CORPORATE GOVERNANCE AND INVESTMENTS

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Abstract

We investigate the impact of corporate governance on physical and R&D investments in a Seemingly Unrelated Regressing (SUR) system. Marginal *q*'s are estimated using firm fundamental information for physical and R&D investments separately. We find that takeover pressure boosts both physical and R&D investments, public pension funds ownership has a U-shaped relation with physical investment, and greater director ownership is associated with lower physical investment and higher R&D investment. As far as investment distortions are concerned, takeover pressure mitigates the free cash flow problem and exacerbates the debt overhang problem, while public pension funds stockholding and director ownership alleviates the debt overhang for physical investment, and R&D investment, respectively.

Keywords: Corporate Governance, Physical Investment, R&D Investment, Free Cash Flow Problem, Debt Overhang

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1. Introduction

In our imperfect world, a firm's investments, in both tangible and intangible assets, often deviate from the optimal levels dictated by the Q theory, partly due to certain agency problems. The most widely cited distorting agency factors include the free cash flow problem (Jensen, 1986) and debt overhangs (Myers, 1977). The former gives rise to overinvestment because of the empire building propensity of self-interested manager; in contrast, the latter is a result of conflict in interest between creditors and shareholders, and leads to underinvestment. Supposedly, corporate governance, with a strong emphasis on shareholders welfare in the Anglo-Saxon world, would contain the manager's empire building propensity but widen the fissure between creditors and shareholders. However, corporate governance is a multi-faceted subject, and various governance mechanisms might have different effects on the manager's behavior and they may interact (e.g., Bhagat and Black, 1997; Gompers, Ishii, and Metrick, 2003; Lemmon and Lins, 2003; Cremers and Nair, 2005; Bhagat and Bolton, 2008), the relation between corporate governance and investment decisions is to some extent an empirical issue.

We examine whether and how takeover pressure, shareholder activism and director ownership influence corporate physical and R&D investments. Takeover pressure, which we measure by a variant of the Gompers, Ishii and Metrick (2003) index of anti-takeover provisions, is found to boost both investments: an additional anti-takeover provision in the firm's corporate governance arrangements lowers physical investment rate by 0.52 percentage point and R&D investment rate by 0.35 percentage point. This effect largely concentrates on "democracy firms", that is, firms most open to the potential takeover, for whom an additional anti-takeover provision reduces physical investment rate by 2.3 percentage points and R&D investment by 1.1 percentage points. Shareholder activism, measured by public pension funds ownership, exerts no discernible influence on R&D investment, but exhibits a U-shaped relationship with physical investment, that is, it discourages physical investment when it increases from zero, but encourages physical investment when it further rises from a high level. We use median director ownership to proxy for the effectiveness of board of directors (e.g., Bhagat, Carey, and Elson, 1999; Ho, Lam, and Sami, 2004; Bhagat and Bolton, 2008), and it is shown to restrain physical investment but enhance R&D investment, and the effects are strong only when the ownership is low.

We further look into the effects of these governance mechanisms on the free cash flow problem and the debt overhang. For this purpose, we divide the sample into overinvestment-prone firms, underinvestment-prone firms, and normal firms, and compare the effects of governance mechanisms in these subsamples. We find takeover pressure curbs the free cash flow problem but exacerbates debt overhang, consistent with typical argument about corporate governance (e.g., Yang, 2006), and the effect is the strongest among firms are most open to the market of control. Public pension funds and board of directors appear ineffective in controlling the free cash flow problem, but they mitigate the debt overhang effect, respectively, on physical and R&D investments.

Our paper is part of the growing efforts to penetrate the black box between corporate governance and firm performance by looking into how corporate governance influences corporate decisions. In particular, we probe a firm's physical and R&D investments in a seemingly unrelated regression (SUR) system. In the real world, both investments contribute to firm growth and performance, and their decisions are made in the same budgeting framework and under the same financial constraint, thus the SUR specification would generate additional estimation efficiency. We employ the instrumental variables (IV) approach to address the potential endogeneity of corporate governance mechanisms.

In order to bring R&D investment under investigation, we capitalize the R&D investment over its useful life, and estimate marginal *q's* of both physical and R&D investments, instead of simply using the Tobin's Q, which is inappropriate for our purpose because of the difficulty in separating physical investment opportunities from R&D investment opportunities. Assuming rational expectations and a Cobb-Douglas production function, we derive marginal *q's* as the sum of discounted sales to capital (physical capital and R&D capital, respectively) ratio over the useful life of capital. Our strategy represents an addition to the literature that uses the present value fundamental q to circumvent measurement errors associated with Tobin's Q.

We are also among the first to inquire whether and how corporate governance, in reality, deals with well-known agency problems in corporate investment behavior. Previous studies assume, implicitly or explicitly, the way corporate governance works on agency problems, but no endeavor has been made to examine what the real effects are. In this paper, we directly delve into the issue and shed some light on the presence and directions of impact of corporate governance on the free cash flow problem and debt overhang. It turns out that not all governance mechanisms mitigate the former and exacerbate the latter as generally expected.

The rest of this paper proceeds as follows. After a brief literature review in Section 2, we describe the data, and the derivation and estimation of the investment equation system in Section 3. Section 4 presents the main findings. Section 5 concludes.

2. Related Literature

In the past decade or so, a growing body of literature examines the effects of corporate governance on capital investment behavior at the firm level. Gompers, Ishii and Metrick (2003), later on referred to as GIM 2003, make a first attempt to link the two aspects, and find a firm's openness to the market of control, measured by an index of anti-takeover provisions (G-index), negatively associates with physical investment. Gugler (2003) finds the corporate governance literature of a firm affects the relation between investment and cash flow. Using a sample of Japanese manufacturing firms, Gedajlovic, Yoshikawa & Hashimoto (2005) document a positive relation between ownership by financial institutions and physical investment, and a negative relationship between ownership by foreign investors and insiders and physical investment. Hartzell, Sun & Titman (2006) find that the investment choices of Real Estate Investment Trusts (REITs) are more closely tied to Tobin's Q if they have greater institutional ownership, or lower director and officer stock ownership, consistent with institutional owners monitoring the firm's investment policies, and with high insider ownership allowing managers to follow their own investment agendas. This is direct evidence that good governance facilitates sound investment decisions, but the results are limited to a very narrow class of firms. Yang (2006) compares the corporate governance's impact on an array of corporate policies, including physical investment and acquisition, at good time vs. bad time, and obtains evidence consistent with better shareholder protection alleviating the free cash flow problem but exacerbating debt overhang. Li (2007) models an entrenched manager whose appropriation becomes more difficult when corporate is better governed, and derives a negative relation between corporate governance and investment, in support of GIM 2003's finding. Cronqvist and Fahlenbrach (2009) identify a strong positive effect of blockholders on a firm's capital investment rate. Billett, Garfinkel and Jiang (2011) reexamine the issue using a hazard model to show that firms with good governance, measured by the G-index, experience longer spells between large investments, consistent with the notion that poor governance associates with overinvestment.

Baysinger, Kosnik, and Turk (1991) is among the earliest of a very small strand of literature that investigates how corporate governance influence a firm's R&D investments. They find that high insider representation on a board and concentrations of equity ownership among institutional investors positively affect corporate R&D spending in a sample of 176 SP-500 firms. Bushee (1998) documents that ownership by long-term institutional investors curbs R&D cuts by managers who are faced with a potential decline in earnings. Osma (2008) finds a similar effect of an independent board of directors on earnings management in the form of R&D cuts. Sapra, Subramanian and Subramanian (2009) find a U-shaped relation between takeover pressure and R&D investment, and an increasing one between internal monitoring intensity and R&D investment.

3. Data and Methodology

3.1 Data

We obtain our investment and other financial data from the Standard & Poor's COMPUSTAT Industrial Annual files. To accommodate the governance measure, the time range is from 1990 to 2006. The estimation of marginal *q*'s and the use of lagged variables cut short the time range of our final sample to 1991-2002. Financial firms (SIC between 6000 and 6999), utility firms (SIC between 4900 and 4999), and firm-year observations with missing/negative Net Property, Plant, and Equipment (data item 8), or missing/negative Net Sales (data item 12) are excluded.

