UNCERTAINTY AND TANGIBLE ASSETS IN FIRM INVESTMENT: INTER-INDUSTRY EVIDENCE FROM APEC COUNTRIES

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The undersigned, appointed by the dean of the Graduate School, have examined the dissertation entitled

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ABSTRACT

This dissertation investigates how the role of cash flow changes with the uncertainty coming from oil price fluctuations, using the annual data obtained from COMPUSTAT global during the period of 1991 to 2004. I construct three measures of oil price volatility and one measure of relative oil price change.

The main empirical findings are that the role of cash flow diminishes with higher oil price volatility for both manufacturing and service industries. Cash flow sensitivity declines more with volatility in more energy intensive industries. Firm investments in energy intensive manufacturing are hurt the most by oil price volatility, and firms in the service industry are hurt less than firms in manufacturing. When relative oil prices are used for the measure of oil price changes, most APEC countries except the U.S. show the role of cash flow increasing during times of higher oil prices. Oil price volatility affects firm investments in the U.S. and Canadian manufacturing negatively and significantly. Manufacturing firms in low income countries and manufacturing-growing countries are less hurt by oil price volatility when they have more cash flow. In the analysis of the effect of tangible assets on firm-level investment, I find that the role of cash flow declines or does little in importance with tangible assets in manufacturing and service industries. The last finding is that sales show very little impact on firm-level investment in the service industry unlike in manufacturing.

Chapter 1

Introduction

In financial markets, the perfect competition assumption in the classical theory is easily violated due to information and incentive problems. As Stiglitz and Weiss (1981) have shown, asymmetric information between lenders and borrowers raises adverse selection and moral hazard problems. The difference between managers' and stockholders' interests leads to incentive problems, where managers may pursue their own interests rather than stockholders'. These information and incentive problems raise financial friction in the financial market, and eventually cost borrowers more for external financing, since the lenders would put some risk premium on the interest rates in consideration of a possible default. Thus, firms who have to pay higher interest rates for borrowing from banks will look for internal financing, which costs less than external. We can presume that financially constrained firms will be more sensitive to cash flow in investment and vice versa for financially unconstrained firms. Since Fazzari, Hubbard and Petersen (1988), most of the studies in this literature show that financially constrained firms are more sensitive to their internal funds. Some studies question these results. Kaplan and Zingales (1997), Cleary (1999), and Gomes (2001) show that financially less constrained firms are more sensitive to internal funds, arguing that internal funds are s dominant source of firm investment for all firms.

Financial friction can come at both the firm-level and country-level. If a country has a more developed financial market, the degree of financial friction of the country will decrease, which influences all the firms in the region. Uncertainty can also be related to the level of financial friction. Uncertainty comes from various sources such as the behavior of prices, wages, consumers' tastes, technology, institutions, exchange rates and others. In times of greater uncertainty, firm managers behave more cautiously and possibly forgo investment opportunities with positive net returns. They become more cautious and perceptive of the turbulence even though they have positive cash flows ("caution effect" by Bloom, Bond, and Reenen (2001)). Thus, we can assume that the role of cash flow diminishes in importance at heightened uncertainty. In other words, uncertainty around firms may reduce firms' responses to cash flow in their investment decisions. Therefore the degree of financial friction will be related not only to the firm's cash flow but also to the degree of uncertainty faced by the firm. As the uncertainty-reflecting both macroeconomic and firm-specific uncertainty-varies, the premium charged by the lenders will systematically vary. The magnitude of financial friction facing a firm becomes a function of the firm's cash flow interacted with measures of uncertainty. Here, I specifically consider the uncertainty coming from oil price volatility and examine the change of cash flow importance in firm investment with the level of oil price volatility. To measure oil price volatility, I use several types of daily oil prices, including future and spot oil prices. I will analyze the oil price volatility effect on investment across manufacturing and service industries. Distinguishing manufacturing and service industries in this study can be meaningful because manufacturing is more energy intensive and also more energy and petroleum consuming. Energy intensive firms tend to be capital intensive (Ramirez and Blok (2005)). I especially focus on the six energy intensive sectors based on the data of US DOE and other studies: petroleum refining, paper products, primary metal, stone and concrete, chemical products, lumber and wood. From this point of view, we believe the energy intensive industries will be hurt more by oil price volatility in terms of production cost and demand for their goods. We can assume that, in the time of heightened oil shock, more energy intensive industries, such as manufacturing will be more cautious in investment in consideration of the irreversibility of investment even if the firm's cash flow increases. Especially, firms in the six energy intensive manufacturing sectors mentioned above will be more cautious at the time of heightened oil price volatility, and the role of cash flow will diminish much more in the investment decisions than other sectors.

At the firm-level, tangible assets (or harder assets) such as real estate, machinery, and the plant may reduce the degree of financial friction (Braun and Larrain (2005)). Land, structures, and most equipment are typically not specific to the firm or the industry, and they can therefore command a higher liquidation value than inventories or intangibles (Shleifer and Vishney (1992)). These tangible assets are able to support the borrower-lender relationship, reducing financial friction. In the leverage literature, we can easily find a positive relationship between tangibility and leverage. "We can expect firms with assets that can be collateralized to use more leverage and agency problems might reduce with the increase of tangible assets" (recited from Schoubben and Hulle (2004)). Ameida and Campello (2006) utilize the credit multiplier effect of tangible assets in their analysis on U.S. firms' investment behavior. The credit multiplier effect implies that contractable tangible assets support more borrowings that in turn allow for further investment in tangible assets, and the credit multiplier is more important for financially constrained firms than for financially unconstrained firms. If the borrowing capacity is high enough, the firm becomes unconstrained and asset tangibility does not amplify the income effect (cash flow effect) on investment. They show that asset tangibility positively affects the cash flow sensitivity of investment of financially constrained firms. In my study, I will see whether the credit multiplier effect exists differently across manufacturing and service industries.

In the literature on firm investment and liquidity sensitivity, most studies focus on manufacturing industries, and some studies are conducted across industries. In this respect, Chrinko and Schaller (1995) are a very exceptional case, and they report the estimation results of cash flow sensitivity between manufacturing and service industries even though the estimation results are ambiguous and the explanation is short. Our world is experiencing a fundamental shift from a manufacturing- to service-based economy. In general, the service industry's relative size is strongly positively related to per capita GDP. More than 60% percent of GDP is generated by the service sector in many middle income economies, and among high income economies, service industries often account for over 70 % of GDP and employment. Because of the service sector's huge contribution to each economy, it is natural to pay attention to service firms' investment behavior. As Chrinko and Schaller (1995) indicated, focusing on manufacturing firms may undervalue or overvalue the liquidity effect in firm investment. Here, I will analyze firms' investment behavior, clearly distinguishing manufacturing and service industries in much detail. In the literature, most studies analyze a single country, and cross-country studies are rare, even though the number of cross-country studies has increased recently.

In this sense, Love (2003)'s work is a very magnificent cross-country study (36 countries), showing how cash sensitivity of investment differs with the degree of financial development, based on solid empirical methods. My study explores firm investment behavior in the APEC region. In the APEC region, the economic gap between member countries is quite large. Some countries' per capita GDP is more than $30,000 as of 2005 (US, Japan, Canada), but some countries have less than $5,000 in per capita GDP. The service industry's contribution to GDP in some countries is over 70% and for some low income countries, it is less than 50%. For the manufacturing industry, the contribution to GDP tends to decline in high income countries, but increases in some low income countries. Again, in this article, I will see how differently the oil price volatility affects the cash flow sensitivities of firm investments across manufacturing and service industries in APEC countries. Also, I will look at how differently the asset tangibility affects the cash flow sensitivity of firm investments across manufacturing and service industries. The rest of the paper is as follows: Chapter 2 discusses the characters of the APEC economy, manufacturing and service, and my hypotheses. Chapter 3 describes the literature review, and chapter 4 studies the theoretical models in the literature. In chapter 5 and 6, I present the empirical models, and describe the data. In chapter 7, I report the empirical findings, while chapter 8 concludes and draws implications for future research.

Chapter 2

APEC countries, and Manufacturing and Service Industries

2.1. Heterogeneous Economic Structure in APEC

The economic structures are quite different among APEC member countries. As of 2004, most of the above countries have per capita GDP of well above $25,000. But some countries in the APEC region show per capita GDP less than $3,000 as of 2003, which is shown in the Table 2-1. As of 2003, the countries with per capita GDP of more than $20,000 are Australia, Canada, Hong Kong, Japan, Singapore, and U.S. Middle income countries are South Korea and Taiwan with per capita GDP of more than $10,000 as of 2003. Thus, well-developed and much less-developed countries co-exist in the APEC region. In the aspect of industrial structure, the service industry's contribution to GDP in the developed countries is quite high (USA: 76.5%, Australia: 71%, Hong Kong: 88.5% as of 2003, Canada: 65.4% as of 2001). In less developed countries, however, the contribution of service to GDP is quite low (China: 41.5%, Indonesia: 40.5%, Malaysia: 41.7% as of 2003). Mexico is not a developed country because its per capita GDP is just over $6,100 in per capita GDP as of 2003, but the contribution of service to GDP is more than 70%. For the manufacturing industry, the contribution to GDP goes the other way: less developed countries have a greater contribution of manufacturing to GDP. These relationships also can hold for employment.

