 equity_{i,t} + \beta_7 size_{i,t} + \gamma_1 time_t + \gamma_2 country_i \times time_t + \alpha_i + \varepsilon_{i,t}. \quad (2)$$

The variable $debt_{i,t}$ corresponds to total liabilities of a firm, while $equity_{i,t}$ refers to issued share capital. Both are scaled by beginning-of-period stock of total assets.

Greater access to equity presumably encourages investment in R&D, especially for firms with low internally generated funds. Access to debt may similarly support innovation spending but only up to a point, as higher leverage might eventually signal financial distress of a firm, leading to higher borrowing costs. Which among the two would dominate would depend on the relative costs and severity of information asymmetry associated with each source of external financing.

To explore how alternative demands for corporate funds (apart from physical investment and working capital) impact on investment in R&D, we also estimate the following equation:

$$R\&D_{i,t} = \beta_1 \Delta sales_{i,t} + \beta_2 sales_{i,t-1} + \beta_3 cfo_{i,t} + \beta_4 \Delta cash_{i,t} + \beta_5 debt_{i,t} + \beta_6 equity_{i,t} + \beta_7 findiv_{i,t} + \beta_8 fininv_{i,t} + \beta_9 size_{i,t} + \gamma_1 time_t + \gamma_2 country_i \times time_t + \alpha_i + \varepsilon_{i,t} \quad (3)$$

where $findiv_{i,t}$ measures dividend payments of the firm and $fininv_{i,t}$ measures its financial asset investment.

Negative coefficients on these variables indicate possible "financialization," as mentioned earlier, a process marked by greater preference for shorter-term returns and consequently shorter planning horizons. Such a shift could be at the expense of real investment, including R&D.

The study uses a fixed effects (FE) model to estimate the above specifications.[5] To capture possible nonlinear relationships of variables, we also estimate a quadratic form of equations (1) to (3), where equation (3), for instance, becomes:

$$R\&D_{i,t} = \beta_1 \Delta sales_{i,t} + \beta_2 sales_{i,t-1} + \beta_3 cfo_{i,t} + \beta_3' cfo_{i,t}^2 + \beta_4 cash_{i,t} + \beta_4' cash_{i,t}^2 + \beta_5 debt_{i,t} + \beta_5' debt_{i,t}^2 + \beta_6 equity_{i,t} + \beta_6' equity_{i,t}^2 + \beta_7 findiv_{i,t} + \beta_8 fininv_{i,t} + \beta_9 size_{i,t} + \gamma_1 time_t + \gamma_2 country_i \times time_t + \alpha_i + \varepsilon_{i,t}. \quad (4)$$

As a robustness check, we include a lag of R&D intensity in the models to capture adjustment costs, which are potentially high for R&D investment, which mostly comes in the

[5] The choice over a random effects model was based on several versions of the Hausman test, including the Wooldridge (2002) robust version. FE estimates in this paper are robust to the problem of heteroskedastic disturbances.

form of compensation to highly skilled technology workers with a great deal of firm-specific knowledge, and possibly higher than for physical investment (Brown, Fazzari and Petersen 2009). We estimate this more dynamic version using a GMM "systems" estimator following Arellano and Bond (1991). Their method, which uses lags of the endogenous variables as instruments, is suitable to short panels and addresses possible endogeneity of financial variables, especially cash flow.

## B. Measuring Cash Flow Sensitivity

Another thrust of this paper is to examine the observed sensitivity of R&D investment to internal cash flow and see whether this may indeed be due to firms being subject to binding financing constraints. We look specifically at how cash flow sensitivity of innovation spending is influenced by firm age, size, and ownership structure. We also explore how the level of financial development of the economy where the firm is located impacts on the relationship.

Firm age and size are commonly used in the literature as proxies for financing frictions and are found to be the variables most related to firms' qualitative reports regarding the presence of financing constraints (Hadlock and Pierce 2010, Brown and Petersen 2009). Younger and smaller firms tend to have higher external financing costs because they are less familiar to the markets and may be seen as carrying higher risk.

To capture the effect of firm age on cash flow sensitivity, we introduce a dummy variable that takes the value of 1 if the firm is younger than the median age of the sample and zero otherwise. We then add an interaction term of the dummy with the cash flow term to the FE regressions (i.e., we incorporate the variable $cfo_{i,t} \times youngfirm_{i,t}$ and estimate the associated coefficient).

To estimate the effect of firm size, we add a dummy variable for small firms which is equal to 1 if the firm is smaller than the median size of sampled firms and zero otherwise. A cross term with the cash flow variable is then added to the FE models (i.e., $cfo_{i,t} \times smallfirm_{i,t}$).

Meanwhile, to examine the influence of ownership structure on cash flow sensitivity of R&D investment, we look at three main areas: domestic ownership concentration, foreign ownership, and ownership type.[6] The influence of large controlling shareholders and foreign owners on cash flow sensitivity would depend heavily on their level of risk aversion and the length of their planning horizon which in turn would determine their willingness to provide steady funding for R&D long term rather than simply cash in on short term gains. The same holds for the various ownership types.

To measure domestic ownership concentration, we introduce a variable on the percentage of the firm owned by the "domestic ultimate owner" (i.e., the highest company in the ownership path that is located in the same country as the firm) and reported by the company as a direct ownership link. We then cross this with the cash flow term ($cfo_{i,t} \times duodirect_{i,t}$) and incorporate into the regression equations.

To represent foreign ownership, we introduce a dummy variable that takes the value of 1 if the ultimate owner is not located in the same country as the firm and zero otherwise and cross

[6] The categories used in this study are limited mainly by the availability of data.

thus with the cash flow variable ($cfo_{i,t} \times foreign_{i,t}$). Similarly, we introduce dummy variables to represent the different categories of owners of the firms, namely: banks, financial companies, foundations or research institutes, industrial companies, mutual and pension funds and trusts, named individuals or families, the state (i.e., government, public authority), and venture capitalists. All dummy variables are interacted with the cash flow term.

**Table 1: Financial Development Indicators for Institutions and Markets**
(2001–2012 average)

| | Institutions | | Markets | |
|---|---|---|---|---|
| | **Financial System Deposits** (% of GDP) | **Private Credit by Banks and Other Financial Institutions** (% of GDP) | **Outstanding Domestic Private Debt Securities + Stock Market Capitalization** (% of GDP) | **Stock Market Total Value Traded** (% of GDP) |
| Group 1 (more developed) | 137.42 | 112.78 | 231.90 | 162.49 |
| Hong Kong, China | 259.57 | 148.20 | 424.19 | 349.13 |
| Republic of Korea | 65.36 | 94.22 | 128.74 | 145.40 |
| Malaysia | 113.57 | 107.55 | 180.83 | 40.30 |
| Singapore | 111.18 | 101.16 | 193.83 | 115.14 |
| Group 2 (developing) | 46.06 | 50.40 | 54.52 | 40.80 |
| People's Republic of China | 44.01 | 111.02 | 76.91 | 81.86 |
| India | 53.81 | 37.79 | 63.92 | 59.60 |
| Indonesia | 36.13 | 22.44 | 29.66 | 13.29 |
| Philippines | 50.30 | 30.35 | 47.57 | 8.45 |
| East Asia (developing) | 37.94 | 35.68 | 53.20 | 10.68 |
| World | 37.82 | 32.11 | 55.33 | 6.56 |

GDP = gross domestic product.

Source: World Bank. April 2013 update. Global Financial Development Database. Washington, DC.

Note: Groups 1 and 2 were defined by the author.

**Table 2: Summary of Financial Development Indicators —Institutions and Markets**
(2001–2012 average)

| | **Development Score for Institutions**[a] | **Development Score for Markets**[b] | **Overall Financial Development Score**[c] |
|---|---|---|---|
| Group 1 (more developed) | 83.40 | 197.20 | 140.30 |
| Hong Kong, China | 135.92 | 386.66 | 261.29 |
| Republic of Korea | 53.19 | 137.07 | 95.13 |
| Malaysia | 73.71 | 110.56 | 92.14 |
| Singapore | 70.78 | 154.49 | 112.63 |
| Group 2 (developing) | 32.15 | 47.66 | 39.91 |
| People's Republic of China | 51.68 | 79.39 | 65.53 |
| India | 30.53 | 61.76 | 46.15 |
| Indonesia | 19.53 | 21.47 | 20.50 |
| Philippines | 26.88 | 28.01 | 27.45 |
| East Asia (developing only) | 24.54 | 31.94 | 28.24 |
| World | 23.31 | 30.95 | 27.13 |

[a]Average of the first two columns of Table 1.
[b]Average of the last two columns of Table 1.
[c]Average of the first two columns of this table.

Source: World Bank. April 2013 update. Global Financial Development Database. Washington, DC. Author's computations.

Similar to Ogawa (2013), we split the sample into two to see how the parameters would differ for firms operating in economies at varying stages of financial development. We use the same dataset (World Bank Global Financial Development Databank), but apply a slightly different scoring system to determine which economies can be categorized as more financially developed and which can be viewed as still developing in terms of their financial intermediaries and debt and equity markets. The indicators we considered were: (i) financial system deposits, (ii) private credit provided by banks and other financial institutions, (iii) total value of outstanding debt and equity securities as a percent of GDP, and (iv) the traded value in the stock market, all as a percent of GDP.