Major variables extracted are physical investment (*I*), R&D investment (*D*), net income (*NI*), sales (*S*), total assets (*A*), long-term and short-term debt. R&D investments are then capitalized to obtain the R&D capital (*R*), and relevant variables including net income, cash flow and total assets are adjusted accordingly. Leverage ratio (*LEV*) is computed as the total debt divided by total assets. Additional variables including firm age (*AGE*), financial slack (*Slack*), market-to-book ratio (*MTB*), current ratio (*Current*), fixed charge coverage (*FCCov*), long-term debt ratio (*debt*), net income margin (*NIM*), sales growth (*SG*), and the slack to net fixed assets ratio (*SKratio*) are also acquired for purposes of controlling for sample selection bias and computing the Cleary (1999) Z-score that serves as a comprehensive measure of financial constraints. *NYSE* is a dummy variable that equals 1 if a firm is listed in NYSE and 0 otherwise; *AMEX*, and *NASD* are defined likewise for listing in AMEX and NASDAQ markets. Details of variable definitions are provided in Appendix A. To remove outliners, we winsorize all variables at the 1st percentile and 99^{th} percentile.

We use three corporate governance measures. The first measure, the G index (*Gindex*), is a variant of the anti-takeover provision index used by GIM 2003, extracted from the RiskMetrics database for year 1991-2004. Anti-takeover provisions insulate the manager from disciplining by the capital market. GIM 2003 constructs the index as the number of anti-takeover provisions (there are 24 such provisions in total) and a higher index represents lower shareholder right protection. They show this measure of corporate governance is related to firm performance. Slightly different from GIM 2003, we use the number of missing anti-takeover provisions so that a higher index corresponds to better governance. In other words, our G index is equal to 24 minus the original GIM 2003 index. Following GIM 2003, we sort the sample with the G index, and call the group with *Gindex > 17* the "democracy" group, and the group with *Gindex < 13* the "dictatorship" group. The democracy group contains firms most open to the market of control, and the dictatorship group contains firms highly insulated from the market of control.

The anti-takeover provision index is a measure of external governance. We also examine two internal governance mechanisms: ownership of public pension funds (*Phold*), and median director ownership in dollars amount (*Dhold*). Public pension funds are known to be aggressive shareholder activists (e.g., Guercio and Hawkins, 1999). Public pension funds and directors monitor firm decisions, from outside and inside the firm, respectively. Cremers and Nair (2005) show public pension funds ownership, when doubled with high takeover pressure, is conducive to better firm performance, while Bhagat and Bolton (2008) document that higher median director ownership in dollar amount contributes to better firm performance. Institutional holdings are available from Thompson Financial, and we pick the ownership data of 18 public pension funds as Cremers and Nair (2005) do, and use the sum of all public pension funds holding as our measure of *Phold*. The list of public pension funds is available in Appendix B. Corporate Library provides information on directors' ownership starting from year 1999 and we extract the data for 1999-2004.

We obtain 65,816 firm-year observations during 1991-2002 but only a minority of them has the both R&D investment rate and corporate governance information available. Specifically, 35,364 observations have R&D rate, 15,797 observations have *Gindex*, 39,929 observations have *Phold*, all for 1991-2002, and 9,268 observations have *Dhold* for 1999-2002. Furthermore, 4,303 observations have both R&D rate and *Gindex*, 8,003 observations have both R&D rate and *Phold*, both for 1991-2002, and only 1,603 observations have both R&D rate and *Dhold* during 1999-2002. The Heckman's two-step procedure is applied to the above subsamples to control for sample selection. When necessary to have a bigger sample, we set *Dhold = 0* for 1991-1998 and for missing *Dhold* during 1999-2002, and define an indicator variable *Dmissing* that equals 1 for observations with *Dhold* missing and 0 otherwise.

Table 1. Descriptive Statistics

This table provides descriptive statistics for 1,644 firms between 1991-2002 (1998-2002 for median director ownership). MPK and MPR are scaled marginal productivity of physical capital and that of R&D capital. They are derived from fundamental information of firms and measure the growth options faced by a firm in physical and R&D investments. For the estimation of these variables please see Section 3.3. Only firm-years for which both the capital and R&D investment rates, and MPK and MPR could be derived from COMPUSTAT are included in the sample. All variables are winsorized at the 1st and 99th percentiles.

Variable	Nobs	Mean	Median	Std Dev	10th Percentile	90th Percentile
Capital Investment Rate (I_t/K_{t-1})	8750	0,310	0,220	0,314	0,089	0,607
R&D Rate (R_t/D_{t-1})	8750	0,439	0,398	0,215	0,253	0,652
Total Assets (*A*, *$m*)	8750	3581,2	432,8	8493,8	39,8	9620,5
Cash Flow (CF_t/TK_{t-1})	8730	0,283	0,270	0,543	-0,107	0,706
Leverage (*LEV*)	8707	0,189	0,164	0,172	0	0,404
Asset Tangibility (*TAN*)	8699	0,450	0,452	0,108	0,313	0,580
Z Score (*Z*)	8464	0,363	0,276	0,148	0,257	0,578
G Index (*Gindex*)	4487	14,46	14	2,75	11	18
Public Pension Funds Owernship (*Phold, %*)	7736	1,115	0,677	1,390	0	2,725
Median director Ownership (*Dhold, $m*)	2065	2,393	0,540	6,060	0,067	5,346
MPK	8750	0,547	0,419	0,525	0,168	1,007
MPR	8750	0,241	0,113	0,407	0,019	0,527

Table 1 provides descriptive statistics of the variables for the 8,750 firm-year observation over 1991-2002 that have both physical and R&D investment information and at least one nonmissing governance mechanism. The physical investment rate averages 0.31 with a median at 0.22; the R&D rate averages 0.44 and the median are 0.40. The R&D rate is calculated as the R&D investment in time period *t* divided by the R&D capital stock at the end of time period *t-1*. The median *Gindex* is 14, or in other words, the median firms have 10 anti-takeover provisions. Not shown in the table, the minimum value and maximum values for *Gindex* is 5 and 22. The mean and median public pension funds ownership are 1.12% and 0.68%, respectively; 2,284 firm-year observations do not have any public pension funds stockholding. The median director ownership averages at 2.39 million U.S. dollars, but the median measure is only 0.68 million dollars. The last two rows, MPK and MPR, representing marginal product of physical capital and marginal product of R&D capital, are measures of marginal *q*'s, and will be explained in section 2.3.

Table 2. Descriptive Statistics for Corporate Governance Subsamples

Panel A: Partitions by the G index ($Gindex_{t-1}$)						
Variable	Dictatorship (Bottom quartile)		In Between (Middle Half)		Democracy (Top quartile)	
	Nobs	Mean	Nobs	Mean	Nobs	Mean
I_t/K_{t-1}	1117	0,215	2490	0,263	697	0,359
R_t/D_{t-1}	1117	0,394	2490	0,416	697	0,480
A ($m)	1117	4771,7	2490	5236,4	697	5641,3
CF_t/TK_{t-1}	1117	0,282	2487	0,317	693	0,355
LEV	1112	0,247	2476	0,212	692	0,185
TAN	1112	0,421	2485	0,427	684	0,445
Z	1087	0,312	2391	0,335	664	0,356
Phold (%)	395	1,041	920	2,662	257	4,053
Dhold (%m)	956	2,061	2071	1,774	590	1,392
MPK	1117	0,440	2490	0,490	697	0,532
MPR	1117	0,211	2490	0,234	697	0,235
Panel B: Partitions by PPF Owernship ($Phold_{t-1}$)						
Variable	Bottom Quartile		In Between		Top Quartile	
	Nobs	Mean	Nobs	Mean	Nobs	Mean
I_t/K_{t-1}	2627	0,322	3374	0,341	2002	0,264
R_t/D_{t-1}	2627	0,427	3374	0,465	2002	0,420
A ($m)	2627	247,7	3374	4196,7	2002	6858,9
CF_t/TK_{t-1}	2624	0,229	3363	0,308	1996	0,328
LEV	2623	0,159	3345	0,185	1993	0,216
TAN	2611	0,472	3357	0,451	1990	0,427
Z	2570	0,393	3239	0,364	1934	0,322
Gindex	247	14,51	1867	14,87	1661	14,05
Dhold &$m)	16	1,537	1312	2,466	705	2,352
MPK	2627	0,669	3374	0,522	2002	0,447
MPR	2627	0,280	3374	0,225	2002	0,207