Table 2-1

Per capita GDP and Contribution to GDP each Industry

Country	Year	pcGDP	Contribution to value added			
			aff	ind	mfg	svc
AUS	2003	27556.7	0.034	0.257	0.119	0.709
CAN	2001	22749	0.022	0.324	0.181	0.654
CHN	2003	1151.29	0.126	0.46		0.415
HKG	2003	23005.4	0.001	0.114	0.041	0.885
IDN	2003	1092.3	0.159	0.436	0.288	0.405
JPN	2003	33124.9	0.013	0.305	0.209	0.682
KOR	2003	12812.9	0.038	0.391	0.264	0.572
MEX	2003	6122.44	0.039	0.258	0.18	0.703
MYS	2003	4253.9	0.096	0.486	0.311	0.417
PHL	2003	987.974	0.13	0.326	0.238	0.544
SGP	2003	21974.1	0.001	0.339	0.269	0.66
THA	2003	2263.38	0.103	0.436	0.348	0.462
USA	2003	37313.3	0.012	0.223	0.149	0.765

Source: (pcGDP) UN (Contribution to value added) World bank
Aff: agriculture, forestry and fishing, ind: industry, mfg: manufacturing, svc: service

Even though it is not presented in the above table, it is very interesting that Japan showed a rapid growth in the service industry during the early 1990-2004 period. In this period, the Japanese economy has been in a slump, but statistically the economy seems to be very successful in changing its industrial structure (from the manufacturing to service industries). In 1990, the service industry's contribution to GDP was 58.2%, and 14 years later (year 2003) it is 68.2%.

2.2. Manufacturing and Service Industries

2.2.1. Industry Classification

The World Bank and OECD use the definition of service industry corresponding to ISIC[1] divisions 50–99 issued by the United Nations. Sometimes, as in the WTO DOHA service agenda, the construction sector is also included in the service industry.

Table 2-2

UN ISIC Code

ISIC code	Name of Industry
01- 02	A - Agriculture, hunting and forestry
05 -	B - Fishing
10-14	C - Mining and quarrying
15-37	D – Manufacturing
40-41	E - Electricity, gas and water supply
45 -	F – Construction
50-54	G - Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and household goods
55 -	H - Hotels and restaurants
60-64	I - Transport, storage and communications
65-67	J - Financial intermediation
70-74	K - Real estate, renting and business activities
75 -	L - Public administration and defense; compulsory social security
80 -	M – Education
85 -	N - Health and social work
90-93	O - Other community, social and personal service activities
95 -	P - Activities of private households as employers and undifferentiated production activities of private households
99 -	Q - Extraterritorial organizations and bodies

[1] ISIC: International Standard Industrial Classification of all economic activities

The SIC of the U.S., as shown in Table 2-3, is slightly different from UN ISIC. By US SIC, the service industry corresponds to 40-99, where Electric, Gas, and Sanitary services are included. It is important to notice that Electric, Gas, and Sanitary services are not included in service sector according to UN ISIC. We also need to notice that codes 70-89 are defined as services in US SIC, and we can consider them as a narrowly defined service industry which is a growing sector in each economy. The shadowed SIC codes are the target service sectors for my analysis. My firm-level data is obtained from the COMPUSTAT global and the firms are classified according to the US SIC code.

Table 2-3

US SIC Code

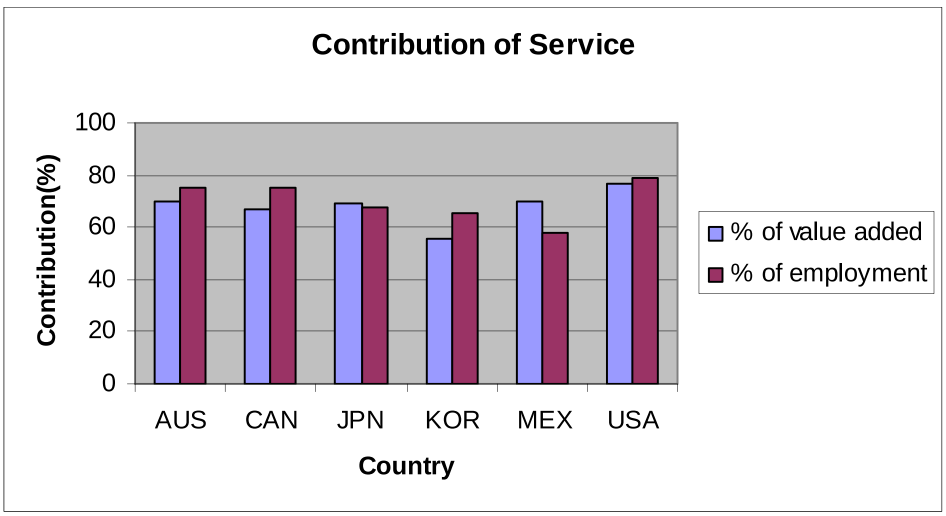
# of Codes	Name of Industry
01 - 09	Division A: Agriculture, Forestry, And Fishing
10 - 14	Division B: Mining
15 - 17	Division C: Construction
20 - 39	Division D: Manufacturing
40 - 49	Division E: Transportation, Communications, Electric, Gas, And Sanitary Services
50 -51	Division F: Wholesale Trade
52 - 59	Division G: Retail Trade
60 -67	Division H: Finance, Insurance, And Real Estate
70 -89	Division I: Services
91 - 99	Division J: Public Administration

2.2.2. Relationship between Contribution to GDP and per capita GDP

As I mentioned earlier, more developed countries have a greater contribution by the service industry to GDP and employment. It is noticeable that contribution of service to employment is greater than contribution of service to GDP in the countries of Australia, Canada, Korea, and the U.S. in the below Figure 2-1.

Figure 2-1

Contribution of Service to Value Added



Source: OECD in figures 2006 -2007,
Year: (Value added) 2004, (employment) 2005

Figure 2-2 shows the relationship between contribution of each industry and per capita GDP over the period of 1991-2005 in APEC 13 countries: Australia, Canada, China, Hong Kong, Indonesia, Japan, Korea, Mexico, Malaysia, Philippines, Singapore, Thailand, and the U.S. As we easily notice, the agriculture, forestry, and fishing industries have declined very sharply with per capita GDP for the given period. For manufacturing, we see the slightly downward slope, illustrating the manufacturing industry's decline with the development of economy overall. We must also distinguish the overall trend and each economy's trend. When we see the trend of the manufacturing industry in each economy, contribution of the manufacturing in some countries such as China, Malaysia, Indonesia, Thailand, and Singapore are increasing for the given periods. Table 2-4 reports manufacturing-growing countries in the APEC region.

For the service industry, most countries show constantly increasing contributions to GDP for the given periods. Thus we can conclude that the service industry plays a greater role in the economy as the economy develops. OECD (2000) points the strategic business service such as marketing, consulting, human resource development, IT service, supporting firm-level competitiveness and economic growth sectors.