Table 1 shows how the sample economies fared in each of these indicators, while Table 2 summarizes the financial development scores. Based on the overall score, we classified the following economies as being more developed in terms of their financial markets and institutions: Hong Kong, China; the Republic of Korea; Malaysia; and Singapore. Meanwhile, considered still financially developing were: the People's Republic of China (PRC), India, Indonesia, and the Philippines.

As an additional exercise, we add interaction terms of the financial variables with cash flow to the FE regressions to determine how their levels influence sensitivity of R&D spending to internal financing availability. We do this for debt, equity, dividend payments, and financial asset investments. We also examine how the presence of firms with persistent negative cash flows (negative sum over the sample period) would affect the sensitivity of R&D investment to cash flow.

## IV. DATA AND TRENDS

### A. Sample Data

Data used in the paper were obtained from the Oriana database, which collects financial information on public and private firms in over 30 countries in the Asia and the Pacific region and the Middle East. The constructed panel dataset covered listed nonfinancial firms with sufficient R&D data operating in eight Asian economies during 2002–2011. These economies were the PRC; Hong Kong, China; India; Indonesia; the Republic of Korea; Malaysia; the Philippines; and Singapore.

Excluded from our panel data were firms from the financial industry and those with less than two time period observations on R&D spending throughout the 10-year period. Following other empirical studies, regression variables were also trimmed of 1% outliers. The sample comprised a total of 11,719 observations after all the restrictions.

### B. Descriptive Statistics

Tables 3 and 4 provide the summary statistics of the regressors for the sample Asian economies organized by financial development level, firm age, and firm size. There is no substantial difference between R&D intensity between the more financially developed economies and those still developing, nor in firm size (measured by the log of total assets measured in thousand United States dollars [USD]) and firm age, or the ratio of leverage and equity.

Net sales (log of levels in thousand USD) likewise do not differ by much, but there appear to be stronger sales growth and presumably higher profit potential in firms operating in financially developing economies. Firms at differing stages of financial development also seem to diverge in terms of internal cash flow levels and holdings of reserve cash. Those located in financially less developed economies have higher cash flow as a proportion of beginning-of-period stock of total assets and keep more of their funds in cash, also as a ratio of total assets, likely as a precautionary measure. They also seem to be investing more in financial assets as a proportion of their total wealth.[7]

Examining the data by age and size, younger firms clearly have higher R&D intensity than older firms regardless of the level of financial development of the economy they operate in, while smaller firms invest in R&D more heavily mainly in financially developed economies, where the smaller companies are also typically the younger ones (the opposite is true for firms in less financially developed economies). This peculiarity of the data also helps explain why newer firms have a higher cash flow ratio in financially developed economies but not in the developing ones, and why there is no substantial difference between small and large firms in terms of cash flow.

Young firms generally hold greater cash as a percentage of total assets compared to mature firms. While there is no marked difference between small and large firms in financially developed economies in terms of their cash holdings, larger firms in financially developing economies tend to carry higher cash reserves.

Meanwhile, newer and smaller firms typically have a higher amount of issued share capital in proportion to total assets than older and larger firms. Young firms generally invest proportionally more than mature firms in financial assets. In terms of size, small firms tend to undertake correspondingly greater financial investments than large firms in the context of developed economies, but the reverse seems to be true for firms in the financially developing areas.

[7] We will not be saying much yet about dividends at this point as the available variables in the database and the way the payouts are measured suggests measured dividends may be capturing the effects of changes in reserve capital. That is: $findiv_{i,t}^{computed} = findiv_{i,t}^{actual} - \Delta reservecapital_{i.t} + \omega_{i,t}$, where $\omega_{i,t}$ captures other possible deviations (e.g., changes in minority interest). Hence, some portion of measured dividend payments may actually be attributable to a change in reserve capital.

**Table 3: Summary Statistics, by Firm Age**

| | | Financially More Developed | | | Financially Less Developed | | | All Asia | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | | **Young** | **Mature** | **Full** | **Young** | **Mature** | **Full** | **Young** | **Mature** | **Full** |
| R&D intensity* | Mean | 0.024 | 0.011 | 0.017 | 0.021 | 0.009 | 0.015 | 0.023 | 0.010 | 0.016 |
| | Median | 0.012 | 0.004 | 0.007 | 0.012 | 0.003 | 0.006 | 0.012 | 0.004 | 0.006 |
| Net sales (log) | Mean | 11.076 | 12.223 | 11.689 | 12.054 | 11.605 | 11.836 | 11.453 | 12.010 | 11.744 |
| | Median | 10.992 | 12.136 | 11.635 | 12.100 | 11.603 | 11.895 | 11.420 | 11.965 | 11.734 |
| Growth in net sales (dlog) | Mean | 13.9% | 9.1% | 11.4% | 24.5% | 13.2% | 18.9% | 18.0% | 10.5% | 14.2% |
| | Median | 14.6% | 10.1% | 11.8% | 23.9% | 14.8% | 19.1% | 18.6% | 11.5% | 14.7% |
| Cash flow from operations* | Mean | 0.085 | 0.045 | 0.063 | 0.124 | 0.114 | 0.119 | 0.100 | 0.069 | 0.084 |
| | Median | 0.081 | 0.043 | 0.057 | 0.103 | 0.099 | 0.100 | 0.090 | 0.059 | 0.074 |
| Cash holdings* | Mean | 0.197 | 0.100 | 0.145 | 0.362 | 0.123 | 0.240 | 0.260 | 0.108 | 0.180 |
| | Median | 0.130 | 0.066 | 0.090 | 0.233 | 0.051 | 0.137 | 0.165 | 0.061 | 0.102 |
| Debt* | Mean | 0.522 | 0.575 | 0.551 | 0.600 | 0.652 | 0.628 | 0.552 | 0.602 | 0.580 |
| | Median | 0.479 | 0.570 | 0.528 | 0.581 | 0.637 | 0.612 | 0.515 | 0.590 | 0.557 |
| Equity (issued share capital)* | Mean | 0.217 | 0.145 | 0.178 | 0.214 | 0.121 | 0.169 | 0.216 | 0.137 | 0.175 |
| | Median | 0.128 | 0.086 | 0.100 | 0.171 | 0.051 | 0.120 | 0.150 | 0.075 | 0.107 |
| Dividends* | Mean | –0.046 | –0.017 | –0.031 | –0.128 | 0.006 | –0.060 | –0.078 | –0.009 | –0.042 |
| | Median | –0.004 | –0.005 | –0.005 | –0.003 | 0.015 | 0.004 | –0.003 | 0.000 | –0.002 |
| Financial asset investment* | Mean | 0.048 | 0.029 | 0.038 | 0.058 | 0.042 | 0.051 | 0.052 | 0.034 | 0.043 |
| | Median | 0.018 | 0.012 | 0.015 | 0.037 | 0.024 | 0.032 | 0.027 | 0.015 | 0.021 |
| Size (log of total assets) | Mean | 11.337 | 12.334 | 11.871 | 12.462 | 11.768 | 12.128 | 11.771 | 12.138 | 11.967 |
| | Median | 11.192 | 12.183 | 11.723 | 12.525 | 11.708 | 12.198 | 11.740 | 12.022 | 11.895 |
| Negative cash flow | Number of observations | 581 | 585 | 1216 | 44 | 86 | 141 | 625 | 671 | 1357 |
| | % of observations | 17.3% | 15.2% | 16.6% | 2.1% | 4.2% | 3.2% | 11.4% | 11.4% | 11.6% |
| Age of firms | Mean | 11.837 | 38.857 | 26.147 | 13.576 | 42.370 | 27.314 | 12.509 | 40.075 | 26.584 |
| | Median | 12 | 37 | 22 | 14 | 36 | 20 | 13 | 37 | 21 |
| Number of firms | | 758 | 631 | 1,418 | 939 | 541 | 1,558 | 1,697 | 1,172 | 2,976 |
| Number of observations | | 3,360 | 3,848 | 7,349 | 2,107 | 2,033 | 4,370 | 5,467 | 5,881 | 11,719 |

* Variables with asterisks are scaled by firm total assets, R&D = research and development.

Source: Oriana Database. Author's computations.