Panel C: Partitions by Median Director Owernship ($Dhold_{t-1}$)						
Variable	Bottom Quartile		In Between		Top Quartile	
	Nobs	Mean	Nobs	Mean	Nobs	Mean
I_t/K_{t-1}	401	0,183	801	0,249	401	0,378
R_t/D_{t-1}	401	0,364	801	0,404	401	0,497
A ($m)	401	4028,2	801	5696,6	401	5706,7
CF_t/TK_{t-1}	401	0,170	801	0,299	394	0,424
LEV	398	0,252	798	0,229	396	0,173
TAN	401	0,414	800	0,406	399	0,436
Z	386	0,387	779	0,344	386	0,361
Gindex	323	13,93	732	14,51	347	15,44
Phold (%)	389	1,384	796	1,551	399	1,433
MPK	401	0,488	801	0,470	401	0,526
MPR	401	0,266	801	0,195	401	0,227

This table presents the descriptive statistics for subsamples classified according to the G index (Panel A), public pension fund ownership (Panel B), and median director ownership (Panel C) in the previous year. MPK and MPR are scaled marginal productivity of physical capital and that of R&D capital. They are derived from fundamental information of firms and measure the growth options faced by a firm in physical and R&D investments. For the estimation of these variables please see Section 3.3. Only firm-years for which both capital and R&D investment rates and MPK and MPR could be derived from COMPUSTAT are included in the sample. A firm is classified as "Democracy" if Gindex >= 18, or as "Dictatorship" if Gindex <=12. When PHold and DHold are used as the criteria, we partion the sample into quartiles. All variables are winsorized at the 1st and 99th percentiles.

Table 2 shows the means of major variables across different governance groups. With *Gindex*, the sample is classified into dictatorship group, democracy group, and the group in between; with *Phold* and *Dhold*, comparisons are made among the bottom quartile, the top quartile, and the middle half. The two investment rates (*I/K* and *R/D*), firm size (*A*), cash flow (*CF/TK*) and *Phold* all rise with the G index; Leverage (*LEV*), the Z-score (*Z*) and *Dhold* decline with the index. Investments appear to be increasing with director ownership, but don't exhibit a monotonic pattern with respect to public pension funds ownership.

3.2 The estimation equation system

A firm chooses investments of physical and R&D capital to maximize the expected present value of the stream of future profits. Since the cost of installing physical capital is unlikely to have an effect on the adjustment cost of R&D, as is argued by Bond and Cummins (2000), additively separable adjustment costs are assumed (Actually even when two types of tangible assets are considered, most prior studies assume additively separable adjustment costs (e.g., Hayashi and Inoue, 1991; Chirinko, 1993; and Bontempi et al, 2004). Then the firm's objective function at time t is given by

$$\max_{\{I_t, D_t\}_{s=0}^{\infty}} E\{\sum_{s=0}^{\infty} \beta^s [F(K_t, R_t) - C_1(I_t, K_t) - C_2(D_t, R_t) - p_1(\vec{h}_t) I_t - p_2(\vec{h}_t) D_t] \mid \Omega_t\} \quad (1)$$

$$s.t. \quad K_t = (1-\delta_1)K_{t-1} + I_t$$

$$\text{and} \quad R_t = (1-\delta_2)R_{t-1} + D_t$$

In this setup, *K* and *I* denote the tangible capital stock and investment, *R* and *D* denote R&D capital stock and investment. *F* is the production function. C_1 and C_2 represent the adjustment costs associated with physical and R&D investments, respectively, which are functions of capital stock and investment at time t. β is the real discount rate, and δ_1 and δ_2 are depreciation rates of tangible and R&D capital, respectively. For expositional simplicity, we assume the discount rate and depreciation rates are constant over time. p_1 and p_2 are prices of tangible and R&D capital goods, and are normalized with respect to the output price. Both costs of capital are a function of an array of firm characteristics $\vec{h}$. Ω indicates the information set at the time of investment decision.

The first-order conditions for the firm's problem are

$$p_1(\vec{h}_t) + \frac{\partial C_1(I_t, K_t)}{\partial I_t} = q_{it}$$

and (2)

$$p_2(\vec{h}_t) + \frac{\partial C_2(D_t, R_t)}{\partial D_t} = q_{2t}$$

where

$$q_{1t} = E\left[\sum_{s=0}^{\infty}\beta^{s}(1-\delta_1)^{s}[\frac{\partial F(K_{t+s},R_{t+s})}{\partial K_{t+s}} - \frac{\partial C(I_{t+s},K_{t+s})}{\partial K_{t+s}}] \mid \Omega_t\right]$$

and (3)

$$q_{2t} = E\left[\sum_{s=0}^{\infty}\beta^{s}(1-\delta_2)^{s}[\frac{\partial F(K_{t+s},R_{t+s})}{\partial R_{t+s}} - \frac{\partial C(D_{t+s},R_{t+s})}{\partial R_{t+s}}] \mid \Omega_t\right]$$

q_{1t} and q_{2t} are the shadow values of physical and R&D capital, respectively, at time *t*. Therefore, the firm will invest in physical (R&D) capital to the point where the marginal purchase and adjustment costs of installing an additional unit of physical (R&D) capital equals its marginal benefit. This shadow value for physical (R&D) investment is the firm manager's expectation of the marginal contribution of new physical (R&D) capital to future profit.

Following the literature, the empirical estimation model take into account a vector of firm characteristics that have an impact on either production function and cost of capital, $\vec{h}_t$.

$$\frac{I_t}{K_t} = \alpha_{10} + \vec{\alpha}_{11}\vec{h}_t + \alpha_{12}q_{1t}$$

and (4)

$$\frac{D_t}{R_t} = \alpha_{20} + \vec{\alpha}_{21}\vec{h}_t + \alpha_{22}q_{2t}$$

3.3 Estimation Methodology

Between (4) and the empirical results there are a few issues to be addressed, including the capitalization of R&D, the estimation of q_1 and q_2, and the econometrics in estimating the equations.

3.3.1 Capitalization of R&D

R&D investment is often known as R&D expenditures largely because GAAP mandates the full expensing of R&D in financial statements. However, an unprecedented growth of R&D investment in U.S. and many other economies in the last twenty years suggests that full expensing of R&D for financial reporting purposes severely distorts the earnings and book values of R&D intensive firms (e.g., Chan, Laknonishok and Sougiannis (2001)), and also firm assessments (e.g., Franzen, Rodgers and Simin, 2007). The issue is addressed with capitalization of R&D investment in a similar way as physical capital accumulation.

Following Lev and Sougiannis (1996) and Chan, Laknoishok and Sougiannis (2001), R&D capital is defined as the sum of the unamortized past R&D investments. Those are the investments that are expected to generate current and future revenues. In practice, we adopt straight-line depreciation in a useful life of 5 years:

$$R_{it} = D_{it} + 0.8 * D_{i,t-1} + 0.6 * D_{i,t-2} + 0.4 * D_{i,t-3} + 0.2 * D_{i,t-4} \quad (5)$$

Effectively we assume an amortization rate of 20 percent a year, which locates in the middle range of different estimates of R&D amortization rate (e.g., Pakes and Shankermana 1979; Nadiri and Prucha, 1996; and Bernstein and Mamuneas, 2005). Our results are qualitatively unaffected with amortization rate of 15% and 25%, though.

Capitalization of R&D investment entails adjustments to a variety of balance sheet items including net income and total assets. Following Franzen, Rodgers and Simin (2007), the adjustments take different forms for firms in black and firms in red. Where net income is positive, the adjustment is as below:

Adj. Net Income = Net Income + R&D – $0.2 * \sum_{k=1}^{5} D_{i,t-k}$ (6)

Adj. Total Assets = Total Assets + R_{it} (7)

For firms with negative net income, the tax effect is taken into account:

Adj. Net Income = Net Income +(R&D – $0.2 * \sum_{k=1}^{5} D_{i,t-k}$ **(1-t))* (8)

$$Adj.\ Total\ Assets = Total\ Assets + R_{it} \tag{9}$$

Here, t is the annual statutory tax rate, and for our sample period, it is 34% for 1991-1992, and 35% over 1993-2002.