Figure 2-2

Relationship between CNTRB to GDP and pcGDP

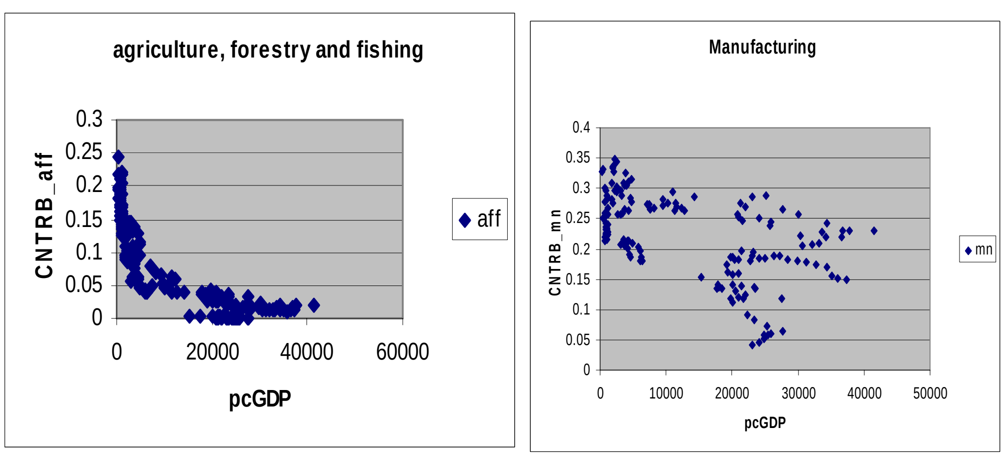
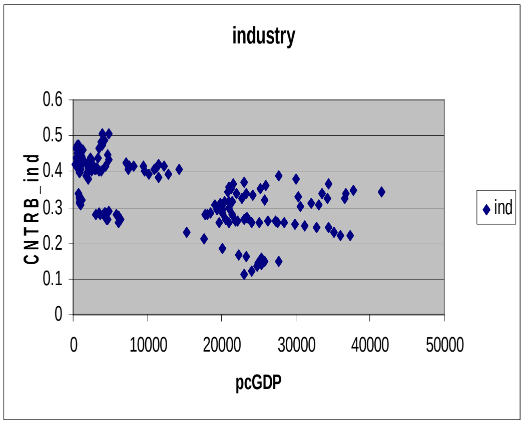


Figure 2-2 (*continued*)



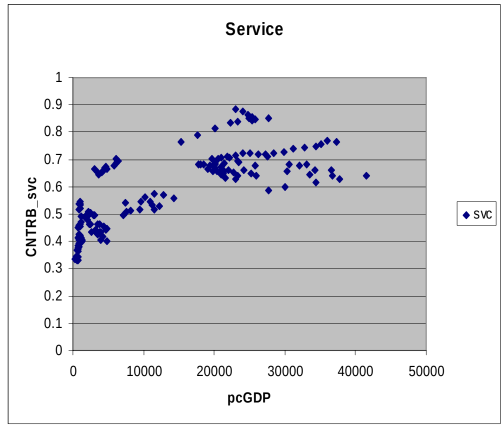


Table 2-4

Manufacturing-growing Countries in Contribution to GDP

Country	year	CNTRB of mfg to GDP	year	CNTRB of mfg to GDP
IDN	1991	0.21	2004	0.28
MYS	1991	0.26	2004	0.31
SGP	1996	0.24	2004	0.29
THA	1991	0.28	2004	0.35

2.3. My Hypotheses

(H1) Cash flow sensitivity decreases with the volatility of oil price, and the decrease is greater for energy intensive industry than for less energy intensive industry.

As I first stated, the role of cash flow diminishes in importance as firm managers behave more cautiously and possibly forgo investment opportunities with positive net returns in times of greater uncertainty. In other words, uncertainty caused by oil price volatility may reduce firms' responses to cash flow in their investment decisions. Especially, *Energy intensive (EI) firms are more cautious at high oil shocks, and for the EI firms, the role of cash flow declines more with oil price volatility.*

Then will the effect of oil price volatility on investment be different across manufacturing and service industries? It is statistically known that manufacturing is more energy intensive and also more energy consuming and petroleum consuming. Energy intensive firms also tend to be capital intensive (Ramirez and Blok (2005)). Manufacturing firms are more energy intensive and capital intensive than service firms. There are many sources on energy intensity. First, US DOE (1998) reports the changes in energy intensity, and in the reports, six EI sectors are petroleum refining, paper products, primary metal, stone and concrete, chemical products, lumber and wood. Table 2-5 shows the changes in energy intensity. Ramirez and Blok (2005) define high energy intensive manufacturing sectors in the Netherlands. High energy intensive manufacturing sectors in the Netherlands are coke and petroleum products, basic metals, chemicals, pulp and paper, and non-metallic mineral products. The most capital-intensive sectors are also the most energy intensive with a positive correlation of greater than 93%. Sutherland (1998) names the six energy-intensive industries as steel, chemicals, paper, and pulp, aluminum, cement and petroleum refining.

Table 2-5
Energy-Intensity Ratio of Total Inputs of Energy per Value of Shipments by Major Manufacturing Groups

(Adjusted to Base Year = 1991)

SIC Code	Major Group	Energy Intensity (thousand Btu/1992 constant dollars)	
		1991	1994
20	Food and Kindred Products	2.41	2.81
21	Tobacco Products	0.69	NA
22	Textile Mill Products	4.26	3.82
23	Apparel and Other Textile Products	0.73	0.47
24	Lumber and Wood Products	6.23	5.38
25	Furniture and Fixtures	1.77	1.18
26	Paper and Allied Products	20.17	19.7
27	Printing and Publishing	0.77	0.75
28	Chemicals and Allied Products	11.02	11.71
29	Petroleum and Coal Products	19.25	25.32
30	Rubber and Misc. Plastics Products	2.38	2.23
31	Leather and Leather Products	1.34	NA
32	Stone, Clay and Glass Products	16.56	15.13
33	Primary Metal Industries	17.84	17.26
34	Fabricated Metal Products	1.98	2.03
35	Industrial Machinery and Equipment	1.04	0.85
36	Electronic and Other Electric Equipment	1.05	0.91
37	Transportation Equipment	0.93	NA
38	Instruments and Related Products	0.8	0.99
39	Misc. Manufacturing Industries	0.96	1.14
	Total	5.51	5.91

Enevoldsen, Ryelund and Andersen (2007) in the study of energy-intensive industries in Scandinavia, report that energy-intensive industries are sawmilling and planning of wood, veneer sheets-plywood-laminboard-particle board-fibre board and other panels and boards, wooden containers, pulp-paper-paperboard, basic chemicals, glass and glass products, and cement-lime-plaster. Roy, Sathaye, Sanstad, Mongia and Schumacher (1999) in the study of productivity trends in India's energy intensive industries, report that the six energy intensive industries are paper and paper products, cement, fertilizer, glass, iron and steel and aluminum.

In the U.S., manufacturing industry contributes to value added by 15% as of 2005 but consumes 23% of U.S. energy as of 2002. As shown in Table 2-6, the high energy-consuming sub-sectors in the manufacturing industry are petroleum and coal products, chemicals, paper, primary metals as of 2002. According to the department of energy (shown in Figure 2-4), U.S. industrial firms (including manufacturing, mining and agriculture, but not service) consume more petroleum than electricity in BTU[2] terms. In US, on the other hand, service industry contributes to value added by 77% as of 2005 but consumes 18% of U.S. energy as of 2002. By the U.S. Department of Energy, the service industry is identified as the commercial sector. When compared to the manufacturing industry, the service industry consumes less energy. The high energy-consuming sub-sectors in service are health care, lodging, food sales, public order and safety, office in terms of energy intensity per building as of 2002, which is shown in Table 2-7. As Figure 2-4 states, the U.S. service sector consumes more electricity than petroleum in BTU terms.

[2] One British Thermal Unit (BTU) is the heat that will raise the temperature of one pound of water by one degree Fahrenheit.

Table 2-6
Consumption of Energy for All Purposes for Selected Industries

(Trillion Btu)

NAICS	Subsector and Industry	1998	2002
311	Food	1,044	1,123
312	Beverage and Tobacco Products	108	105
313	Textile Mills	256	207
314	Textile Product Mills	50	60
315	Apparel	48	30
316	Leather and Allied Products	8	7
321	Wood Products	509	377
322	Paper	2,747	2,363
323	Printing and Related Support	98	98
324	Petroleum and Coal Products	7,320	6,799
325	Chemicals	6,064	6,465
326	Plastics and Rubber Products	328	351
327	Nonmetallic Mineral Products	979	1,059
331	Primary Metals	2,560	2,120
332	Fabricated Metal Products	445	388
333	Machinery	217	177
334	Computer and Electronic Products	205	201
335	Electrical Equip., Appliances, and Components	143	172
336	Transportation Equipment	492	429
337	Furniture and Related Products	88	64
339	Miscellaneous	89	71
	Manufacturing	23,796	22,666

Sources: Energy Information Administration, US DOE , May 2006

Table 2-7
U.S. Commercial Buildings Energy Intensity Using Primary Energy

(Million Btu per Building)

Principal Building Activity	Survey Years			
	1992	1995	1999	2003
U.S. Total *	2,170	2,312	2,574	2,822
Education	3,739	3,428	3,570	4,067
Food Sales	2,796	2,752	3,071	2,975
Food Service	2,255	2,346	2,530	2,906
Health Care	10,961	9,398	7,734	8,497
Lodging	5,488	5,292	5,523	6,908
Mercantile and Service	1,395	1,550	2,162	2,437
Office	3,449	3,380	3,570	3,137
Public Assembly	2,370	2,429	2,442	2,560
Public Order and Safety	2,491	2,549	2,537	3,422
Religious Worship	472	632	631	779
Warehouse and Storage	1,220	1,173	1,500	1,590
Other **	4,350	4,830	3,738	6,979
Vacant	642	334	204	464

* Sum of major fuels.