**Table 4: Summary Statistics, by Firm Size**

| | | Financially More Developed | | | Financially Less Developed | | | All Asia | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Variable** | | **Small** | **Large** | **Full** | **Small** | **Large** | **Full** | **Small** | **Large** | **Full** |
| R&D intensity* | Mean | 0.026 | 0.012 | 0.017 | 0.016 | 0.014 | 0.015 | 0.023 | 0.013 | 0.016 |
| | Median | 0.013 | 0.005 | 0.007 | 0.004 | 0.007 | 0.006 | 0.009 | 0.005 | 0.006 |
| Net sales (log) | Mean | 10.049 | 12.639 | 11.689 | 9.846 | 12.579 | 11.836 | 9.987 | 12.614 | 11.744 |
| | Median | 10.198 | 12.437 | 11.635 | 10.116 | 12.447 | 11.895 | 10.171 | 12.442 | 11.734 |
| Growth in net sales (dlog) | Mean | 11.0% | 11.5% | 11.4% | 13.9% | 20.8% | 18.9% | 11.9% | 15.3% | 14.2% |
| | Median | 11.0% | 12.1% | 11.8% | 15.3% | 20.3% | 19.1% | 12.5% | 15.5% | 14.7% |
| Cash flow from operations* | Mean | 0.059 | 0.065 | 0.063 | 0.116 | 0.119 | 0.119 | 0.077 | 0.087 | 0.084 |
| | Median | 0.062 | 0.055 | 0.057 | 0.098 | 0.101 | 0.100 | 0.074 | 0.074 | 0.074 |
| Cash holdings* | Mean | 0.163 | 0.134 | 0.145 | 0.141 | 0.277 | 0.240 | 0.156 | 0.192 | 0.180 |
| | Median | 0.099 | 0.087 | 0.090 | 0.050 | 0.168 | 0.137 | 0.085 | 0.109 | 0.102 |
| Debt* | Mean | 0.482 | 0.591 | 0.551 | 0.605 | 0.636 | 0.628 | 0.520 | 0.609 | 0.580 |
| | Median | 0.440 | 0.580 | 0.528 | 0.550 | 0.633 | 0.612 | 0.474 | 0.601 | 0.557 |
| Equity (issued share capital)* | Mean | 0.282 | 0.118 | 0.178 | 0.228 | 0.147 | 0.169 | 0.266 | 0.130 | 0.175 |
| | Median | 0.182 | 0.070 | 0.100 | 0.132 | 0.117 | 0.120 | 0.168 | 0.083 | 0.107 |
| Dividends* | Mean | –0.049 | –0.021 | –0.031 | –0.004 | –0.080 | –0.060 | –0.035 | –0.045 | –0.042 |
| | Median | –0.007 | –0.004 | –0.005 | 0.009 | 0.003 | 0.004 | –0.003 | –0.001 | –0.002 |
| Financial asset investment* | Mean | 0.041 | 0.037 | 0.038 | 0.039 | 0.055 | 0.051 | .040 | 0.044 | 0.043 |
| | Median | 0.013 | 0.016 | 0.015 | 0.019 | 0.035 | 0.032 | 0.015 | 0.024 | 0.021 |
| Size (log of total assets) | Mean | 10.262 | 12.804 | 11.871 | 10.027 | 12.911 | 12.128 | 10.190 | 12.847 | 11.967 |
| | Median | 10.434 | 12.521 | 11.723 | 10.220 | 12.740 | 12.198 | 10.381 | 12.613 | 11.895 |
| Negative cash flow | Number of observations | 701 | 515 | 1216 | 86 | 55 | 141 | 787 | 570 | 1357 |
| | % of observations | 26.0% | 11.1% | 16.5% | 7.2% | 1.7% | 3.2% | 20.3% | 7.3% | 11.6% |
| Age of firms | Mean | 19.979 | 29.725 | 26.147 | 29.458 | 26.517 | 27.314 | 22.883 | 28.417 | 26.584 |
| | Median | 16 | 28 | 22 | 25 | 19 | 20 | 18 | 22 | 21 |
| Number of firms | | 646 | 999 | 1,418 | 457 | 1,226 | 1,558 | 1,103 | 2,225 | 2,976 |
| Number of observations | | 2,695 | 4,654 | 7,349 | 1,187 | 3,183 | 4,370 | 3,882 | 7,837 | 11,719 |

* = variables with asterisks are scaled by firm total assets, R&D = research and development.

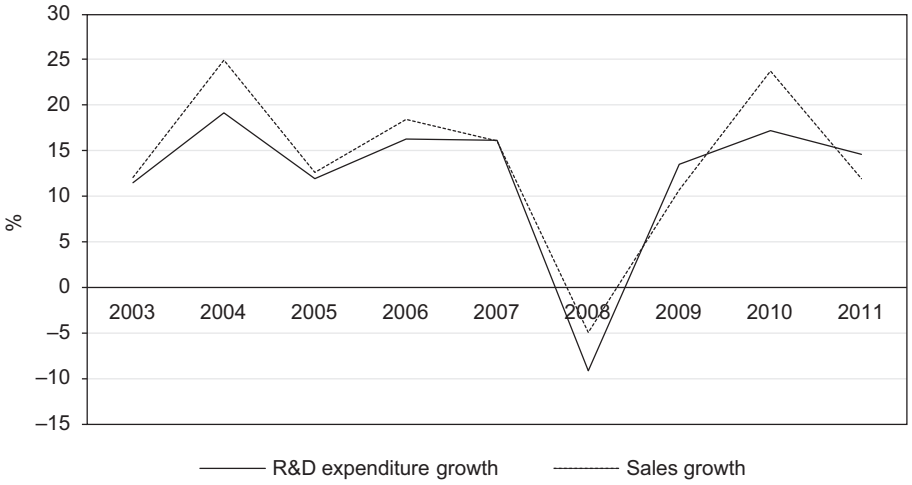
Source: Oriana Database. Author's computations.

## C. Sample Trends

Figure 1 shows the growth trends of R&D spending and sales over the sample period. The two variables move together through time, both declining sharply in 2008, at the peak of the global financial crisis. R&D intensity dipped in 2008, but continued to rise even through the European debt crisis of 2011 (Figure 2). In contrast, sales growth again dropped during the European crisis.

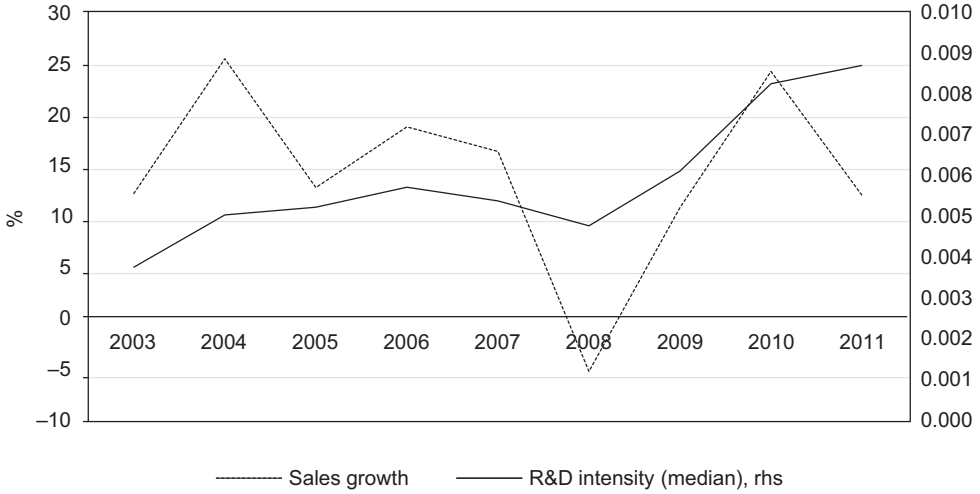
R&D investment of firms also appeared to follow similar paths as both internal cash flow and cash holdings (Figures 3 and 4). All the variables declined visibly in 2008, but managed to recover soon after. Cash flow, however, again visibly dipped in 2011, as a new global financial crisis developed in the euro zone.

**Figure 1: R&D Spending and Sales Growth Trends**



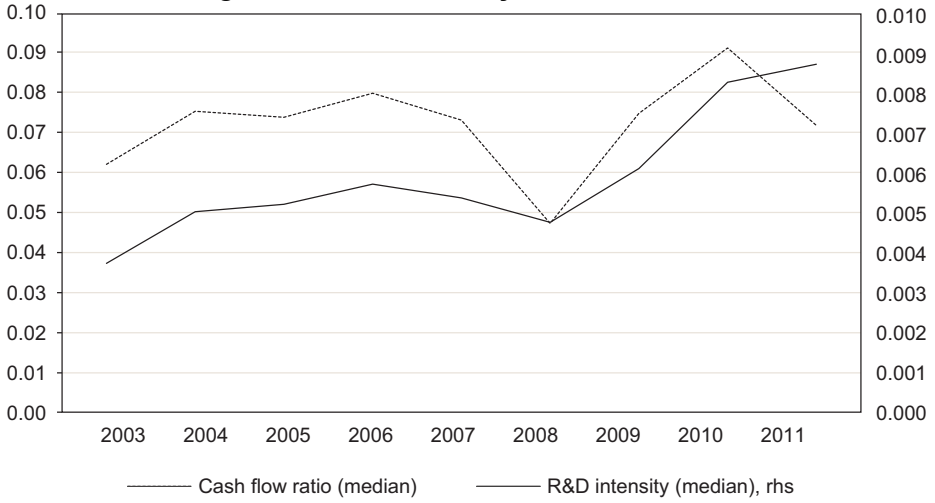

Source: Oriana database. Author's computations.