3.3.2 Estimation of marginal q's

In (5), q_{1t} and q_{2t} are unobservable and a natural way out is to find observable proxies for them. Since Hayashi (1982), a widely used measure of q_{1t} is the average q_{1t}, also known as Tobin's Q, which is computed as the market valuation of the firm's capital stock to its replacement cost. However, Tobin's Q is a poor proxy of q_{1t} given frictions in the product market and capital market (Chirinko and Schaller, 1996; Hubbard, 1998; Erickson and Whited, 2000). More importantly, Tobin's Q is defined to reflect the shadow value of tangible assets, and the counterpart for q_{2t} is not readily available (Using Tobin's Q for both physical and R&D investments implicitly assumes that growth options evaluated by the market are proportionally attributable to tangible and intangible assets, which is at best unclear.). Thus, we are faced with the task of developing measures of marginal q for both physical and R&D investments.

The strategy we adopt is to estimate marginal q's using ex-post marginal product of capital. Suppose a Cobb-Douglas production function

$$F(K,R,X) = AK^{\alpha_K} R^{\alpha_R} X^{\alpha_X} \tag{10}$$

for all firms, where A is the total factor of productivity, and X is a factor input other than K and R, α_K, α_R and α_X are elasticities of production with respect to physical, R&D, and other input. Note that introducing more factor inputs does not alter our result. Substituting (10) into (3), we obtain q_{1t} and q_{2t} in the following form:

$$q_{1t} = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_K \left(\frac{S}{K}\right)_{t+s} \mid \Omega\right] - E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \frac{\partial C_{1,t+s}}{\partial K_{t+s}} \mid \Omega\right] \tag{11}$$

$$q_{2t} = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_R \left(\frac{D}{R}\right)_{t+s} \mid \Omega\right] - E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \frac{\partial C_{2,t+s}}{\partial R_{t+s}} \mid \Omega\right] \tag{12}$$

The second items in (11) and (12), marginal adjustment costs with respect to capital, are difficult to obtain because the exact function form of adjustment costs is unknown (Cooper and Haltiwanger, 2006). To facilitate the estimation, we assume that marginal adjustment costs with respect to capital are linear functions of a family of firm characteristics:

$$q_{1t} = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_K \left(\frac{S}{K}\right)_{t+s} \mid \Omega\right] + \gamma_1 \vec{h}_t \tag{13}$$

$$q_{2t} = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_R \left(\frac{D}{R}\right)_{t+s} \mid \Omega\right] + \gamma_2 \vec{h}_t \tag{14}$$

Then the estimation equations (6) become

$$\frac{I_t}{K_t} = \beta_{10} + \vec{\beta}_{11}\vec{h}_t + \beta_{12} MPK_t$$

and (15)

$$\frac{D_t}{R_t} = \beta_{20} + \vec{\beta}_{21}\vec{h}_t + \beta_{22} MPR_t$$

where $MPK_t = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_K \left(\frac{S}{K}\right)_{t+s} \mid \Omega\right]$, $MPR_t = E\left[\sum_{s=0}^{\infty} \beta^s (1-\delta_1)^s \alpha_R \left(\frac{D}{R}\right)_{t+s} \mid \Omega\right]$.

They are marginal product of physical capital and R&D capital, respectively. The parameters in (15) are linear combinations of those in (4) and γ_1 and γ_2. Thus we depart from the direct derivation of marginal q's, and instead express them as a function of marginal product of capital and firm characteristics.

Assuming rational expectations, we can estimate *MPK* and *MPR* using realized *S/K and S/R* ratios in the future. In other words, while making investment decisions, the manager on average could correctly foresee the future sales to physical capital ratio and sales to R&D capital ratio, and hence be able to appraise the investment opportunities. Assume physical capital has a life time of N years, then for year *t*, we could estimate MPK_t using the current sales to physical capital ratio and the ratios in the subsequent N-1 years. Likewise, MPR_t is derived from contemporaneous and future sales to R&D capital ratios.

The idea of generating marginal *q* in a rational expectations present value model can be traced back to Abel and Blanchard (1986), which estimates marginal q_1 as the present value of a stream of marginal profit which are in turn estimated from a vector autoregression (VAR) forecasting system. The method has become a way to circumvent measurement error associated with Tobin's Q in investment literature (e.g, Blanchard, Rhee and Summers,1993; Gilchrist and Himmelberg,1995, 1998; Bond and Cummins, 2000; and Cummins, Hassett, and Oliner, 2006).

In practice, estimation of MPK and MPR involves the identification of the following parameters: time preference discount rate (β), depreciation rate of physical capital (δ_1), amortization rate of R&D capital (δ_2), elasticity of output to physical capital (α_K), and elasticity of output to R&D capital (α_R). Following extant literature, we assume $\beta = 0.88$, $\delta_1 = 0.125$, $\delta_2 = 0.20$ for all firms. The depreciation rate of 0.125 and the R&D amortization rate of 0.20 effectively assume a useful life time of 8 years and 5 years for physical capital and R&D capital, respectively, hence marginal productivities and marginal costs are estimated as

$$MPK = \sum_{s=0}^{7} \beta^s (1-\delta_1)^s \alpha_K \left(\frac{S}{K}\right)_{t+s}$$

$$MPR = \sum_{s=0}^{4} \beta^s (1-\delta_2)^s \alpha_R \left(\frac{S}{R}\right)_{t+s} \quad (16)$$

Although the literature provide estimates of α_K and α_R (Recent examples include Funke and Strulik (2000), which estimate α_K at 0.36, and Guellec and de la Potterie (2001), which estimate α_R at 0.132), it's probably unreasonable to assume all industries have a uniform value for the two elasticity measures. Here we borrow from Gilchrist and Himmelberg (1998) to estimate industry-specific α_K and α_R. Specifically, for all firms in industry *j*, $i \in I(j)$, and years $t \in T(i)$, the elasticity measures are estimated as

$$\alpha_{Kj} = \left(\frac{1}{N_j} \sum_{i\in I(j)} \sum_{t\in T(i)} \left(\frac{S}{K}\right)_{it} \right)^{-1} \frac{1}{N_j} \sum_{i\in I(j)} \sum_{t\in T(i)} (r_{it} + \delta_{1it})$$

and (17)

$$\alpha_{Rj} = \left(\frac{1}{N_j} \sum_{i\in I(j)} \sum_{t\in T(i)} \left(\frac{D}{R}\right)_{it} \right)^{-1} \frac{1}{N_j} \sum_{i\in I(j)} \sum_{t\in T(i)} (r_{it} + \delta_{2it})$$

where N_j is the number of firm-year observations for industry *j*, r_{it} is the risk-adjusted discount rate, δ_{1it} and δ_{1it} are the depreciation rate of physical capital and amortization rate of R&D capital, respectively. In practice, it is assumed that $\sum_{i\in I(j)} \sum_{t\in T(i)} (r_{it} + \delta_{1it}) \,/N_j$ = 0.185 and $\sum_{i\in I(j)} \sum_{t\in T(i)} (r_{it} + \delta_{1it}) \,/N_j$ = 0.26 for all industries.[12]

The statistic summary of estimated MPK and MPR are also displayed in the Tables 1 and 2. MPK and MPR averages at 0.547 and 0.241, respectively. Their means in the governance subsamples increases with takeover pressure, decreases with public pension funds ownership, but do not exhibit a monotonic pattern as director ownership gets higher. In Table 3, they are significantly and positively correlated with physical investment rate and R&D rate, respectively, as we have expected.

[12] The estimation of MPK using sales to physical capital ratio in subsequent seven years would shrink our sample size remarkably. In practice, we assume the *S/K* ratio stay constant at the level of the 4th year's level in the 5th to 7th year. This would not change our results materially as the marginal product of physical capital in the 5th-7th years have weights of merely 0.079, 0.046, and 0.020, respectively. Robustness checks using the full seven-year period to estimate MPK yield qualitatively similar results.