** Laboratory buildings are included in the "Other" category.

Notes: Primary energy consumption is the amount of site consumption, plus losses that occur in the generation, transmission, and distribution of energy.

Sources: Energy Information Administration, US DOE, 2007

Figure 2-3: Energy Consumption by Sector, US DOE (2005)

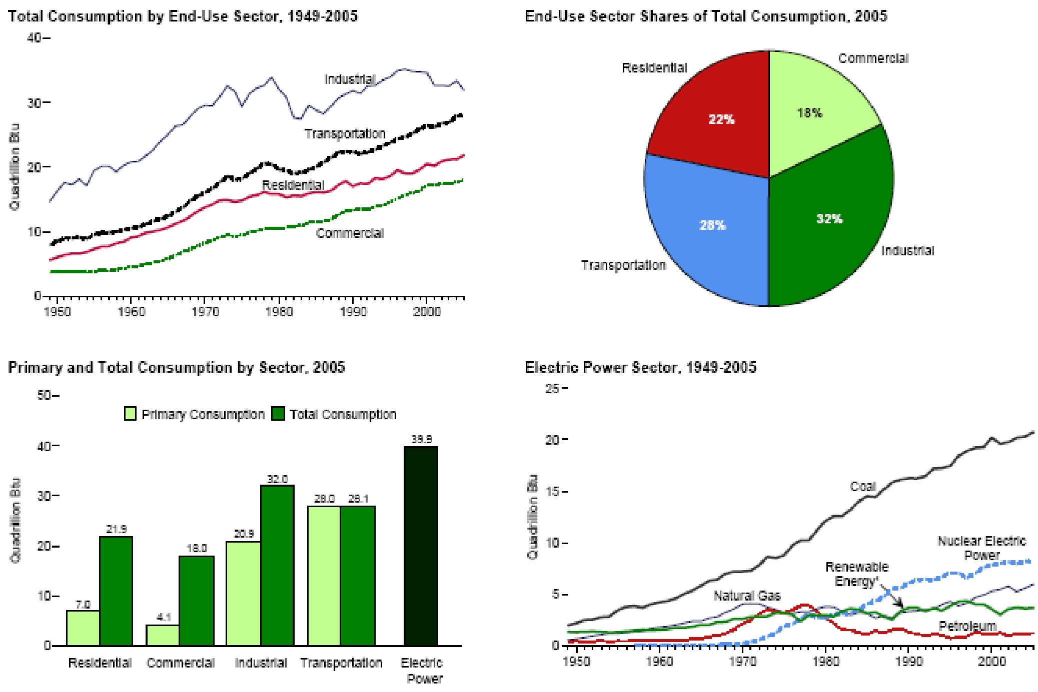
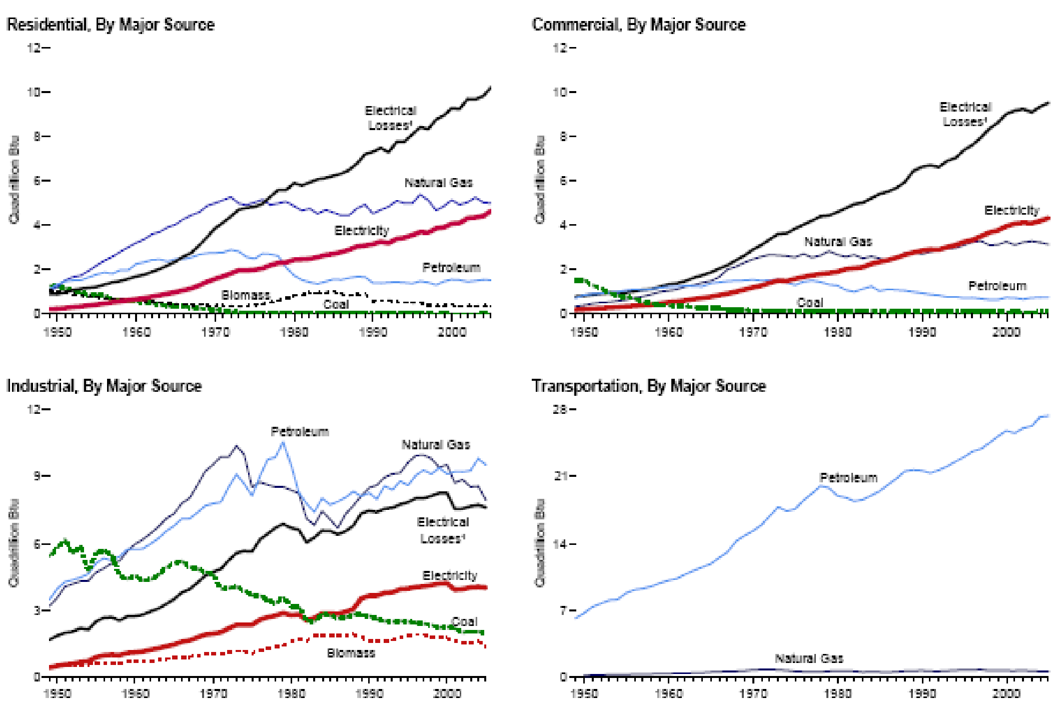


Figure2-4: Energy Consumption by End-Use Sector, US DOE (2005)



The six energy intensive manufacturing firms in the data show that they are likely to be more capital intensive. It is difficult to calculate the exact capital intensity from the dataset, but we can guess a rough capital intensity through the sales to capital ratio. The sales to capital ratio (SK ratio) in the six energy intensive manufacturing is smaller than those in the less energy intensive manufacturing and also in the service industry.

Table 2-8

Sales to Capital (SK) Ratio

	6 EI mfg	Less EI mfg	Service
SK ratio	2.9	4.55	6.54

Source: my dataset from COMPUSTAT global industrial and commercial

From the above statistical information on the energy intensity and energy consumption across manufacturing and service industries, we can assume that, in a heightened oil shock time, more energy-intensive firms (here, manufacturing firms) are more cautious in investment in consideration of the irreversibility of investment even if the firm's cash flow increases. In other words, *for manufacturing firms, which are more energy intensive, the role of cash flow diminishes more with oil price volatility than for service industry firms. For the more energy intensive manufacturing firms, the role of cash flow diminishes more with oil price volatility than for the less energy intensive manufacturing firms.*

(H2) Marginal effects of tangible assets on cash flow sensitivity of firm investments are likely to be different across manufacturing and service industries. The increase in cash flow can directly increase firm investment, and higher contractable asset tangibility enables firms to borrow more external funds. Higher asset tangibility enables financially constrained firms to invest much more with the rise in cash flow. In other words, given that a firm is financially constrained, asset tangibility will amplify the positive effect of cash flow (exogenous income shocks) on investment spending. Almeida and Campello (2006) call this the credit multiplier effect of tangible assets. Then will these credit multiplier effects be different across manufacturing and service industries? *If the fixed assets are more important in firm performance for the financially constrained manufacturing firms than for the financially constrained service firms, we may assume that the cash flow sensitivity increases more with asset tangibility for the manufacturing firms.* The situation is not that simple. There can be several issues on whether or not the credit multiplier effect differs across manufacturing and service. Let me present those issues as follows:

There is a pretty clear distinction between manufacturing and service because service tends to: (1) be produced and delivered simultaneously (inseparability) and perishable; (2) be more people-intensive than manufacturing (Brouthers and Brouthers (2003)). The convergence of services and manufacturing in many areas is making it increasingly difficult to classify firms uniquely under either category. For example, the production of a car involves a wide range of service activities such as marketing and technical research, development and design, and human resource management. Although the distinction between manufacturing and services is vague, we still think that the substantial costs and advantages of many manufacturing firms come from the mass-producing process for market (OECD(2000)), Kwaku Atuahene-Gima (1996)), and that advantages of many service firms more importantly come from intangible resources[3] such as training in human resources, R&D, and technical support. Suppose both firms in service and manufacturing are financially constrained and have the same level of tangible assets. If the above argument on firm performance and advantages is correct, some service firms are likely to invest less in fixed tangible assets and more in intangible assets than manufacturing firms. The amplification (credit multiplier) effect of tangible assets on firm investment will be smaller in some service industries than in manufacturing. As mentioned in the above, if the convergence of manufacturing and service firms is dominant, and manufacturing firms involves more investment on intangible service activities such as R&D, design, and marketing, then the amplification (credit multiplier) effect of tangible assets on firm investment will not be different across service and manufacturing when everything else constant.