**Figure 2: R&D Intensity and Sales Growth**



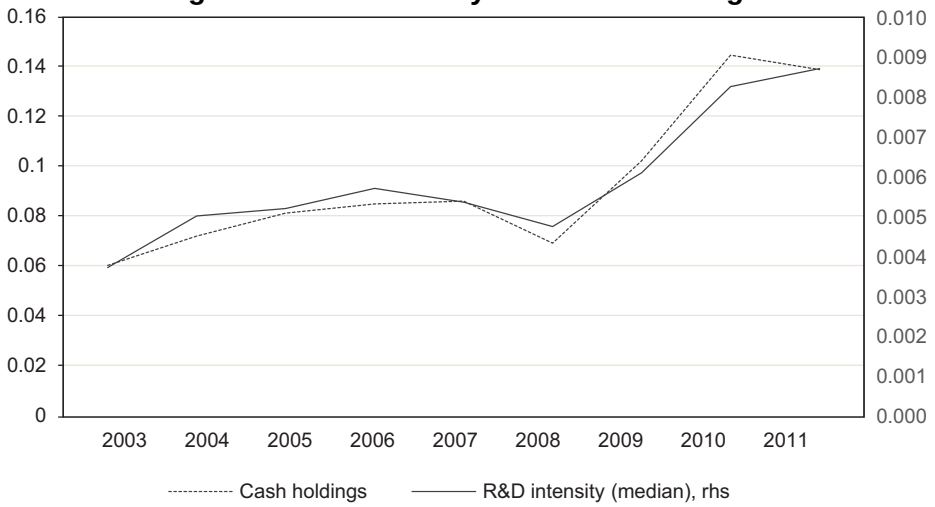

Source: Oriana database. Author's computations.
*Scaled by beginning-of-period total assets.

**Figure 3: R&D Intensity and Cash Flow***




Source: Oriana database. Author's computations.
*Scaled by beginning-of-period total assets.

**Figure 4: R&D Intensity and Cash Holdings***




Source: Oriana database. Author's computations.
*Scaled by beginning-of-period total assets.

## V. RESULTS

### A. Panel Regressions

Tables 5 and 6 summarize the fixed effects regression results of the R&D investment models in equations (1) to (4). Coefficients on the sales accelerator are mostly significant indicating some power of the variables to account for the profitability of firms. The cash flow variable shows strong positive significance in the panel regressions, suggesting that firms respond systematically to the level of internal finance.

The absence of a negative impact of a change in cash holdings indicates that firms do not typically resort to sudden cash drawdowns to fund R&D spending. Cash reserves likely have a significant positive impact on R&D as these also reflect the internal funding capacity of the firm.

Debt appears to play a greater role than equity given highly significant parameters. This is in contrast to studies on US firms, where stock issuance is the more important source of external financing for R&D. Hall (2002), for instance, notes the typically lower debt levels of R&D-intensive companies compared to the typical firm.

The effect is robust across all specifications, suggesting that leverage has a positive effect on R&D and likely remains at levels considered to be relatively safe.[8] The dominance of debt over equity however may be simply due to bank-centered financial systems in Asia and the absence of specialized markets for R&D more than information asymmetries or relative costs. Lee (2012) has a similar finding for the Republic of Korea and attributes this to the institutional setting in the country, where banks play a central role in corporate financing due in large part to policy history.

**Table 5: FE Regression Results Linear R&D Investment Models**

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.004** | 0.005** |
| | (4.50) | (4.00) | (4.97) |
| $sales_{i,t-1}$ | 0.003** | 0.005** | 0.006** |
| | (2.94) | (3.95) | (4.84) |
| $cfo_{i,t}$ | 0.024** | 0.022** | 0.020** |
| | (5.84) | (5.50) | (4.87) |
| $\Delta cash_{i,t}$ | 0.002* | 0.002** | 0.001 |
| | (2.49) | (3.28) | (1.44) |
| $debt_{i,t}$ | | 0.007** | 0.006** |
| | | (5.57) | (4.89) |
| $equity_{i,t}$ | | 0.001 | –0.000 |
| | | (0.27) | (0.16) |
| $findiv_{i,t}$ | | | –0.006** |
| | | | (5.59) |
| $fininv_{i,t}$ | | | 0.003+ |
| | | | (1.71) |
| $size_{i,t}$ | –0.006** | –0.007** | –0.009** |
| | (4.55) | (5.39) | (6.53) |
| *Constant* | 2.317** | 2.265** | 2.366** |
| | (3.28) | (3.24) | (3.40) |
| *Observations* | 10,337 | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.07 | 0.08 | 0.09 |

+ = significant at 10%,* = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

[8] Note however the significant negative sign on the coefficient of squared debt, implying higher leverage would eventually have a dampening effect on R&D investment.

**Table 6: FE Regression Results Quadratic R&D Investment Models**

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** | 0.005** |
| | (6.21) | (5.42) | (5.68) |
| $sales_{i,t-1}$ | 0.005** | 0.005** | 0.006** |
| | (4.84) | (5.38) | (5.64) |
| $cfo_{i,t}$ | 0.009** | 0.010** | 0.009** |
| | (2.61) | (2.75) | (2.60) |
| $cfo_{i,t}^2$ | 0.058** | 0.054** | 0.052** |
| | (5.58) | (5.15) | (4.91) |
| $cash_{i,t}$ | 0.010** | 0.009** | 0.008** |
| | (3.83) | (3.42) | (2.71) |
| $cash_{i,t}^2$ | –0.000 | –0.000 | –0.001 |
| | (0.33) | (0.09) | (0.74) |
| $debt_{i,t}$ | | 0.009** | 0.009** |
| | | (4.58) | (4.29) |
| $debt_{i,t}^2$ | | –0.002** | –0.002* |
| | | (2.63) | (2.53) |
| $equity_{i,t}$ | | –0.000 | –0.001 |
| | | (0.07) | (0.27) |
| $equity_{i,t}^2$ | | –0.001 | –0.000 |
| | | (0.91) | (0.44) |
| $findiv_{i,t}$ | | | –0.003* |
| | | | (2.22) |
| $fininv_{i,t}$ | | | 0.003+ |
| | | | (1.77) |
| $size_{i,t}$ | –0.007** | –0.008** | –0.008** |
| | (6.40) | (6.90) | (7.38) |
| *Constant* | 1.799** | 1.883** | 1.842** |
| | (2.92) | (3.06) | (2.98) |
| *Observations* | 11,719 | 11,719 | 11,719 |
| *Number of firms* | 2,976 | 2,976 | 2,976 |
| *Adjusted R-squared* | 0.09 | 0.10 | 0.10 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

Measured dividend payments seem to divert internal funds from R&D, as implied by the highly significant negative coefficients. As mentioned earlier, however, some of the effects may be due to a mismeasurement of dividends in that the variables may also be capturing the effects of changes in reserve capital, which are funds set aside for future investment. For instance, the estimated decline (increase) in R&D spending due to higher (lower) dividend payouts may in fact be due to a fall (rise) in reserve capital.

Investment in financial assets does not appear to crowd out investment in R&D. On the contrary, the related coefficient is significantly positive in at least one specification. This means that, at the very least, financial asset investment has no negative influence on innovation spending. This stands in contrast to the findings of Seo, Kim, and Kim (2012) for the Republic of Korea, where increased financial investment and profit opportunities were found to crowd out R&D investment.

Meanwhile, the Schumpeterian hypothesis does not seem to hold in the present sample as smaller firms tend to invest more heavily in R&D (highly significant and negative coefficient on size as measured by the log of total assets). There have been similar findings recently. For instance, Akcigit (2009) found R&D spending out of total revenues to be higher for smaller firms in the US, while Sjoholm and Lundin (2013) and Jefferson et al. (2006) found a negative effect of firm size on R&D intensity in Chinese firms.

## B. Determinants of Cash Flow Sensitivity

Results show that the sensitivity of R&D spending to internal funds availability is systematically related to firm characteristics that make it more likely to face financing constraints. Tables 7 and 8 show significant positive coefficients on interaction variables between cash flow and the dummies for age and size.

Younger and smaller firms, which are more likely to face financing frictions and pay higher external financing costs, tend to have higher cash flow sensitivity than older and larger firms which can more easily tap debt and equity markets. The results are robust across the different specifications.

The study also finds that the greater the direct share of the domestic owner in a firm, or the higher the ownership concentration, the lower is the sensitivity of R&D spending to changes in the level of internal funds as reflected by operational cash flow (significantly negative parameters of the interaction terms in Tables 9 and 10). This suggests greater commitment of controlling shareholders to the longer-term prospects of the firm—e.g., greater willingness to fund R&D—with a bigger in the company.

In the same way, foreign ownership of a firm tends to lower cash flow sensitivity of R&D investment, suggesting greater stability of funding for innovation research (Tables 11 and 12). As in Arikawa, Kawanishi, and Miyajima (2011) for Japan, we find little evidence of myopic behavior of foreign investors that could possibly lead them to underinvest in technology.