3.3.3 Estimation of the equation system

As the variables of our main interest, corporate governance measures are surely a part of the firm characteristics vector $\vec{h}$. Other firm characteristics serve as controlling variables, including lagged cash flow (CF), the natural logarithm of total assets (A), leverage ratio (LEV), asset tangibility (TAN) , and the Cleary's (1999) Z-score that measures financial distress (*Z*). They all take the one year lagged values.

An additional set of explanatory variables are inverse mills ratios derived from Heckman's two-step procedure to mitigate the sample selection bias. Not all firms report R&D investment, and nor is corporate governance information available for all firms. Heckman (1979) show that a two-step procedure could correct the sample selection bias, in which an inverse mills ratio (also known as selection hazard, denoted as *Mills*) from a first-step probit model is used in the main regression[13].

Error terms in the two above equations might be correlated for a few reasons. First, both investment decisions are made simultaneously to best probe growth opportunities. As a matter of fact, the equations are derived from the one firm's problem. Second, investments in physical and R&D capital compete for funds which are usually not unrestrictive. In addition, agency problems might impact both investment decisions. Therefore, we estimate (18) in a seemingly unrelated regression (SUR) system.

An econometric issue to be addressed is the potential endogeneity of corporate governance. On one hand, economic shocks to a firm could lead to changes in both corporate governance measures and investment decisions. On the other hand, directors and public pension funds could adjust their holdings in expectation of certain investment behavior; it's also possible that a firm adds or removes some anti-takeover provisions to facilitate subsequent financing and investment. Even though governance measures in the previous period are used, we go further to address the potential endogeneity from two fronts: first, we control for unobservable heterogeneity by removing the fixed Fama-French industry effects and fixed year effects; second, we estimate the equation system with an instrumental variable (IV) approach.

The instruments we choose for *Gindex*, the measure of openness to the market of control, are *StateG*, the index of state-level anti-takeover provisions, and the average *Gindex* of all firms in the same Fama-French 48 industry over 1991-2002. The instruments for *Phold*, public pension funds ownership, are *Indep*, the percentage of independent directors in the firm's board, and the average *Phold* of all firms in the same Fama-French 48 industry over the sample period. We also use *Indep* as the instrument for *Dhold*. Given the instruments, we run a 2SLS estimation of the SUR system, that is, in the first step, we predict the corporate governance measures using their respective instruments, and in the second step, estimate the SUR system with the predicted values of corporate governance measures. Heteroscedasticity and serial correlation are controlled with White's correction and Newey-West correction, respectively.

We conduct the Staiger and Stock (1997) and Stock and Yogo (2004) weak instrument tests and Durbin-Wu-Hausman tests to diagnose the validity of the above instruments. The results are displayed in Table 3. Panel A shows that the instruments we choose are not weak in the sense that the 2SLS size for a 5% Wald test does not statistically exceed 10%. Panel B indicates that the 2SLS procedure significantly improves the estimation by reducing the bias in estimated coefficients.

[13] For each subsample we use for regression, we define a dummy variable that is equal to 1 for firm-year observations in the subsample and 0 otherwise, and run a probit regression on firm total assets, age, market-to-book ratio, leverage, asset tangibility, Cleary's Z score, a dummy variable indicating whether the firm is in a high-tech industry, and dummies that indicate whether the firm is listed in NYSE, AMEX or NASD. The inverse Mills ratio is computed as the probability distribution function divided by the cumulative distribution function for each firm-year observation.

Table 3. Diagnosis Tests for Instrument Variable (IV) Estimation

This table presents the results of Stock-Yogo weak instrument tests and Durbin-Wu-Hausman Tests for the use of instruments for the governance measures. Instruments for Gindex are Gindex_Ind, the average Gindex for all firms in the same Fama-French 48 industry, and StateG, the state-level number of anti-takeover provisions. The instrument for Phold is the average Phold for all firms in the same Fama-French 48 industry and Indep, the percentage of independent directors in the firm's board. The instrument for Dhold is Indep. Weak instrument tests are conducted for the three measures separately and jointly between Gindex and each of the two internal governance measures. The joint tests are conducted separately in the physical investment and R&D investment equation, and gmin is the Cragg-Donald statistic as defined in Stock and Yogo (2004) . The Durbin-Wu-Hausman tests are conducted separately for the three governance measures in the physical and R&D investments equation system. Gr represents the residual of Gindex/Phold/Dhold from the first-step regression.

Panel A: Stock-Yogo Weak Instrument Tests				
	Instruments		First-stage F	Critical Value
GIndex	*StateG, Gindex_Ind*		369,9	10
Dhold	*Indep*		137,7	10
Phold	*Indep, Phold_Ind*		873,3	10
			g_{min}	Critical Value
Gindex & *Phold*	*StateG, Gindex_Ind, indep, Phold_Ind*	in the I_t/K_{t-1} Equation	54,26	13,43
		in the R_t/D_{t-1} Equation	55,79	13,43
Gindex & *Dhold*	*StateG, Gindex_Ind, Indep*	in the I_t/K_{t-1} Equation	25,66	13,43
		in the R_t/D_{t-1} Equation	28,10	13,43
Panel B: Durbin-Wu-Hausman Tests				
			Gr Coefficient	Pr > |t|
Gindex	I_t/K_{t-1}		-0,019	0,000
	R_t/D_{t-1}		-0,008	0,036
Phold	I_t/K_{t-1}		0,011	0,097
	R_t/D_{t-1}		0,005	0,378
Dhold	I_t/K_{t-1}		0,006	0,011
	R_t/D_{t-1}		0,007	0,001

Therefore the empirical estimation equation is

$$\frac{I_t}{K_t} = \alpha_0 + \alpha_1 GOV_{t-1} + \alpha_2 MPK_{t-1} + \alpha_3 CF_{t-1} + \alpha_4 A_{t-1} + \alpha_5 LEV_{t-1} + \alpha_6 TAN_{t-1} + \alpha_7 Z_{t-1} + \alpha_8 Mills$$

$$\frac{D_t}{R_t} = \beta_0 + \beta_1 GOV_{t-1} + \beta_2 MPR_{t-1} + \beta_3 CF_{t-1} + \beta_4 A_{t-1} + \beta_5 LEV_{t-1} + \beta_6 TAN_{t-1} + \beta_7 Z_{t-1} + \beta_8 Mills \quad (18)$$

4. How do corporate governance mechanisms influence investments?

4.1 General impact of governance on capital and R&D investments

To examine the impact of the anti-takeover provisions, activist shareholders and director ownership on capital and R&D investments, we estimate the equation system (18) with *Gindex*, *Phold*, and *Dhold*, respectively, as the measure of governance, and report the results in Table 4.

Table 4. General Impact of Governance on Physical and R&D Investments

This table presents the estimation results of the physical and R&D investment equation system with each of the three governance measure as an explanatory variable. In the parenthesis under each coefficient is the Pr > |t|. Heckman's two-step procedure is employed to estimate the Seemingly Unrelated Regression system with the inverse Mills ratios (Mills) on the right-hand side as an additional variable to control for sample selection. Standard errors are adjusted with respect to heteroscedasticity and serial correlations.

	Gov = Gindex		Gov = Phold		Gov = Dhold	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
Gov	0,021	0,014	-0,005	0,000	-0,008	0,006
	(0.000)	(0.000)	(0.423)	(0.995)	(0.046)	(0.041)
MPK	0,067		0,076		0,053	
	(0.000)		(0.000)		(0.000)	
MPR		0,060		0,037		0,017
		(0.001)		(0.001)		(0.406)
CF_t/TK_{t-1}	0,043	0,047	0,018	0,024	0,049	0,033
	(0.001)	(0.000)	(0.048)	(0.000)	(0.000)	(0.006)
LEV	-0,255	-0,051	-0,296	-0,026	-0,095	-0,030
	(0.000)	(0.014)	(0.000)	(0.177)	(0.060)	(0.368)
TAN	0,106	0,155	0,309	0,290	0,223	0,174
	(0.029)	(0.000)	(0.000)	(0.000)	(0.002)	(0.002)
A	0,009	0,004	0,004	-0,002	-0,005	-0,002
	(0.007)	(0.203)	(0.121)	(0.185)	(0.437)	(0.761)
Z	0,001	-0,112	0,034	-0,101	0,179	-0,086
	(0.976)	(0.000)	(0.323)	(0.000)	(0.002)	(0.056)
Mills	-0,096	-0,040	-0,074	0,014	0,004	0,024
	(0.000)	(0.005)	(0.001)	(0.344)	(0.915)	(0.424)
Nobs	4304		8003		1603	
2nd Stage R^2	0,111	0,088	0,078	0,063	0,079	0,125

The three governance measures have different effects on investments. The G index has positive coefficients in both the capital and R&D investment equations and they are both statistically significant at the one percent level. In other words, firms that are more open to the market of corporate control tend to invest more both in physical and R&D capital. As for the economic significance, a quick gauge shows that an addition of an anti-takeover provision, on average, lowers the physical investment rate by 0.52 percentage point, and lowers the R&D rate by 0.35 percentage point. In contrast, we observe close-to-zero coefficients on *Phold*, and opposite signs of coefficients on *Dhold*, Apparently public pension funds don't have an unambiguous impact on a firm's investment decisions, while directors with higher ownership discourage physical investment but encourage R&D investment.