I leave some arguments about the competitiveness of service and manufacturing firms in the following. Kwaku Atuahene-Gima (1996) finds that human resource and intangible assets are more important in the service industry in his study exploring managers' perceptions of the factors necessary for successful new service development and new product development. Manufacturers focus primarily on product innovation advantage and quality. Compared to manufactures, successful service firms must place

[3] Intangible asset is defined as something of value that cannot be physically touched, such as a brand, franchise, trademark, or patent.

greater emphasis on the selection, development, and management of employees who work directly with customers. Brouthers and Brouthers (2003) in their study of the entry-mode in FDI (foreign direct investment) argue that behavioral uncertainties and trust between FDI partners influence service providers' entry mode, and the competitive advantage of service firms is normally derived from intangibles such as patent and copyrights. Manufacturing firms get their advantages from more tangible sources. Villalonga (2004) in the study of intangible sources' effect on sustainable firm performance finds that intangibles play an effective role in sustaining a firm's competitive advantage in certain industries, but that some industries show negative effects of intangibles on firms' sustainable performance. Goddard et al (2005) in finding determinants of profitability in European firms argue that on average manufacturing firms were more profitable than service industry firms, and that this could be due to significant economies of multi-plant operations and distribution networks. OECD (2000) in its comprehensive exploring of the service industry, argues that "services are a diverse group of economic activities that include high-technology, knowledge-intensive sub-sectors, as well as labor-intensive and low-skill areas, and typically involve the provision of human value added in the form of labor, advice, managerial skill, entertainment, training, intermediation and the like." In the analysis of competitiveness of each industry, the substantial costs of manufacturing come from the mass-producing process for markets, and in the service industry such costs are small. In the case of electronically distributed items such as software, for example, most of the costs come from intangible processes such as product development, marketing, and technical support.

Chapter 3

Literature Review

3.1. Single-country Studies on Financial Friction

One mainstream argument of the literature is that more financially constrained firms are more sensitive to internal funds. Fazzari, Hubbard and Petersen (1988) assume that firms with weak financial status face expensive costs for external funding and are inclined to keep larger internal funds. Using Tobin Q for firms' investment opportunities and classifying firms according to retention ratio(=(income-dividends)/income), they find that firms with more retention are more sensitive to cash flow than firms with a lower retention ratio, distributing more dividends to shareholders. This supports asymmetric information explanations. Hoshi, Kashyap and Scharfstein (1991) pay attention to Japanese Keiretsu representing Japanese particular industrial group system, where firms in Keiretsu have a close relationship with group banks. They classify Japanese firms as either under Keiretsu or under non-Keiretsu system. They regresses on liquidity (cash flow), Tobin's q, and lagged production, and find out that firms distantly linked to banks were more affected by liquidity in investment than firms with close links to banks. Hadlock (1998) examines the effect of ownership structure on firm investment behavior, finding "a nonlinear relationship between insider shareholdings and sensitivity of investment to its cash flow." He uses managers' ownership stakes in their firms as the measure of the alignment of interests between managers and shareholders. Using Tobin Q and cash flow for investment opportunity and internal funds, he finds that as insider holdings increases higher from zero, cash flow has a stronger effect on investment. He finds that this positive relationship between investment and cash flow is ruined "after a certain point." Rather, cash flow shows a negative impact on investment after this point. This is "inconsistent with free cash-flow problems (over-investment theory) and consistent with asymmetric information explanations (under-investment theory)." If managers typically over-invest internal cash, investment-cash flow sensitivity should decrease with insider shareholdings, but his estimates on the interaction term of cash flow and insider shareholding ratio showed positive signs at lower level of insider shareholdings. Chirinko and Schaller (1995) try to analyze the relationship between liquidity and investment of 212 Canadian firms and find that as internal funds increase, investment was more sensitive to capital, which supports asymmetric information explanations. They argue that examining only manufacturing firms may exaggerate the importance of liquidity effects. Manufacturing firms have more specialized assets, which are hard to collateralize, but non-manufacturing firms have more standardized assets. Many service firms have a high portion of intangible assets that are also difficult to collateralize. In their OLS estimation without firm and year effects (including fixed effects caused little change in the results), sensitivity for manufacturing firms is twice as large as that for non-manufacturing, and this difference is statistically significant. Accordingly, they argue that previous studies that focused solely on manufacturing firms may have overstated the magnitude of liquidity effects. Their limits are such that in different estimations, the results were reversed. They do not provide any explanations about the reversed results. Thus, I argue that their estimation results are ambiguous for the difference in liquidity sensitivity over manufacturing and service industries. Calem and Rizzo (1995) try to analyze the relationship between investment and liquidity in U.S. hospital industry from 1985 to 1989. They try to do an empirical study outside the manufacturing industry. In order to control for expected marginal product of capital, they use employee expenses to total fixed assets, full-time employees per bed, occupancy rate, and market growth rate. Utilizing a large amount of information over 1,400 hospitals, they classify firms into small and stand-alone hospitals and large or affiliated hospitals assuming that chain-affiliated institutions and large institutions are less likely to be financially constrained. They find that small and stand-alone hospitals are more sensitive to internal finance in investment than large or affiliated hospitals. Cash-flow is the most important determinant in investment to small and stand-alone hospitals.

Other studies oppose Fazzari et al (1988) and argue that less financially constrained firms are likely to be more sensitive to internal funds. Kaplan and Zingales (1997) examine 49 low-dividend paying firms that Fazzari, Hubbard and Petersen (1988) identified as having extremely high investment-cash flow sensitivity, and find the least financially constrained firms exhibit the greatest investment-cash flow sensitivity. They present several reasons for this result: (i) cash flow may act as a proxy for investment opportunity not captured by Tobin Q. (ii) differences in sensitivities may have been driven by some outliers. According to their estimation results, we can say that managers choose to rely primarily on internal cash flow for investment, despite the availability of additional low cost external funds. Policies designed to make credit more available during recessions may not lead to an increase in investment by firms with high investment-cash flow sensitivities. They have some shortfalls. They use too small homogeneous sample, which leads the behavior of a very few firms to drive the results. They also use fairly high quality firms, and their sorting criteria are somewhat subjective. Cleary (1999) assumes that the financial status may vary continuously, for example, every year. He classifies firms with regard to their financial constraints from the data of qualitative and quantitative information such as "letters to shareholders, management discussions of operations and liquidity, financial statements, notes to those statements for each firm-year. He found that firms with "high creditworthiness" (that is, less financially constrained firms) are more sensitive to liquidity. He argues that this result is consistent with the free cash flow theory provided by Jensen (1986), which states managers have incentives to cause firms to grow beyond the optimal size. He recites Kaplan and Zingales (1997) by saying that "managerial risk aversion may contribute to the correlation between investment and liquidity." He also finds that liquidity is an important determinant of investment and more important than investment opportunity variables such as market-to-book value. He uses the data of 1,317 U.S. firms from 1987 to 1994, which was obtained from the SEC Worldscope Disclosure dataset.

Most of studies utilize the priori determined firm classification when they separate more financially constrained firms from less financially constrained firms. Hu and Schiantarelli (1998) use an endogenous switching regression[4] model in estimation. Without a priori classifying firms as constrained or unconstrained, investment may be more sensitive to the availability of internal funds in one regime than in another regime.

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[4] If the errors in the switching function are assumed to be correlated with the errors in the investment function, the model is an "endogenous switching model." (Maddala (1986))

These differences reflect the extent of financial constraints faced by firms. Following Hu and Schiantarelli (1998)'s switching regression model, Hovakimian and Titman (2003) try to fix the measurement problem coming from the use of Tobin Q in measuring investment opportunities. Q is not enough for firms suffering from problems of information asymmetry since Q incorporates only market value. Thus, cash flows may also reflect investment opportunities that are not captured by proxies for Q. He suggests identifying shifts in firms' internal funds that are uncorrelated with shifts in investment opportunities, and the proper variable for this purpose is cash obtained from voluntary divestitures. Sale of assets not related to a firm's core operations is unlikely to convey information about growth opportunities from the firm's remaining lines of business. Financially constrained firms may sell assets to raise cash for alternative investments. In the estimation of 20 year firm data, the coefficient of asset sales was much larger in the constrained regime in the structural equation. In the selection equation, firms that are larger, older, more likely to pay dividends, and have bond ratings are likely to operate in less financially constrained regimes. Almeida and Campello (2006) examine the effect of tangible assets on U.S. firms' investment behavior, using the switching regression model.