**Table 7: FE Regression Results – Effect of Firm Age and Size and Cash Flow Sensitivity of R&D Spending** (Linear)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.004** | 0.004** |
| | (4.01) | (3.51) | (4.48) |
| $sales_{i,t-1}$ | 0.003** | 0.004** | 0.005** |
| | (2.70) | (3.65) | (4.50) |
| $cfo_{i,t}$ | 0.005 | 0.003 | 0.000 |
| | (1.24) | (0.93) | (0.01) |
| $\Delta cash_{i,t}$ | 0.002* | 0.002** | 0.001 |
| | (2.55) | (3.42) | (1.57) |
| $debt_{i,t}$ | | 0.007** | 0.006** |
| | | (5.39) | (4.82) |
| $equity_{i,t}$ | | 0.000 | -0.001 |
| | | (0.19) | (0.23) |
| $findiv_{i,t}$ | | | –0.007** |
| | | | (5.90) |
| $fininv_{i,t}$ | | | 0.002 |
| | | | (1.55) |
| $size_{i,t}$ | –0.006** | –0.007** | –0.009** |
| | (4.29) | (5.08) | (6.14) |
| $cfo_{i,t} \times youngfirm_{i,t}$ | 0.019** | 0.018** | 0.015* |
| | (3.15) | (2.98) | (2.51) |
| $cfo_{i,t} \times smallfirm_{i,t}$ | 0.013* | 0.014** | 0.018** |
| | (2.55) | (2.83) | (3.70) |
| *Constant* | 2.312** | 2.327** | 2.460** |
| | (2.89) | (2.92) | (3.09) |
| *Observations* | 10,002 | 10,002 | 10,002 |
| *Number of firms* | 2,835 | 2,835 | 2,835 |
| *Adjusted R-squared* | 0.07 | 0.09 | 0.10 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 8: FE Regression Results – Firm Age and Size and Cash Flow Sensitivity of R&D Spending** (Quadratic)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** | 0.005** |
| | (5.90) | (5.18) | (5.45) |
| $sales_{i,t-1}$ | 0.005** | 0.005** | 0.006** |
| | (4.64) | (5.14) | (5.38) |
| $cfo_{i,t}$ | –0.009* | –0.008* | –0.009* |
| | (2.22) | (2.10) | (2.28) |
| $cfo_{i,t}^2$ | 0.058** | 0.054** | 0.052** |
| | (5.35) | (4.95) | (4.77) |
| $cash_{i,t}$ | 0.010** | 0.009** | 0.008** |
| | (3.81) | (3.40) | (2.66) |
| $cash_{i,t}^2$ | 0.000 | 0.000 | –0.001 |
| | (0.02) | (0.27) | (0.43) |
| $debt_{i,t}$ | | 0.009** | 0.008** |
| | | (4.32) | (3.99) |
| $debt_{i,t}^2$ | | –0.002* | –0.002* |
| | | (2.40) | (2.29) |
| $equity_{i,t}$ | | –0.001 | –0.002 |
| | | (0.15) | (0.34) |
| $equity_{i,t}^2$ | | –0.001 | –0.000 |
| | | (0.83) | (0.36) |
| $findiv_{i,t}$ | | | –0.003* |
| | | | (2.27) |
| $fininv_{i,t}$ | | | 0.003+ |
| | | | (1.77) |
| $size_{i,t}$ | –0.007** | –0.008** | –0.008** |
| | (6.00) | (6.50) | (6.96) |
| $cfo_{i,t} \times youngfirm_{i,t}$ | 0.010+ | 0.010+ | 0.010+ |
| | (1.72) | (1.75) | (1.71) |
| $cfo_{i,t} \times smallfirm_{i,t}$ | 0.020** | 0.019** | 0.020** |
| | (4.09) | (4.08) | (4.22) |
| *Constant* | 1.803** | 1.958** | 1.927** |
| | (2.61) | (2.81) | (2.76) |
| *Observations* | 11,348 | 11,348 | 11,348 |
| *Number of firms* | 2,869 | 2,869 | 2,869 |
| *Adjusted R-squared* | 0.10 | 0.11 | 0.11 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 9: FE Regression Results – Domestic Ownership Concentration and Cash Flow Sensitivity of R&D Spending** (Linear)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.003** | 0.004** |
| | (3.32) | (2.81) | (3.58) |
| $sales_{i,t-1}$ | 0.003* | 0.004** | 0.005** |
| | (2.04) | (2.91) | (3.58) |
| $cfo_{i,t}$ | 0.066** | 0.063** | 0.059** |
| | (3.95) | (3.74) | (3.61) |
| $\Delta cash_{i,t}$ | 0.003* | 0.003** | 0.002** |
| | (2.44) | (3.72) | (3.66) |
| $debt_{i,t}$ | | 0.006** | 0.005** |
| | | (4.22) | (3.51) |
| $equity_{i,t}$ | | 0.001 | –0.000 |
| | | (0.23) | (0.12) |
| $findiv_{i,t}$ | | | –0.006** |
| | | | (4.88) |
| $fininv_{i,t}$ | | | 0.005** |
| | | | (2.83) |
| $size_{i,t}$ | –0.005** | –0.006** | –0.008** |
| | (2.98) | (3.57) | (4.54) |
| $cfo_{i,t} \times duodirect_{i,t}$ | –0.052** | –0.050** | –0.049** |
| | (2.78) | (2.67) | (2.68) |
| *Constant* | 2.475** | 2.516** | 2.642** |
| | (2.65) | (2.73) | (2.90) |
| *Observations* | 6,386 | 6,386 | 6,386 |
| *Number of firms* | 1,848 | 1,848 | 1,848 |
| *Adjusted R-squared* | 0.07 | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 10: FE Regression Results – Domestic Ownership Concentration and Cash Flow Sensitivity of R&D Spending** (Quadratic)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.004** | 0.004** |
| | (4.59) | (3.88) | (4.18) |
| $sales_{i,t-1}$ | 0.004** | 0.005** | 0.005** |
| | (3.49) | (4.06) | (4.33) |
| $cfo_{i,t}$ | 0.052** | 0.051** | 0.050** |
| | (3.27) | (3.21) | (3.15) |
| $cfo_{i,t}^2$ | 0.056** | 0.052** | 0.050** |
| | (4.49) | (4.19) | (3.99) |
| $cash_{i,t}$ | 0.009** | 0.008* | 0.007* |
| | (3.07) | (2.54) | (2.00) |
| $cash_{i,t}^2$ | –0.000 | 0.000 | –0.000 |
| | (0.04) | (0.23) | (0.34) |
| $debt_{i,t}$ | | 0.008** | 0.007** |
| | | (3.47) | (3.09) |
| $debt_{i,t}^2$ | | –0.002* | –0.002* |
| | | (2.21) | (2.13) |
| $equity_{i,t}$ | | 0.002 | 0.001 |
| | | (0.33) | (0.14) |
| $equity_{i,t}^2$ | | –0.001 | –0.001 |
| | | (0.81) | (0.39) |
| $findiv_{i,t}$ | | | –0.003* |
| | | | (2.00) |
| $fininv_{i,t}$ | | | 0.004* |
| | | | (2.30) |
| $size_{i,t}$ | –0.007** | –0.007** | –0.008** |
| | (4.93) | (5.29) | (5.87) |
| $cfo_{i,t} \times duodirect_{i,t}$ | –0.052** | –0.050** | –0.049** |
| | (2.94) | (2.84) | (2.79) |
| *Constant* | 1.884* | 1.972* | 1.916* |
| | (2.28) | (2.41) | (2.32) |
| *Observations* | 7,235 | 7,235 | 7,235 |
| *Number of firms* | 1,872 | 1,872 | 1,872 |
| *Adjusted R-squared* | 0.09 | 0.10 | 0.10 |

+ = significant at 10%, * = significant at 5%, ** significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 11: FE Regression Results – Foreign Ownership and Cash Flow Sensitivity of R&D Spending** (Linear)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.004** | 0.005** |
| | (4.43) | (3.95) | (4.90) |
| $sales_{i,t-1}$ | 0.003** | 0.005** | 0.006** |
| | (2.90) | (3.89) | (4.77) |
| $cfo_{i,t}$ | 0.026** | 0.024** | 0.021** |
| | (5.91) | (5.53) | (4.90) |
| $\Delta cash_{i,t}$ | 0.002* | 0.002** | 0.001 |
| | (2.51) | (3.28) | (1.45) |
| $debt_{i,t}$ | | 0.007** | 0.006** |
| | | (5.47) | (4.83) |
| $equity_{i,t}$ | | 0.001 | –0.000 |
| | | (0.25) | (0.17) |
| $findiv_{i,t}$ | | | –0.006** |
| | | | (5.57) |
| $fininv_{i,t}$ | | | 0.002+ |
| | | | (1.69) |
| $size_{i,t}$ | –0.006** | –0.007** | –0.009** |
| | (4.51) | (5.34) | (6.45) |
| $cfo_{i,t} \times foreign_{i,t}$ | –0.021* | –0.019* | –0.016* |
| | (2.49) | (2.26) | (2.03) |
| *Constant* | 2.350** | 2.296** | 2.390** |
| | (3.34) | (3.29) | (3.43) |
| *Observations* | 10,337 | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.07 | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 12: FE Regression Results – Foreign Ownership and Cash Flow Sensitivity of R&D Spending** (Quadratic)