Takeover pressure can be a double-edged sword in addressing the separation between ownership and control. Takeover pressure could align the interest of the manager with that of the shareholders; however, a very high pressure of takeover might reduce the manager's incentive to work hard because chances are she would not be able to enjoy the benefits from company growth. Similar arguments can be made about ownership by activist shareholders, too. On one hand, holding shares of a firm surely motivates a subject to feel the shareholders' needs and to monitor the self-interested manager; on the other, a high ownership could lead the subject to deviate from all shareholders' interests. Possible scenarios include, but not limited to, that the subject becomes excessively conservative because of the inadequately diversified risk, and the manager may "bribe" the subject to bind their interests together. The literature has documented the nonlinear relationship between CEO ownership and financial policies. For example, Ghosh, Moon and Tandon (2007) find that R&D investments increase and then decline across increasing levels of CEO stock ownership. Similarly, we wonder if a nonlinear relationship between corporate governance mechanisms under investigation and investments.

To answer this question, we partition the sample, according to the predicted value of a corporate governance measure in the first-step regression, into the top quartile, the bottom quartile and the middle half, and examine the impact of corporate governance on investments in the three subsamples. For each governance measure, we define indicator variables, *High*, *Med*, and *Low*, which represent the three groups of observations from the top to the bottom, respectively, and construct interaction items between them and the governance measure itself. Table 5 reports the results. *Gindex* has no impact on either physical or R&D investment among dictatorship firms (bottom quartile), positively influences both physical and R&D investments among democracy firms, and negatively influences physical investment among firms in between. Therefore, the positive coefficients on *Gindex* in Table 4 is mainly attributable to democracy firms, that is, enhanced investments are due to significantly higher investments among firms that are most open to the market of corporate control. Among democracy firms, an additional anti-takeover provision is associated with a decline of 2.9 percentage point in physical investment and a decline of 0.94 percentage point in R&D investment. The coefficients on *Phold* are significantly negative in both the bottom quartile and the middle half, but significantly positive in the top quartile when we consider the capital expenditure equation. This indicates a U-shaped relation between public pension fund ownership and capital investment, in the sense that public pension funds discourage physical investment when their holdings increase, but encourage physical investment when their holding is very high. As far as director ownership is concerned, directors appear to curb physical investment but boost R&D investment when their ownership is low; when their ownership gets higher, they continue to constrain physical investment but no longer enhance R&D investment on average.

Table 5. Corporate Governance vs. Investments in Subsamples

	Gov = Gindex		Gov = Phold		Gov = Dhold	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
*Gov*Low*	0,005	0,006	-0,412	0,011	-0,010	0,013
	(0.441)	(0.265)	(0.000)	(0.917)	(0.069)	(0.005)
*Gov*Med*	-0,066	0,002	-0,348	-0,026	-0,019	0,000
	(0.003)	(0.904)	(0.006)	(0.842)	(0.074)	(0.969)
*Gov*High*	0,115	0,047	0,088	-0,005	-0,002	0,001
	(0.000)	(0.001)	(0.001)	(0.853)	(0.771)	(0.871)
MPK	0,077		0,100		0,067	
	(0.000)		(0.000)		(0.000)	
MPR		0,052		0,035		0,025
		(0.001)		(0.001)		(0.191)
CF_t/TK_{t-1}	0,034	0,044	0,022	0,036	0,043	0,024
	(0.000)	(0.000)	(0.194)	(0.000)	(0.005)	(0.005)
LEV	-0,219	-0,040	-0,287	-0,019	-0,105	0,000
	(0.000)	(0.055)	(0.000)	(0.325)	(0.056)	(0.990)
TAN	0,108	0,157	0,207	0,240	0,194	0,179
	(0.029)	(0.000)	(0.000)	(0.000)	(0.010)	(0.000)
A	0,013	0,005	0,004	-0,002	-0,004	-0,006
	(0.001)	(0.059)	(0.148)	(0.339)	(0.593)	(0.172)
Z	-0,003	-0,129	0,033	-0,114	0,187	-0,104
	(0.948)	(0.000)	(0.443)	(0.000)	(0.003)	(0.006)
Mills	-0,102	-0,039	-0,065	0,020	0,001	0,051
	(0.000)	(0.005)	(0.005)	(0.165)	(0.986)	(0.058)
Nobs	3817		6840		1530	
2nd Stage R^2	0,120	0,129	0,088	0,099	0,085	0,125

This table presents the estimation results of the physical and R&D investment equation system when the samples are divided into three groups according to corporate governance. In the parenthesis under each coefficient is the Pr > |t|. The Heckman's two-step procedure is used to estimate the Seemingly Unrelated Regression system with the Inverse Mills ratios (Mills) as an additional variable that control for sample selection. Standard errors are adjusted with respect to heteroscedasticity and serial correlations.

4.2 Corporate governance and investment distortions

There exist various information and agency problems that distort corporate investment behavior. Certain problem dominates others sometimes, but in many cases multiple agency problems co-exist. The effect of corporate governance on investments is the sum of their effects on these information and agency problems. Two prominent and relevant agency problems are the free cash flow problem (Jensen (1986)) and debt overhang (Myers (1977)). The former argues self-interested managers tend to overinvest, particularly when they have abundant free cash flow, while the later predicts debt-laden firms are more likely to exhibit underinvestment by passing by positive-NPV projects to protect incumbent shareholders. In this section we'll investigate whether the corporate governance mechanisms under study mitigate or exacerbate these two agency problems.

For that purpose, we define two indicator variables, *Freecash*, which equals 1 for firms that are likely to be subject to the free cash flow problem and 0 otherwise, and Overhang, which equals 1 for firms that are debt overhang prone and 0 otherwise. A firm is classified as prone to the free cash flow problem if its physical/R&D investment opportunities belong to the bottom half and its financial slack belongs to the top half. In other words, firms with little investment opportunities but a lot of free cash are more likely to overinvest. The physical and R&D investment opportunities are measured by *MPK* and *MPR*, respectively. Note that *Freecash* may take different values in the physical and R&D equations. A firm is classified as prone to debt overhang if its leverage ratio is above 0.25 (roughly the top tercile, but different cutoffs don't alter our results) and its asset tangibility is in the bottom half. Then we construct the interaction items between the indicator variables and governance measures, and put them on the right-hand side of the equation system. Then the coefficients on the interaction items should be able to capture the impacts of corporate governance on the agency problems, if any.

Note that for investigating the free cash flow problem, we'll remove debt overhang prone firms from the sample to single out the effects of corporate governance on the free cash flow problem. For convenience, we call the subsample of free cash flow problem prone firms the overinvestment firms, the one of debt overhang prone firms the underinvestment firms, and the rest normal firms. The purge of underinvestment firms gives prominence to the comparison between overinvestment firms and normal firms. Likewise, we'll exclude overinvestment firms to study the effects of corporate governance on debt overhang.

4.2.1 Free cash flow problem

One way in which the manager's interest diverges from those of shareholders is that the manager may extract private benefits from running a large firm. Jensen (1986) argues that empire-building preferences will cause the manager to spend essentially all available funds on investment projects and hence dubs it the "free cash flow problem". Li (2007) models this overinvestment tendency and predicts that better shareholder protection would lower investment.