Literature built on the Q model uses average Q instead of marginal Q because marginal Q is not observable, but average Q is appropriate only under the assumption of perfectly competitive markets and constant-return-to-scale technology. Hubbard, Kashyap and Whited (1995) set up a neoclassical investment model under perfect capital markets and estimate based on the Euler equation representation of firms' investment decision. They observe "proxies for internal finance as explanatory variables, holding constant measures of firm opportunities or the cost of capital." They argue that large cash flow can imply the firm (or its manager) has a good investment opportunity, and thus the liquidity effect on investment may have a measurement error. To overcome this problem, they use tax payments "since tax payments are very imperfectly correlated with firm profitability." Using 428 manufacturing firms during 1976-87 obtained from the U.S. COMPUSTAT, they test the null hypothesis of perfect frictionless capital markets (standard neoclassical model), finding that the null hypothesis is easily rejected for the entire sample. They also easily reject the frictionless capital market model for firms with low dividend payouts, but they are unable to reject the frictionless capital market model for firms with high dividend payouts. Bond and Meghir (1994) also set up a neoclassical model and derived a Euler equation. They provide the evidence that the coefficient of the cash flow-capital is positive, which implies that firms are sensitive to cash flow in investment, and financial constraints exist. Gilchrist and Himmelberg (1998) develop an investment function.

$$\left(\frac{I}{K}\right)_t = \alpha_0 + \alpha_1 E_t \sum_{S=1}^{\infty} \beta^S MPK_{t+S} + \alpha_2 E_t \sum_{S=1}^{\infty} \sum_{k=1}^{S=1} \beta^S FIN_{t+k} + f_i + d_t + \omega_{it} ,$$ where

MPK is the marginal profitability of capital and FIN is the financial variable, and f and d represent firm-specific and time effects.. They use sales to capital stock ratio for MPK and net income for FIN, and find that small firms and firms without bond ratings show a very strong response to cash and equivalents, while bond-rated firms show little response.

3.2. Cross-country and Inter-industry Studies

Most papers focused on the effect of financial development on financial constraints and investment (or economic growth). Love (2003) estimates the effect of the financial liberalization of 36 countries on the level of financial constraints and the cost of external financing. She also studies the problem of the Tobin Q approach and derives the Euler equation solving the first order conditions of a firm's problem maximizing the net present value. In the empirical test of 36 countries and 4794 firms from 1988 to 1998, she finds that firm investments are significantly sensitive to cash stock, and the magnitude of the sensitivity decreases with financial development. Also she shows that small firms are disproportionately more disadvantaged in less financially developed countries than are large firms, and the improvement in financial development decreases firms' financial constraints. Galindo, Schiantarelli, and Weiss (2005) examine whether financial liberalization succeeds in directing resources towards those with higher marginal returns. They develop a new summary index of the efficiency of investment allocation (IAE) and measures of financial liberalization (FL), and then relate the former to the latter[5]. Using firm-level data over 12 developing countries, they see a strongly positive association between IAE and FL. By regressing IAE on FL, they find in the estimation that financial liberalization leads to an improvement in resource allocation. In their robustness check, they find that the coefficient of the sales to capital ratio increases significantly with FL,

[5] IAE equals the sum of the total return to investment for each firm divided by a benchmark. And total return to investment for each firm is calculated by multiplying the firm's investment by the firm's marginal return to investment. And firm's marginal return to investment is measured by the sales to capital ratio or by the ratio of operating profits to capital. FL is measured by a dating of interest rate deregulation, reduction of entry barriers, reduction of reserve requirements, reduction of credit controls, privatization of state banks, and strengthening of prudential regulation.

which implies that firms become more reactive to changes in fundamentals with FL. Firms' reaction for cash stock looks ambiguous, but they see a case of decrease in its size during the post liberalization period. Wurgler (2000) examines the effect of financial development on the efficiency of capital allocation in manufacturing industries across 65 countries. Those with developed financial sectors increase more in their growing industries and decrease investment more in their declining industries than those with under-developed financial sectors. Strong minority investor rights appear to curb over-investment in declining industries. To obtain the measure of the efficiency of capital allocation (CAE), he regresses the growth in investment on the growth in value added. Value added growth is a reasonable measure of investment opportunities after checking the correlation between industry value added and Q. To get the measure of financial development (FD), he uses quantity data, assuming that more financing activity reflects a lower cost of capital and more competitive financial markets. The quantity data is the size of a country's equity and credit markets relative to GDP[6]. We need to observe the international differences in the elasticity of industry investment to value added. He checks the plot of CAE and FD, which shows a strong positive relationship between CAE and FD (Correlation=0.554).

[6] Wurgler (2000) calculates stock market capitalization (STK) to GDP and credit (CRED) to GDP, and creates an index for the level of financial development, FD, which is the sum of ((STK/GDP) + (CRED/GDP)).

3.3. Asset Tangibility and Financial Friction

Almeida and Campello (2006) examine the effect of tangible assets on U.S. firms' investment behavior when credit friction exists by using the switching regression model. The variables that increase a firm's ability to contract external finance may influence observed investment spending when investment is constrained by credit imperfections. Assets that are more tangible sustain more external financing. They show that investment-cash flow sensitivities are increasing in the tangibility of financially constrained firms' assets. In contrast, tangibility has no effect on investment-cash flow sensitivities of financially unconstrained firms. Braun and Larrain (2005) have the idea that in a world with incomplete financial contractibility, holding assets that can be easily transferred to investors (i.e. hard assets) improves a firm's access to external funding. They find that the production of industries more dependent on external funds is more strongly affected during recessions when they are located in countries with poor financial contractibility and when their assets are softer or less protective of financiers. The difference in the impact of recessions is significantly higher for those industries that rely less on hard assets.[7] Even though there is a non-monotonic relationship, they find that non-monotonicities are not a prominent feature of the data, at least when comparing broad groups or countries.[8] They used data on yearly production, 28 manufacturing industries over 100 countries. 1963-1999. Braun (2003) argues that where financial contractibility is poor, external finance requires higher proportions of assets that more

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[7] Financial frictions can come from industrial level. Industry tangibility equals aggregate asset tangibility that is (net property, plant, and equipment)/total assets.

[8] The issue should be less of a concern when working with industries as opposed to working with firms. In every industry, there are probably more constrained and less constrained firms at each point in time, making the industry as a whole sensitive to changes in financial frictions.

easily remain with investors if the relation deteriorates. An important characteristic of poorly developed capital markets is the excessive weight they give to the availability of hard assets in the allocation of financial funds. In poorly developed capital markets, external finance demands a higher proportion of tangible assets when financial contractibility is poor. Harder, tangible assets provide the security the environment does not. The degree of financial contractibility and the availability of hard assets are substitutes in the sustainability of external financing. Tangibility has been consistently shown to be positively associated with firms' leverage and has become a standard variable in financial literature. In the analysis of 28 manufacturing industrial segments in several countries he finds that industries with less tangible assets perform disproportionately worse in terms of growth and GDP contribution in countries with poorly developed financial systems. A Plot of the aggregate level of tangibility of the manufacturing sector against the level of financial development shows a strong and significantly negative association. Leverage is less sensitive to tangibility in better-working capital markets. Claessens and Laeven (2003) study the effect of intangibility and property rights on the industry-level growth and find that industries that rank high in the index of intangibility experience growth rates that are disproportionately higher in countries with more property rights protection. In countries with more secure property rights, firms allocate resources better and consequently grow faster because the returns on intangibles assets are relatively more protected. For the financial development index, they use a ratio of private credit to GDP, and for intangible intensity, they calculate the ratio of intangible to fixed assets using U.S. firm data with 5,241 observations, and construct the benchmark intangible intensity in different industrial sectors on a two-digit SIC level. Villalonga (2004), in the study of the effect of intangibility on U.S. firms' performance, assumes that some of the intangible resources that can be a source of advantage are likely to vary across different industries and sectors. A firm's technological knowledge base built through research and development is more likely to be a source of competitive advantage in the manufacturing sector than in the lodging and entertainment industries. The efficacy of different mechanisms for ensuring the appropriation by firms of the value generated by intangible resources is also likely to vary across industries. Intangible resources may exist at different levels within the firm: human resources, teams, functions, processes, projects, or the organization as a whole.[9] In mining and construction, manufacturing, transportation, wholesale and retail trade, the greater a firm's Tobin Q, the greater the persistence of its firm-specific profits. Some sectors such as agriculture, food-textile-chemicals exhibit a negative effect for some sub-samples and intangibility measures. R&D and advertising investments are unlikely to be sources of competitive advantage in this sector.

[9] For the measures of resource intangibility, the author uses Tobin Q and the predicted value from a hedonic regression of Tobin Q on several accounting measures of intangibles including R&D stock, advertising stock, and intangibles-in-books. For the measure of sustainability, the persistence of firm-specific profits (FSP) is used.

3.4. Uncertainty and Firm Investment

Uncertainty comes from various sources such as prices, wages, consumers' tastes, technology, institutions, exchange rates and more. Articles study the relationship between several types of uncertainty, and aggregate investment and firm-level investment.