| | Internal Finance | External Finance | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** | 0.005** |
| | (6.16) | (5.38) | (5.63) |
| $sales_{i,t-1}$ | 0.005** | 0.005** | 0.006** |
| | (4.80) | (5.34) | (5.58) |
| $cfo_{i,t}$ | 0.010** | 0.011** | 0.010** |
| | (2.74) | (2.85) | (2.68) |
| $cfo_{i,t}^2$ | 0.057** | 0.053** | 0.051** |
| | (5.55) | (5.13) | (4.89) |
| $cash_{i,t}$ | 0.010** | 0.009** | 0.008** |
| | (3.81) | (3.40) | (2.71) |
| $cash_{i,t}^2$ | –0.000 | –0.000 | –0.001 |
| | (0.34) | (0.09) | (0.73) |
| $debt_{i,t}$ | | 0.009** | 0.009** |
| | | (4.57) | (4.28) |
| $debt_{i,t}^2$ | | –0.002** | –0.002* |
| | | (2.64) | (2.54) |
| $equity_{i,t}$ | | –0.000 | –0.001 |
| | | (0.07) | (0.27) |
| $equity_{i,t}^2$ | | –0.001 | –0.001 |
| | | (0.92) | (0.45) |
| $findiv_{i,t}$ | | | –0.003* |
| | | | (2.20) |
| $fininv_{i,t}$ | | | 0.003+ |
| | | | (1.75) |
| $size_{i,t}$ | –0.007** | –0.008** | –0.008** |
| | (6.38) | (6.86) | (7.33) |
| $cfo_{i,t} \times foreign_{i,t}$ | –0.012 | –0.012 | –0.011 |
| | (1.63) | (1.57) | (1.49) |
| *Constant* | 1.818** | 1.901** | 1.859** |
| | (2.96) | (3.09) | (3.01) |
| *Observations* | 11,719 | 11,719 | 11,719 |
| *Number of firms* | 2,976 | 2,976 | 2,976 |
| *Adjusted R-squared* | 0.09 | 0.10 | 0.10 |

+ = significant at 10%, * = significant at 5%, ** significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 13: FE Regression Results – Ownership Type and Cash Flow Sensitivity of R&D Spending**

| | Linear | | | Quadratic | | |
|---|---|---|---|---|---|---|
| **Owner Type** | **Internal Finance** | **External Finance** | **All** | **Internal Finance** | **External Finance** | **All** |
| Bank | –0.011 | –0.011 | –0.009 | –0.010 | –0.011+ | –0.010 |
| | (1.17) | (1.27) | (0.93) | (1.56) | (1.84) | (1.59) |
| Financial company | 0.019 | 0.021 | 0.018 | 0.011 | 0.013 | 0.013 |
| | (0.93) | (1.04) | (0.89) | (0.54) | (0.66) | (0.63) |
| Foundation or research institute | –0.031+ | –0.032+ | –0.033+ | –0.006 | –0.010 | –0.011 |
| | (1.72) | (1.84) | (1.93) | (0.26) | (0.45) | (0.49) |
| Industrial company | –0.010 | –0.010 | –0.010 | –0.011 | –0.010 | –0.010 |
| | (1.30) | (1.30) | (1.32) | (1.51) | (1.44) | (1.41) |
| Mutual or pension fund or trust | 0.004 | 0.003 | 0.002 | –0.010 | –0.010 | –0.011 |
| | (0.15) | (0.12) | (0.06) | (0.45) | (0.46) | (0.50) |
| Named individuals or families | 0.011 | 0.011 | 0.011 | 0.015+ | 0.014+ | 0.014+ |
| | (1.28) | (1.27) | (1.30) | (1.93) | (1.79) | (1.73) |
| Government | –0.011 | –0.011 | –0.009 | –0.011 | –0.010 | –0.008 |
| | (1.26) | (1.30) | (1.16) | (1.43) | (1.27) | (1.10) |
| Venture capital | 0.141** | 0.138** | 0.139** | 0.133** | 0.127** | 0.128** |
| | (17.97) | (18.18) | (18.88) | (14.17) | (14.12) | (14.59) |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 14: FE Regression – Comparative Results on Firms in Financially Developed and Financially Developing Economies**
(Linear R&D Investment Models)

| | **Internal Finance** (developed) | **Internal Finance** (developing) | **External Finance** (developed) | **External Finance** (developing) | **All** (developed) | **All** (developing) |
|---|---|---|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.006** | 0.005** | 0.005** | 0.005** | 0.005** | 0.006** |
| | (4.22) | (3.51) | (3.61) | (3.52) | (4.14) | (4.09) |
| $sales_{i,t-1}$ | 0.004** | 0.003+ | 0.005** | 0.004* | 0.006** | 0.006** |
| | (3.29) | (1.74) | (3.97) | (2.35) | (4.56) | (3.16) |
| $cfo_{i,t}$ | 0.017** | 0.024** | 0.017** | 0.021** | 0.016** | 0.018** |
| | (3.48) | (3.73) | (3.56) | (3.50) | (3.35) | (3.03) |
| $\Delta cash_{i,t}$ | 0.003* | 0.004** | 0.003* | 0.004** | 0.002 | 0.002+ |
| | (2.39) | (5.55) | (2.06) | (5.09) | (1.61) | (1.90) |
| $debt_{i,t}$ | | | 0.008** | 0.004** | 0.007** | 0.004** |
| | | | (3.97) | (3.14) | (3.38) | (3.21) |
| $equity_{i,t}$ | | | –0.000 | 0.002 | –0.001 | 0.002 |
| | | | (0.04) | (0.78) | (0.31) | (0.68) |
| $findiv_{i,t}$ | | | | | –0.010** | –0.004** |
| | | | | | (4.11) | (2.73) |
| $fininv_{i,t}$ | | | | | 0.004 | 0.003+ |
| | | | | | (1.43) | (1.78) |
| $size_{i,t}$ | –0.005** | –0.004** | –0.007** | –0.005** | –0.008** | –0.007** |
| | (4.05) | (2.91) | (4.77) | (3.49) | (5.83) | (4.61) |
| *Constant* | 2.302** | 1.756** | 2.355** | 1.653** | 2.599** | 1.606** |
| | (3.16) | (3.72) | (3.21) | (3.49) | (3.55) | (3.39) |
| *Observations* | 6493 | 3873 | 6493 | 3873 | 6493 | 3873 |
| *Number of firms* | 1417 | 1527 | 1417 | 1527 | 1417 | 1527 |
| *Adjusted R-squared* | 0.05 | 0.14 | 0.06 | 0.15 | 0.07 | 0.16 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 15: FE Regression – Comparative Results on Firms in Financially Developed and Financially Developing Economies**
(Quadratic R&D Investment Models)

| | **Internal Finance** (developed) | **Internal Finance** (developing) | **External Finance** (developed) | **External Finance** (developing) | **All** (developed) | **All** (developing) |
|---|---|---|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** | 0.004** | 0.005** | 0.005** | 0.005** |
| | (4.49) | (4.52) | (3.87) | (4.19) | (4.22) | (4.36) |
| $sales_{i,t-1}$ | 0.005** | 0.004** | 0.005** | 0.005** | 0.006** | 0.005** |
| | (4.04) | (2.70) | (4.46) | (3.16) | (4.85) | (3.39) |
| $cfo_{i,t}$ | 0.011** | 0.016** | 0.012** | 0.016** | 0.012** | 0.014* |
| | (2.68) | (2.72) | (2.89) | (2.79) | (2.88) | (2.48) |
| $cfo_{i,t}^2$ | 0.068** | 0.029+ | 0.065** | 0.023 | 0.059** | 0.025 |
| | (5.94) | (1.86) | (5.69) | (1.48) | (5.32) | (1.60) |
| $cash_{i,t}$ | 0.012** | 0.003 | 0.010** | 0.003 | 0.009* | –0.000 |
| | (3.20) | (1.16) | (2.62) | (0.87) | (2.25) | (0.11) |
| $cash_{i,t}^2$ | –0.001 | 0.002 | –0.001 | 0.002+ | –0.002 | 0.002 |
| | (0.43) | (1.57) | (0.28) | (1.70) | (0.81) | (1.29) |
| $debt_{i,t}$ | | | 0.006+ | 0.009** | 0.006 | 0.009** |
| | | | (1.84) | (3.24) | (1.62) | (3.14) |
| $debt_{i,t}^2$ | | | 0.000 | –0.002 | 0.000 | –0.002 |
| | | | (0.01) | (1.49) | (0.12) | (1.41) |
| $equity_{i,t}$ | | | –0.007 | 0.001 | –0.008 | –0.000 |
| | | | (1.06) | (0.23) | (1.23) | (0.05) |
| $equity_{i,t}^2$ | | | 0.004 | -0.001 | 0.005 | 0.000 |
| | | | (1.15) | (0.46) | (1.38) | (0.10) |
| $findiv_{i,t}$ | | | | | –0.006** | –0.004** |
| | | | | | (2.81) | (2.77) |
| $fininv_{i,t}$ | | | | | 0.002 | 0.003+ |
| | | | | | (0.90) | (1.82) |
| $size_{i,t}$ | –0.006** | –0.006** | –0.008** | –0.006** | –0.009** | –0.007** |
| | (5.16) | (4.37) | (5.70) | (4.57) | (6.41) | (4.90) |
| *Constant* | 2.282** | 1.517** | 2.357** | 1.483** | 2.425** | 1.383** |
| | (3.55) | (3.52) | (3.65) | (3.41) | (3.74) | (3.15) |
| *Observations* | 7,483 | 4,276 | 7,483 | 4,276 | 7,483 | 4,276 |
| *Number of firms* | 1,439 | 1,540 | 1,439 | 1,540 | 1,439 | 1,540 |
| *Adjusted R-squared* | 0.09 | 0.14 | 0.09 | 0.15 | 0.10 | 0.15 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, FE = fixed effects, R&D = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

Table 13 summarizes the coefficients and their t-statistics on the cross terms between internal cash flow and ownership type. For the linear models, fixed effects regression show systematically lower cash flow sensitivity of R&D spending if a firm is owned by a foundation or research institution (i.e., significant and negative coefficients on the interaction variable). A firm, however, is more vulnerable to fluctuations in internal financing if controlled by venture capital. For the quadratic models, vulnerability of innovation spending tends to be higher also for firms owned by venture capitalists and known families and firms.