Table 6. Corporate Governance and Overinvestment

This table presents part of the estimation results of the physical and R&D investment equation system with interactions between corporate governance measures and Freecash, an indicator variable that equals 1 for firms likely to be subject of the overinvestment and 0 otherwise, included on the right-hand side. Only firms that are not likely subject to underinvestment are included in the sample. Indicator Low equals 1 for firms in the dictatorship group (for Gindex) or bottom quartile (for Phold and Dhold), and 0 otherwise. High is defined in a similar fashion for firms in the democracy group or top quartile. Med is so defined for firms in between. All controlling variables are omitted in the table. A firm-year observation is classified as overinvestment prone if its growth opportunities (measured by MPK for physical investment and MPR for R&D) is below the median and its financial slack is above the median; a firm is classified as underinvestment-prone if its leverage ratio is above 25% and the asset tangibility is below the median. For the estimation of the Seeminly Unrelated Regression system please see Section 3.4. In the parenthesis under each estimated coefficient is Pr > |t|. Standard errors are adjusted with respect to heteroscedasticity and serial correlations.

Panel A: General Impact						
	Gov = Gindex		*Gov = Phold*		*Gov = Dhold*	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
Gov	0,029	0,011	-0,021	-0,019	-0,007	0,002
	(0.000)	(0.022)	(0.026)	(0.007)	(0.203)	(0.621)
Freecash	0.031	-0.002	0.068	-0.002	0.104	0.019
	(0.003)	(0.766)	(0.000)	(0.707)	(0.000)	(0.159)
*Gov*Freecash*	-0,019	-0,004	0,010	0,037	0,004	-0,005
	(0.074)	(0.731)	(0.705)	(0.008)	(0.784)	(0.423)
2nd Stage R^2	0,092	0,117	0,087	0,098	0,067	0,094
Panel B: Subsample Impacts						
	Gov = Gindex		*Gov = Phold*		*Gov = Dhold*	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
*Gov*Low*	0,012	0,004	-0,535	0,037	-0,010	0,010
	(0.125)	(0.536)	(0.000)	(0.809)	(0.274)	(0.147)
*Gov*Med*	-0,049	0,017	-0,460	0,009	-0,021	-0,011
	(0.089)	(0.394)	(0.005)	(0.961)	(0.175)	(0.357)
*Gov*High*	0,128	0,032	0,089	-0,028	-0,002	0,001
	(0.000)	(0.057)	(0.013)	(0.389)	(0.860)	(0.858)
Freecash	0.038	-0.009	0.052	-0.093	0.067	0.015
	(0.048)	(0.363)	(0.434)	(0.031)	(0.039)	(0.515)
*Gov*Low*Freecash*	-0,009	-0,014	0,293	-0,408	0,008	-0,006
	(0.603)	(0.361)	(0.359)	(0.047)	(0.716)	(0.696)
*Gov*Med*Freecash*	-0.030	-0.056	-0,567	-0,527	0,031	0,013
	(0.730)	(0.136)	(0.165)	(0.048)	(0.450)	(0.634)
*Gov*High*Freecash*	-0,084	0,031	0,024	0,160	-0,019	-0,009
	(0.062)	(0.338)	(0.795)	(0.009)	(0.529)	(0.466)
2nd Stage R^2	0,110	0,100	0,094	0,100	0,086	0,101

Table 6 displays part of our estimation results. We omit all controlling variables to save space, and focus on the coefficients of the interaction items between *Freecash* and governance. In Panel A, *Freecash* loads positively in the physical investment equation but doesn't in the R&D investment equation with no exception, indicating the free cash flow problem be relevant mainly for physical investment. This is actually consistent with observations that R&D investments are typically expensed and do not contribute to the firm size in terms of book value and that R&D investments are relatively more risky than physical investments. Therefore below we'll focus on the interaction items in the physical investment equation.

When the governance measure is *Gindex*, in Panel A the coefficient on the interaction item between governance and *Freecash* is -0.019, which is statistically significant. This is equivalent to shrinkage of 0.48 percentage point in the gap in physical investment between the overinvestment group and the normal group. Hence the market of corporate control does mitigate the free cash flow problem. However, neither public pension funds ownership or director ownership seem helpful in curbing overinvestment in the full sample (normal firms and overinvestment firms). In Panel B we look into each governance subsample to accommodate possible nonlinearity in governance's effect on the free cash flow problem. The interaction item between *Gindex* and *Freecash* is negative in all the three subsamples, with increasing magnitude as *Gindex* gets higher, and turned statistically significant in the democracy subsample. This substantiates the full-sample finding that takeover pressure alleviates the free cash flow problem, and also indicates that the impact is most obvious when the pressure is high. In the democracy group, on average the removal of an anti-takeover provision would narrow the gap in physical investment between overinvestment firms and normal firms by 2.1 percentage points, which is huge. In contrast, when we turn to the coefficients of interactions between internal governance mechanisms and *Freecash*, we find none of them is statistically different from zero.

Therefore, the market of corporate control does mitigate the overinvestment tendency due to free cash flow, and the marginal effect is the greatest when the takeover pressure is high. The internal governance mechanisms under investigation, either public pension funds or director ownership, do not have a discernible impact on the free cash flow problem.

4.2.2 Debt overhang

Unlike the free cash flow problem, the idea of debt overhang is based on the conflict of interests between the manager and the creditors of a firm. The best-known concept of debt overhang is developed by Myers (1977), who argues that a leveraged firm may pass up positive NPV investment projects if the benefits go to the creditors only. As a matter of fact, the effect of debt on investment decisions goes beyond this. First, leverage jacks up the cost of new debts, particularly if the new debt claims are junior to the existing debt; and second, the manager of a leveraged firm might be more conservative in taking up risky investments due to the career consideration (Hirshleifer and Thaker, 1992). All these effects lead to underinvestment, while people have conveniently stuck to the term of debt overhang (e.g., Hennessy, 2004; Moyen 2007).

Table 7. Corporate Governance and Underinvestment

This table presents part of the estimation results of the physical and R&D investment equation system with interactions between corporate governance measures and Overhang, an indicator variable that equals 1 for firms likely to be subject of the underinvestment problem and 0 otherwise, included on the right-hand side. Only firms that are not likely subject to overinvestment are included in the sample. Indicator Low equals 1 for firms in the dictatorship group (for Gindex) or bottom quartile (for Phold and Dhold), and 0 otherwise. High is defined in the same fashion for firms in the democracy group or top quartile. Med is so defined for firms in between. All controlling variables are omitted in the table. A firm-year observation is classified as underinvestment prone if its leverage is above 25% and its asset tangibility is below the median; a firm is classified as overinvestment prone if its investment opportunities (measured by MPK for physical and MPR for R&D investments) is below the median and its financial slack is above the median. For the estimation of the Seemingly Unrelated Regression system please see section 3.4. In the parenthesis under each estimated coefficient is Pr > |t|. Standard errors are adjusted with respect to heteroscedasticity and serial correlations.

Panel A: General Impact						
	Gov = Gindex		*Gov = Phold*		*Gov = Dhold*	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
Gov	0,030	0,015	-0,016	-0,018	-0,001	0,004
	(0.000)	(0.002)	(0.109)	(0.019)	(0.852)	(0.224)
Overhang	-0.030	-0.020	-0.047	-0.017	-0.016	-0.007
	(0.000)	(0.012)	(0.000)	(0.031)	(0.213)	(0.488)
*Gov*Overhang*	-0,027	-0,002	0,043	0,000	-0,007	0,012
	(0.005)	(0.825)	(0.006)	(0.996)	(0.345)	(0.043)
2nd Stage R^2	0,089	0,123	0,074	0,093	0,056	0,105
Panel B: Subsample Impacts						
	Gov = Gindex		*Gov = Phold*		*Gov = Dhold*	
	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}	I_t/K_{t-1}	R_t/D_{t-1}
*Gov*Low*	0,019	0,011	-0,316	0,147	-0,007	0,012
	(0.032)	(0.112)	(0.017)	(0.354)	(0.435)	(0.089)
*Gov*Med*	-0.066	0.016	-0.124	0.110	-0.022	-0.013
	(0.035)	(0.429)	(0.465)	(0.576)	(0.167)	(0.296)
*Gov*High*	0,138	0,032	0,025	-0,051	0,005	0,004
	(0.000)	(0.076)	(0.510)	(0.247)	(0.628)	(0.540)
Overhang	-0,055	-0,033	-0,028	-0,018	-0,011	0,006
	(0.000)	(0.005)	(0.529)	(0.713)	(0.519)	(0.707)
*Gov*Low*Overhang*	-0.052	-0.017	-0.040	-0.069	-0.005	0.009
	(0.000)	(0.089)	(0.855)	(0.783)	(0.698)	(0.350)
*Gov*Med*Overhang*	-0,021	-0,019	0,335	0,034	0,003	0,046
	(0.641)	(0.685)	(0.233)	(0.916)	(0.894)	(0.032)
*Gov*High*Overhang*	0,034	0,057	0,018	0,003	-0,004	0,007
	(0.339)	(0.234)	(0.753)	(0.961)	(0.794)	(0.607)
2nd Stage R^2	0,119	0,126	0,081	0,094	0,083	0,138