First, uncertainty can affect aggregate-level investment. Guo and Kliesen (2005) study the effect of uncertainty coming from oil price variance on future GDP and aggregate investment[10] over the period of 1984 to 2004. Calculating quarterly realized oil price variance to measure the level of uncertainty using daily prices of 1-month and 12-month future oil prices, they find that oil price volatility measured by daily crude oil future prices has a negative and significant effect on future GDP and real business fixed investment. Beaudry, Caglayan, and Schiantarelli (2001) use the unbalanced sample of 988 quoted UK manufacturing firms over 1970 to 1990, and provide evidence that macroeconomic uncertainty captured by inflation variability has a significant negative effect on firm investment at the aggregate and industry level.

Second, uncertainty can forgo or delay firm-level investment. Leahy and Whited (1996) study uncertainty and investment based on the theory of irreversible investment. In a panel of U.S. manufacturing firms over the period of 1981 to 1987, they find a negative relationship between investment and various uncertainty measures.[11] They obtain one uncertainty measure from the firm's daily stock return for each year. Bloom,

[10] "Oil price volatility can affect output mainly because it deters business investment in capital goods. If an investment is irreversible, increased uncertainty raises the option value of waiting to invest."(Guo and Kliesen (2005))

[11] Leahy and Whited (1996) also argue that the effect of uncertainty on firm investment operates through marginal Q. In their estimation, the coefficient on uncertainty become insignificant when both Tobin Q and uncertainty are added in empirical equation (not interacted each other). My estimation is not this case.

Bond, and Reenen (2001) assume that uncertainty reduces firms' responsiveness to demand shocks (sales) because firms become more cautious during times of heightened environmental uncertainty. They add an interaction term between uncertainty and sales growth to the firm-level investment equations to test for the 'caution effect' of uncertainty. Using UK firms from 1972 to 1991 and a stock returns-based measure of uncertainty, they find that the sales growth sensitivity of firm investment decreases with the level of stock returns-based uncertainty. Baum et al (2007) assume that cash flow will be less important as firm managers behave more cautiously and possibly forgo investment opportunities with positive net returns in times of greater uncertainty. They add an interaction term between uncertainty and cash flow to the firm-level investment equations to test for the 'caution effect' of uncertainty while measuring the intrinsic and extrinsic uncertainty by calculating the variations of the firm's own daily stock returns and S&P 500 index returns along with a CAPM-based risk measure [12]. Using an unbalanced panel of U.S. manufacturing firms during 1984 to 2003, they find that the intrinsic uncertainty derived from firms' own daily stock returns and the CAPM-based uncertainty have a significant negative effect on firms' cash flow sensitivity of investment. Reducing the financial friction facing the firm would have a smaller effect on investment spending for those firms with higher levels of intrinsic uncertainty.

[12] CAPM-based risk measure: covariance of a firm's return with the market as a whole. An increase in the covariance should increase the riskiness of investment. The greater the covariance in returns the less incentive to invest.

Chapter 4

Theoretical Models

4.1. Internal Funds Model and Q Model

4.1.1. Internal Funds Model

According to Chirinko and Schaller (1995), due to a long-term need for relatively costly external finance, the desired capital stock is related to both the level of sales and the flow of liquidity or internal funds. K* = f(sales, ifunds), where K* is the desired capital stock and ifunds is internal funds. Both sales and internal funds will be positively associated with the desired capital stock. By taking logarithms of both sides, we get;

$$I / K = b_0 + b_1 * (change\ in\ sales / sales) + b_2 * (change\ in\ ifunds / ifunds) + u$$

4.1.2. Q Model

But the internal funds models are based essentially on static expectations. Lagged observations of investment will affect today's investment. We can include in our model lags of past observations as proxies for unknown expectations. The critical problem with developing an estimable investment equation is relating unobservable expectation to observable variables. Tobin Q can use the information in financial markets to address the unobserved expectations. The marginal adjustment cost of investment is equal to the shadow price of capital, denoted by Q. According to this theory, Marginal Q determines investment, where Marginal Q is the ratio of the discounted future revenues from an additional unit of capital to its purchasing price. As long as Marginal Q is greater than zero, the firm has the incentive to increase its capital stock. Since Marginal Q is unobservable, empirical studies have used Average Q, where Average Q is defined as the financial value of the firm to the replacement cost of its existing capital stock.

$I/K = b_0 + b_1 * Q + b_2 * LIQ + u$, where Q equals average Q, and LIQ equals internal funds. As with the internal funds models, finance constraints are evaluated in terms of the coefficients on the liquidity variable for firms.

4.2. The Euler Equation Model

Like in Hubbard, Kashyap and Whited (1995), and Bond and Meghir (1994), Love (2003) uses the Euler equation model discarding the Q model due to the measurement error problem using the average Q. Love (2003) considers a firm's net present value, "which is equal to the expected discount value of dividends subject to the capital accumulation and external financing constraints."

$$V_t(K_t, \xi_t) = \max_{\{I_{t+s}\}_{s=0}^{\infty}} D_t + E_t\left[\sum_{s=1}^{\infty} \beta_{t+s-1} D_{t+s}\right] \qquad (1)$$

subject to

$$D_t = \Pi(K_t, \xi_t) - C(I_t, K_t) - I_t \qquad (2)$$

$$K_{t+1} = (1-\delta)K_t + I_t \qquad (3)$$

$$D_t \geq 0 \qquad (4)$$

D_t: the dividend paid to shareholders

β_{t+s-1}: a discounter factor from the period t+s to period t

K_t : capital stock, I_t : investment expenditure, δ : the depreciation rate

$\Pi(K_t, \xi_t)$: restricted profit function, $C(I_t, K_t)$: the adjustment cost of investment

"The financial frictions are introduced via a non-negativity constraint on dividends (equation (4)), and the multiplier on this constraint is denoted λ_t. This multiplier equals the shadow cost associated with raising new equity, which implies that external (equity) financing is costly; this extra cost is due to information or contracting costs."

By solving the above maximization problem, he gets the Euler equation.

$$1+\left(\frac{\partial C}{\partial I}\right)_t = \beta_t E_t\left[\Theta_t\left\{\left(\frac{\partial \Pi}{\partial K}\right)_{t+1} + (1-\delta)\left(1+\left(\frac{\partial C}{\partial I}\right)_{t+1}\right)\right\}\right] \qquad (5)$$

"LHS means the marginal cost of investment of today (equal to the price of investment goods, normalized to one plus the adjustment cost). RHS means the discounted marginal cost of postponing investment till tomorrow (equal to the foregone marginal benefit of an extra unit in capital (MPK) plus (the adjustment cost plus the price of investment goods tomorrow))." When solving the profit maximization problem, MPK is a function of sales to capital ratio(MPK= f(S/K)). $\Theta_t = \dfrac{1+\lambda_{t+1}}{1+\lambda_t}$ is the relative cost of external finance in periods t and t+1, and Love parameterizes it as a linear function of the cash stock, and financial development decreases financing constraints.

Thus $\Theta_t = a_0 + (a_1 + a_2 FD_c)Cash_{t-1}$, (6)

where FD_c is the country-level measure of financial development.

Love expects the coefficient of the interaction term, a_2, to be negative. With equations (5) and (6), Love derives her empirical equation as follows.

$$(\frac{I}{K})_{i,t} = \beta_1(\frac{I}{K})_{i,t+1} + \beta_2(\frac{I}{K})_{i,t-1} + \beta_3(\frac{S}{K})_{it-1} + \beta_4 Cash_{it-1} + \beta_5 Cash_{it-1} FD_c + d_{c,t} + f_i + e_{it}$$

where i is the firm, t equals the time period, I equals investment, K is capital stock, S equals sales, Cash is cash flow, d_t equals time-specific error, f_i equals firm-specific error, and ε_{it} is idiosyncratic error. Baum et al (2007) assume that the degree of financial constraints will be related not only to the firm's cash flow but also to the degree of uncertainty faced by the firm. As the uncertainty-reflecting both macroeconomic and firm-specific uncertainty-varies, the premium charged by lenders over the risk-free rate will systematically vary. The magnitude of the financial constraints facing a firm will be a function of the firm's cash flow interacted with measures of uncertainty.

$\Theta_t = (a_1 + a_2 \sigma_{t-1_c}) Cash\,Flow_t$, where σ is the level of uncertainty.