Although not significantly so, cash flow sensitivity of R&D spending generally tends to be lower for banks, industrial companies (the largest category), and state-owned firms, and higher for known individuals and families. The results for the most part are intuitive, except for the coefficients on the cross terms of the dummies for institutional investors (i.e., mutual pension funds and financial companies apart from banks), which are not significant.

Tables 14 and 15 show a comparison of the fixed effects regression results for firms in financially developed versus those in financially developing economies. The hypothesis is that companies operating in weaker financial environments, and hence more likely to face financing frictions a priori, will exhibit greater responsiveness to fluctuations in internal financing. However, the coefficients on the cash flow term in the R&D investment models do not appear to be very much different for the two groups, particularly in the full specifications.[9]

We also do not find significant coefficients on the cross terms of cash flow with debt, equity, dividend payments, or financial asset investment. However, the presence of firms with persistent negative cash flows, defined as the case where the sum over the 10-year sample period is less than zero, tend to lower the measured cash flow sensitivity of innovation spending of firms overall (significant Appendix Table A.6). Brown, Fazzari, and Petersen (2009) note that in the US, such firms often make heavy use of public equity to expand investment when internal funds are low. In Asia, they are a more common feature of financially developed economies than financially developing ones (Table 1).

## C. Robustness Check

Finally, we use the Arellano-Bond (1991) systems difference Generalized Method of Moments (GMM) estimator, which addresses endogeneity issues and allows us to include a lag of the dependent variable as a regressor in the empirical models.[10] Table 16 summarizes the results of the estimation.

Tests of instrument validity (Sargan/Hansen J test) and autocorrelation confirm the appropriateness of the empirical models. Robust results from the fixed regressions are the significant (and now even higher) coefficients on cash flow and cash reserves. Results confirm the vulnerability of R&D investment of firms to the availability of internally generated funds.

The decline in influence of the sales accelerator terms is also a notable result. Highly significant and positive coefficients on the lag of the dependent variable suggest it may be proxying for a lot of unobserved determinants earlier captured by the sales variables.

[9] To further explore this hypothesis, we also introduced a dummy variable for firms in developing economies (equal to 1 if operating in a financially developing economy) and crossed this with the cash flow term. The interaction term was not found to be statistically significant in the various specifications. We do not incorporate the results in this paper for brevity.

[10] Following Bond and Meghir (1994) and Brown and Petersen (2009), we use the third to fifth lag of the endogenous variables as instruments.

Alternatively, the result suggests very high adjustment costs of firms, leading them to smooth R&D spending over time.

Meanwhile, debt losing its importance in the linear R&D investment models does not exactly negate our earlier conjecture. With reverse causality problems addressed in estimation, insignificant impact of debt may even be interpreted as lending little support to the hypothesis that leverage worsens a firm's risk profile, raising external financing costs and reducing investment. Debt, however, continues to play a positive role based on the quadratic investment models and still a much more dominant one than equity.

**Table 16: GMM Estimates of Linear R&D Models**

| | Internal Finance Variables | External Finance Variables | All |
|---|---|---|---|
| $R\&D_{i,t-1}$ | 0.301** | 0.304** | 0.281** |
| | (4.90) | (5.46) | (5.66) |
| $\Delta sales_{i,t}$ | 0.031+ | 0.005 | 0.012 |
| | (1.82) | (0.37) | (1.08) |
| $sales_{i,t-1}$ | –0.007 | –0.011 | 0.008 |
| | (0.59) | (0.81) | (0.67) |
| $cfo_{i,t}$ | 0.095** | 0.079** | 0.043* |
| | (3.05) | (3.49) | (2.33) |
| $\Delta cash_{i,t}$ | 0.014** | 0.015** | 0.005 |
| | (6.33) | (7.62) | (1.17) |
| $debt_{i,t}$ | 0.007 | –0.000 | 0.011 |
| | (0.55) | (0.00) | (1.63) |
| $equity_{i,t}$ | | 0.014 | 0.020 |
| | | (0.64) | (0.94) |
| $findiv_{i,t}$ | | | –0.021* |
| | | | (2.44) |
| $fininv_{i,t}$ | | | 0.011 |
| | | | (1.06) |
| $size_{i,t}$ | | 0.009 | –0.010 |
| | | (0.63) | (0.83) |
| *Observations* | 8,665 | 8,665 | 8,665 |
| *Number of firms* | 2830 | 2830 | 2830 |
| *AR(1) p-value* | 0.000 | 0.000 | 0.000 |
| *AR(2) p-value* | 0.330 | 0.375 | 0.503 |
| *Sargan/Hansen test* | 0.613 | 0.151 | 0.365 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, GMM = Generalized Method of Moments, RD = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table 17: GMM Estimates of Quadratic R&D Models**

| | Internal Finance Variables | External Finance Variables | All |
|---|---|---|---|
| $R\&D_{i,t-1}$ | 0.287** | 0.264** | 0.244** |
| | (5.66) | (5.68) | (5.39) |
| $\Delta sales_{i,t}$ | 0.025+ | 0.005 | 0.007 |
| | (1.90) | (0.39) | (0.80) |
| $sales_{i,t-1}$ | 0.005 | –0.003 | 0.009 |
| | (0.43) | (0.23) | (0.73) |
| $cfo_{i,t}$ | 0.065* | 0.058** | 0.035* |
| | (2.09) | (2.79) | (2.24) |
| $cfo_{i,t}^2$ | 0.046 | 0.039 | 0.052+ |
| | (0.97) | (1.11) | (1.68) |
| $cash_{i,t}$ | 0.028+ | 0.039** | 0.034* |
| | (1.67) | (2.61) | (2.24) |
| $cash_{i,t}^2$ | –0.000 | –0.001 | –0.002 |
| | (0.09) | (0.85) | (1.37) |
| $debt_{i,t}$ | | 0.036** | 0.046** |
| | | (2.71) | (3.14) |
| $debt_{i,t}^2$ | | –0.012** | –0.014** |
| | | (2.70) | (2.81) |
| $equity_{i,t}$ | | –0.015 | –0.017 |
| | | (0.55) | (0.72) |
| $equity_{i,t}^2$ | | 0.006 | 0.007 |
| | | (0.70) | (0.78) |
| $findiv_{i,t}$ | | | –0.012 |
| | | | (1.20) |
| $fininv_{i,t}$ | | | 0.015+ |
| | | | (1.70) |
| $size_{i,t}$ | –0.003 | 0.002 | –0.010 |
| | (0.25) | (0.15) | (0.76) |
| *Observations* | 8,665 | 8,665 | 8,665 |
| *Number of firms* | 2,830 | 2,830 | 2,830 |
| *AR(1) p-value* | 0.000 | 0.000 | 0.000 |
| *AR(2) p-value* | 0.415 | 0.297 | 0.435 |
| *Sargan/Hansen test* | 0.215 | 0.212 | 0.399 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%, GMM = Generalized Method of Moments, RD = research and development.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

## VI. CONCLUDING REMARKS

Noting the importance of innovation in fuelling future growth in Asia, this paper investigates the financial determinants of R&D investment in the region. Given how R&D spending is especially difficult to finance, corporate financing choices are clearly at the core of investment decisions. In view of this, we estimate an R&D investment model based on a sales accelerator and featuring variables that represent internal as well as external financing and that capture the impact of alternative uses of corporate funds.

We sample listed nonfinancial firms located in eight Asian economies for the period 2002–2012 and estimate the empirical model by fixed effects panel regression. We also apply the GMM systems estimator developed by Arellano and Bond (1991) as a check. A robust finding across estimations is the highly significant and positive coefficient on the cash flow term, representing the availability of internal funds. This suggests financing constraints felt by firms and dependence on internally generated funds.

We examine further the nature of cash flow sensitivity of R&D spending and find that it tends to be higher for younger and smaller firms than for the more mature and larger firms. However, it is significantly lower for firms with large (domestic) controlling shareholders and those with majority foreign ownership, suggesting stability of funding and high commitment of their owners to the long-term growth of the company. The study found no substantial difference in behavior among firms operating in financially more developed economies and those located in still financially developing countries.