Table 7 reports our investigations on how corporate governance influences debt overhang. The coefficients on *Overhang* as reported in Panel A are consistently negative in all scenarios and in both the physical investment equation and the R&D equation, and statistically significant in most cases, indicating that debt overhang occurs on both physical and R&D investments.

In the full sample (normal firms and underinvestment firms), the interaction item between *Gindex* and *Overhang* loads negatively in the physical investment equation, that between *Phold* and *Overhang* does positively in the physical investment equation, and that between *Dhold* and *Overhang* positively in the R&D equation. Thus greater takeover pressure exacerbates underinvestment in physical capital due to debt overhang, higher public pension funds ownership mitigates debt overhang with respect to physical investment, and firms with higher directors' ownership mitigates debt overhang with respect to R&D investment. Looking into the subsample results (Panel B), we find that the interaction between *Gindex* and *Overhang* has significantly negative coefficients in dictatorship group for both physical and R&D investment, negative but insignificant coefficients in the middle group, and positive but insignificant coefficients in the democracy group. This indicates that when takeover pressure is low, debt overhang is more severe for firms more open to the market of control, which is sensible – increased disciplining by the market of control aligns the manager's interest better with the shareholders, which makes it less likely that the manager takes the side of the creditors when the conflict in interests is present between shareholders and creditors. The marginal effect of removal of anti-takeover provisions on debt overhang vanishes as the firm has already been very open to the market of control. Public pension funds ownership doesn't load in the subsamples. Director ownership has a positive coefficient in each of the subsamples for R&D investment, and the one is statistically significant in the middle subsample. So, directors' ownership seems to mitigate debt overhang with respect to R&D investment, and the marginal effect is the strongest when the ownership is in the moderate range.

The literature finds that better shareholder protection is typically associated with higher cost of debt financing (e.g., Klock, Mansi and Maxwell, 2005) , and people attribute this to worsened debt overhang because of the widening gap between the interest of the manager and that of creditors (e.g., Yang, 2006) . This is exactly what we have observed on the external governance mechanism, but not on the internal governance mechanism. A possible explanation is that the stockholding by public pension funds and directors is a sign of good quality which would reduce the information asymmetry between the firms and the potential creditors, which in turn leads to lower cost of debt financing. Besides, Cremers, Nair and Wei (2007) find that shareholder control could be associated with lower cost of debt if the firm is protected from takeovers, which may help understand our debt overhang findings regarding internal governance mechanism.

In summary, the market of control exacerbates the debt overhang, and the marginal effect is strongest particularly for firms least open to the takeover market. Internal governance mechanism under study mitigate debt overhang; particularly, higher public pension funds ownership is associated with lower sensitivity of physical investment to debt overhang, while higher director ownership is associated with lower sensitivity of R&D investment to debt overhang.

Conclusion

We investigate the effects of corporate governance on corporate investment behavior in a seemingly unrelated regression system that takes into account both physical investment and R&D investment. Our empirical evidence show that different corporate governance mechanisms have different impacts on corporate investments, and that the impacts of a mechanism may differ on a firm's physical investment and R&D investment. Specifically, the external governance from the market of control boosts both physical and R&D investments; public pension funds ownership has a U-shaped relation with respect to physical investment, but does not influence R&D investment; increasing director ownership discourages physical investment but encourages R&D investment. Besides, the market of control interacts with public pension funds ownership on physical investment: increasing public pension funds ownership reduces the positive effect of takeover pressure on physical investment at first, and jacks up the effect of takeover pressure further when it is high.

We also examine whether and how the external and internal governance mechanisms influence the well-known free cash flow problem and debt overhang. The market of control appears to mitigate the free cash flow problem but aggravate the debt overhang problem, which is consistent with the idea that better shareholder protection aligns the manager's interest with that of the shareholders. In contrast, neither public pension funds ownership nor director ownership alleviates the free cash flow problem, but they do assuage the underinvestment due to debt overhang.

A question follows: why does takeover pressure enhances investments, given that it curbs the overinvestment tendency linked with the free cash flow problem and exacerbates the underinvestment tendency associated with debt overhang? Since we have not brought the information problem related to external financing into the current investigations, the above findings hint at a negative effect of external governance on information asymmetry between the firm and its potential fund suppliers. In other words, better shareholder protection helps clear the informational barriers for external financing (Myers and Majluf, 1984) and hence makes both physical and R&D investments more likely. In this regard, we have direct evidence from Ferreira and Laux (2007) that finds firms with fewer anti-takeover provisions facilitates information production about the firm. In Tables 7 and 8, the coefficient on *Gindex* remains always significantly positive even after we control for the free cash flow problem and the debt overhang, consistent with the presence of an effect on the information problem.

Appendix A: Variable definition

The variables are defined using information from COMPUSTAT, RiskMetrics, Corporate Library and Thompson Financial f13. Data items are from the COMPUSTAT annual data file:

(1) I = data128
(2) R = data46
(3) K = data8
(4) $R_{it} = D_{it} + 0.8*D_{i,t-1} + 0.6*D_{i,t-2} + 0.4*D_{i,t-3} + 0.2*D_{i,t-4}$
(5) A = data6 + R
(6) logA = log(A)
(7) NI =data172 + R – $0.2*\sum_{k=1}^{5} D_{i,t-k}$ *(1-t)**1**, where **1** is an indicator for data172>0*
(8) Total capital TK = K + R
(9) Gindex = 24 – number of anti-takeover provisions that are present
(10) Phold = sum of ownership of the 18 public pension funds in Appendix B
(11) Dhold = median director ownership in US dollar amount
(12) CF = data14 + data18+ R - $0.2*\sum_{k=1}^{5} D_{i,t-k}$
(13) LEV = (data9 + data34) / A
*(14) Asset Tangibility: TAN = (0.715*data2 + 0.547*data3 + 0.535*data8 + data1)/A (Defined as in Almeida & Campello (2007))*
(15) Sales: S = data12
*(16) Market to book ratio: MTB = (data6 + data24*data35 – data60 – data74) / A*
(17) Current ratio: Current = data4 / data5
(18) Long-term Debt ratio: Debt = data9 / A
(19) Fixed charge coverage ratio: FCCov = data178 / (data15 + data19)
(20) Net income margin: NIM = (data18 – data48) / data12
(21) Dividend: Div = data19 + data21
*(22) Financial slack: Slack = (data1 + 0.5*data3 + 0.7*data2 – data206) / TK*
(23) Dividend growth: Divup = 1 if Div_t / Div_{t-1} *> 1, and 0 otherwise*
(24) Sales growth: SG = 1 if S_t / S_{t-1} *> 1, and 0 otherwise*

Appendix B: List of Public pension funds

California Public Employees Retirement System
California State Teachers Retirement
Colorado Public Employees Retirement Association
Florida State Board of Administration
Illinois State Universities Retirement System
Kentucky Teachers Retirement System
Maryland State Retirement and Pension System
Michigan State Treasure
Montana Board of Investment
New Mexico Educational Retirement Board
New York State Common Retirement Fund
New York State Teachers Retirement System
Ohio Public Employees Retirement System
Ohio School Employees Retirement System
Ohio State Teachers Retirement System
Texas Teachers Retirement System
Virginia Retirement System
State of Wisconsin Investment Board

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