Debt is the more dominant source of external financing based on our empirical findings, while equity financing seemingly plays only a tiny role. This contrast with results in advanced economies outside of Asia, where financial markets are deeper and specialized markets exist. In the context of alternative uses of funds, we do not find strong evidence of financialization of Asian nonfinancial firms, as the measurement of dividend payments in the paper may have affected the results, while financial investment (i.e., investment in financial instruments) appears to be positively rather than negatively related to R&D spending.

Overall, there does not seem to be a shift in preference of firm shareholders for shorter-term financial gains at the expense of longer-term real investment and future productivity. However, financially constrained firms can clearly gain with better access to external financing for R&D.

# APPENDIX

## Table A.1: List of Data

| Variable | Definition |
|---|---|
| $R\&D_{i,t}$ | R&D expenditures/Beginning-of-period total assets |
| $\Delta sales_{i,t}$ | Log difference of net sales |
| $sales_{i,t-1}$ | Log of net sales |
| $cfo_{i,t}$ | (Net income + depreciation)/Beginning-of-period total assets |
| $cash_{i,t}$ | Cash and cash equivalents/Beginning-of-period total assets |
| $debt_{i,t}$ | (Noncurrent liabilities + Current liabilities)/Beginning-of-period total assets |
| $equity_{i,t}$ | Issued share capital/Beginning-of-period total assets |
| $findiv_{i,t}$ | (Net income - Annual change in shareholder funds)/Beginning-of-period total assets |
| $fininv_{i,t}$ | (Other fixes assets + Other current assets – Cash and cash equivalent)/Beginning-of-period total assets |
| $size_{i,t}$ | Log of total assets |

**Table A.2: Other Regression Results—**
**Cash Flow and Debt Interaction** (Linear)

| | External Finance Variables | All |
|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.005** |
| | (4.08) | (4.98) |
| $sales_{i,t-1}$ | 0.005** | 0.006** |
| | (3.97) | (4.84) |
| $cfo_{i,t}$ | 0.018** | 0.017** |
| | (3.18) | (2.98) |
| $\Delta cash_{i,t}$ | 0.002** | 0.001 |
| | (3.57) | (1.53) |
| $debt_{i,t}$ | 0.006** | 0.006** |
| | (5.06) | (4.62) |
| $equity_{i,t}$ | 0.001 | –0.000 |
| | (0.29) | (0.14) |
| $findiv_{i,t}$ | | –0.006** |
| | | (5.34) |
| $fininv_{i,t}$ | | 0.003+ |
| | | (1.80) |
| $size_{i,t}$ | –0.007** | –0.009** |
| | (5.38) | (6.54) |
| $cfo_{i,t} \times debt_{i,t}$ | 0.006 | 0.004 |
| | (1.23) | (0.72) |
| *Constant* | 2.266** | 2.364** |
| | (3.24) | (3.39) |
| *Observations* | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table A.3: Other Regression Results—**
**Cash Flow and Equity Interaction** (Linear)

| | External Finance Variables | All |
|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.005** |
| | (3.99) | (4.94) |
| $sales_{i,t-1}$ | 0.005** | 0.006** |
| | (3.94) | (4.81) |
| $cfo_{i,t}$ | 0.023** | 0.020** |
| | (5.06) | (4.52) |
| $\Delta cash_{i,t}$ | 0.002** | 0.001 |
| | (3.27) | (1.42) |
| $debt_{i,t}$ | 0.007** | 0.006** |
| | (5.54) | (4.89) |
| $equity_{i,t}$ | 0.001 | -0.000 |
| | (0.36) | (0.07) |
| $findiv_{i,t}$ | | –0.006** |
| | | (5.64) |
| $fininv_{i,t}$ | | 0.002+ |
| | | (1.70) |
| $size_{i,t}$ | –0.007** | –0.009** |
| | (5.36) | (6.49) |
| $cfo_{i,t} \times equity_{i,t}$ | –0.003 | –0.003 |
| | (0.32) | (0.38) |
| *Constant* | 2.260** | 2.361** |
| | (3.23) | (3.38) |
| *Observations* | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** significant at 1%.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table A.4: Other Regression Results—**
**Cash Flow and Dividends Interaction** (Linear)

| | Financialization Variables | All |
|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** |
| | (5.55) | (4.98) |
| $sales_{i,t-1}$ | 0.005** | 0.006** |
| | (4.17) | (4.84) |
| $cfo_{i,t}$ | 0.020** | 0.019** |
| | (4.80) | (4.69) |
| $\Delta cash_{i,t}$ | 0.001 | 0.001 |
| | (1.25) | (1.38) |
| $debt_{i,t}$ | | 0.006** |
| | | (4.88) |
| $equity_{i,t}$ | | –0.000 |
| | | (0.17) |
| $findiv_{i,t}$ | –0.006** | –0.006** |
| | (3.42) | (3.36) |
| $fininv_{i,t}$ | 0.004** | 0.003+ |
| | (3.07) | (1.76) |
| $size_{i,t}$ | –0.008** | –0.009** |
| | (6.00) | (6.52) |
| $cfo_{i,t} \times findiv_{i,t}$ | –0.004 | –0.004 |
| | (0.48) | (0.47) |
| *Constant* | 2.383** | 2.358** |
| | (3.41) | (3.39) |
| *Observations* | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table A.5: Other Regression Results—**
**Cash Flow and Financial Asset Investment Interaction** (Linear)

| | Financialization Variables | All |
|---|---|---|
| $\Delta sales_{i,t}$ | 0.005** | 0.005** |
| | (5.54) | (4.97) |
| $sales_{i,t-1}$ | 0.005** | 0.006** |
| | (4.16) | (4.84) |
| $cfo_{i,t}$ | 0.020** | 0.019** |
| | (4.73) | (4.61) |
| $\Delta cash_{i,t}$ | 0.001 | 0.001 |
| | (1.30) | (1.45) |
| $debt_{i,t}$ | | 0.006** |
| | | (4.89) |
| $equity_{i,t}$ | | –0.000 |
| | | (0.15) |
| $findiv_{i,t}$ | –0.006** | –0.006** |
| | (5.58) | (5.45) |
| $fininv_{i,t}$ | 0.004* | 0.002 |
| | (2.46) | (1.26) |
| $size_{i,t}$ | –0.008** | –0.009** |
| | (6.02) | (6.55) |
| $cfo_{i,t} \times fininv_{i,t}$ | 0.005 | 0.005 |
| | (0.53) | (0.55) |
| *Constant* | 2.381** | 2.356** |
| | (3.40) | (3.38) |
| *Observations* | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** significant at 1%.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

**Table A.6: Other Regression Results—**
**Cash Flow and Persistent Negative Cash Flow** (Linear)

| | Internal Finance Variables | External Finance Variables | All |
|---|---|---|---|
| $\Delta sales_{i,t}$ | 0.004** | 0.004** | 0.005** |
| | (4.43) | (3.97) | (4.81) |
| $sales_{i,t-1}$ | 0.003** | 0.005** | 0.006** |
| | (2.92) | (3.88) | (4.68) |
| $cfo_{i,t}$ | 0.031** | 0.029** | 0.026** |
| | (6.63) | (6.22) | (5.47) |
| $\Delta cash_{i,t}$ | 0.002* | 0.002** | 0.001 |
| | (2.58) | (3.33) | (1.50) |
| $debt_{i,t}$ | | 0.006** | 0.006** |
| | | (5.35) | (4.77) |
| $equity_{i,t}$ | | 0.000 | –0.000 |
| | | (0.21) | (0.17) |
| $findiv_{i,t}$ | | | –0.006** |
| | | | (5.17) |
| $fininv_{i,t}$ | | | 0.002 |
| | | | (1.38) |
| $size_{i,t}$ | –0.006** | –0.007** | –0.009** |
| | (4.55) | (5.37) | (6.48) |
| $cfo_{i,t} \times negcfo_{i,t}$ | –0.030** | –0.028** | –0.024** |
| | (3.71) | (3.53) | (2.98) |
| *Constant* | 2.269** | 2.225** | 2.326** |
| | (3.26) | (3.22) | (3.37) |
| *Observations* | 10,337 | 10,337 | 10,337 |
| *Number of firms* | 2,939 | 2,939 | 2,939 |
| *Adjusted R-squared* | 0.07 | 0.08 | 0.09 |

+ = significant at 10%, * = significant at 5%, ** = significant at 1%.

Note: Robust t-statistics in parentheses.

Source: Author's computations.

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**Empirical Determinants and Patterns of Research and Development Investment in Asia**

This paper examines the financial determinants of R&D investment in Asia, sampling listed nonfinancial firms from eight economies in the region for the period 2002–2011. Panel data regressions indicate reliance of firms on internal financing and a greater role of debt as a source of external funds. Sensitivity of R&D investment to cash flow, which measures the availability of internal funds, tends to be lower for firms with higher domestic ownership concentration and for those with majority foreign ownership, suggesting greater stability of funding for innovation.

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