4.3. Tangible Asset Model

According to Almeida and Campello (2006), when firms are able to pledge their assets as collateral, investment and borrowing become endogenous. Pledgeable assets support more borrowings that in turn allow for further investment in pledgeable assets. They call this the credit multiplier effect. Investment-cash flow sensitivities are increasing in the degree of tangibility of constrained firms. If firms are unconstrained, however, investment-cash flow sensitivities are unaffected by asset tangibility. If a firm's physical assets are seized by its creditors at time1, only a fraction $\tau \in (0,1)$ of I can be recovered. τ is a natural function of the tangibility of the firm's physical assets and of other factors, such as the legal environment that dictates relations between borrowers and creditors.

Firms with high τ are able to borrow more because they invest in assets whose value can be largely recaptured by creditors in liquidation states.

The capacity for external finance generated by new investments is a positive function of the tangibility of the firm's assets (the credit multiplier).

$$B \leq \tau I \tag{7}$$

$$\max_{i} \; f(I) - I, \; s.t. \tag{8}$$

$$I \leq W + \tau I \tag{9}$$

where B is the amount of new debt, and W is the amount of internal funds.

The first-best level of investment, I^{FB}, is such that $f'(I^{FB})=1$.

If the constraint in (9) is satisfied at I^{FB}, the firm is financially unconstrained.

Thus, investment is constrained (e.g. $I^{*} < I^{FB}$) when the firm's real τ is less than the optimal τ for the first best investment(τ^{*}).

$$\tau < \tau^{*}(W, I^{FB}) = \max(1 - \frac{W}{I^{FB}}, 0)$$

That is, if τ is less than the optimal τ for the first best investment (τ^{*}), then the firm's investment will be less than the first best investment, where we can say the investment is constrained. The general expression for the optimal level of investment is:

$$\begin{aligned} I(W,\tau) &= \frac{W}{(1-\tau)}, \quad if \quad \tau < \tau^{*}(W, I^{FB}) \\ &= I^{FB}, \; if \quad \tau \geq \tau^{*}(W, I^{FB}) \end{aligned}$$

Investment-cash flow sensitivity is given by:

$$\begin{aligned} \frac{\partial I}{\partial W}(W,\tau) &= \frac{1}{(1-\tau)}, \quad if \quad \tau < \tau^{*}(W, I^{FB}) \\ &= 0, \quad if \quad \tau \geq \tau^{*}(W, I^{FB}) \end{aligned}$$

Investment-cash flow sensitivity is non-monotonic in the tangibility of the firm's assets.

At low levels of tangibility ($\tau < \tau^{*}(W, I^{FB})$), the firm is financially constrained, and $\frac{\partial I}{\partial W}$ increases in asset tangibility.

At high levels of tangibility ($\tau \geq \tau^{*}(W, I^{FB})$), the firm is financially unconstrained, and $\frac{\partial I}{\partial W}$ is independent of asset tangibility.

Chapter 5

My Empirical Models

5.1. Model of Uncertainty and Firm Investment

Following Bloom, Bond and Reenen (2001), and Baum et al (2007), I use a Q model and interaction term of cash flow times uncertainty derived from daily future oil prices. The following regression equation is estimated using fixed firm and year effects:

$$\frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it} \qquad (10)$$

where i = firm t = time period

I = investment K = capital stock

CF= cash flow VOL= uncertainty(oil price volatility)

f = firm-specific effect d = year-specific effect

u = idiosyncratic error

I include lagged uncertainty measures to capture the effect that investment plans have been formulated based on the prior period's observed levels of uncertainty. For the robustness test, I use sales instead of Tobin Q, and cash instead of cash flow. Here, I expect β_1 and β_2 to be positive. Also I expect β_3 to be negative, suggesting a diminishing impact of cash flow on firm investment behavior. Furthermore, this diminishing impact of cash flow on investment will be greater for energy intensive industries.

5.2. Model of Asset Tangibility and Firm Investment

Following Almeida and Campello (2006), I use a Q model and interaction term of liquidity times asset tangibility. The following regression equation is estimated using fixed effects to control for firm and time specific influences:

$$\frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 TANG_{it-1} + \beta_4 (\frac{CF_{it}}{K_{it-1}}) * TANG_{it-1} + f_i + d_t + u_{it} \quad (11)$$

where i = firm t = time period

I = investment K = capital stock

CF= cash flow TANG= asset tangibility

f = firm-specific effect d = year-specific effect

u = idiosyncratic error

For robustness test, I use sales instead of Tobin Q, and cash instead of cash flow. If we want to observe the cash flow sensitivity, we have to calculate ($\beta_2 + \beta_4 TANG$). Unlike other papers, the estimate for only β_2 can say little about cash flow sensitivity. With respect to the sign of the estimates in the empirical equation, my main hypothesis is that β_4 of manufacturing will be greater than β_4 of service industries since I assume that the credit multiplier effect will be greater for capital intensive industries such as some manufacturing sectors while intangible assets are more important for some service industries.

Chapter 6

Data Description

6.1. Countries, Dataset and Data Selection Rules

There are 21 members in APEC: Australia, Brunei Darussalam, Canada, Chile, People's Republic of China, Hong Kong China, Indonesia, Japan, Republic of Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, Philippines, Russia, Singapore, Chinese Taipei, Thailand, United States, and Vietnam. I choose 14 countries with more than 100 observations each year given the sample period. The 14 countries are Australia, Canada, China, Hong Kong, Indonesia, Japan, Korea, Mexico, Malaysia, Philippines, Singapore, Thailand, Taiwan and the U.S.

I obtain the data from COMPUSTAT global: financial statements from COMPUSTAT global industrial/commercial, stock issues and prices from COMPUSTAT global issues, exchange rates from COMPUSTAT global currency. All firm-level data from the COMPUSTAT global contains data on publicly traded firms. For the estimation I have to merge the three different types of datasets. For oil prices and their annual volatility, I utilize the volatility measures of Guo and Kliesen (2005), which are computed on daily future oil prices. I collect the daily OK WTI Cushing spot oil prices from the U.S. Department of Energy to create an additional oil price volatility measure.

The sample period is 1991 to 2004, but due to lagged variables, estimations are conducted over the 13 year period, 1992 to 2004. My firm data is classified by the U.S. SIC. According to the U.S. SIC, manufacturing codes are 2000-3999, and transportation, communications, electric, gas, and sanitary services are 4000-4999 (S1). Wholesale trade and retail trade are 5000-5999 (S2). Services (narrowly defined service, S3) are 7000-8999. Since most of the firms in S1 have a large capital stock, I will call S1 "hard service industry," and the other services (S2 and S3) will be called "soft service industries." In estimation, first I regress for manufacturing industry. Next, I regress for S1, S2, and S3, respectively. I regress for soft service industries (S2+S3) or for the entire service industry (S1+S2+S3).

Following Gomes (2001), Love (2003), Almeida and Campello (2006), I eliminate firms that appear in COMPUSTAT global for less than 3 years. Some studies (e.g. Chirinko-Shaller (1995)) use firms which appear for the entire sample period. As Almeida and Campello (2006) point out, in that case, there is high probability for survivorship biases. If a firm has lived and provided financial statements for 14 years, then the firm can be assumed to be quite competitive in the industry. I only use firms with at least three year observations. Capital stock must be positive. (Gomes2001). Tobin Q should be positive and less than 10 to treat measurement error in Q. I delete observations with abnormal jumps in business activity (M&A, reorganization, etc). I/K should be less than 2.5. Growth rate of K can not exceed 2.0. CF/K can't exceed 5.0, and I exclude 1% on each side of each variable for each country. Also, because the U.S. has too many firm observations, 50% of all U.S. firms are randomly selected.

6.2. Measure of Oil Price Changes

I construct three kinds of oil price volatility measures: two from daily future oil prices and one from daily spot oil prices. Also I construct one index of relative oil price change: weighted real oil prices from monthly oil prices. According to Guo and Kliesen (2005), relative oil price changes are known to bring symmetric effect on investment. When oil price goes up, investment and GDP growth fall. When oil price falls, investment and GDP growth rise. But uncertainty coming from oil price fluctuation (or volatility) brings asymmetric effect to the economy. Sharp oil price change – either up or down- affects investment and GDP growth adversely. But we should notice that our main test is not to check the symmetric or asymmetric effect of oil price changes on investment. Rather, we aim to see how cash flow sensitivity changes with various measures of oil price changes.

For future oil price volatility, I utilize the volatility indices obtained directly from Guo and Kliesen(2005). Guo and Kliesen (2005) calculated quarterly realized oil price variance as the sum of squared daily price change in a quarter (RV_O);

$$RV\_O_t = \sum_{d=1}^{D_t} (RET\_O_d)^2$$

where RET_O_d is the change in daily futures prices in day d of quarter t.[13]

They use the prices for daily crude oil 1-month and 12-month futures traded on the New York Mercantile Exchange (NYMEX) from 1984 to 2004, producing two volatility measures. One is the volatility index derived from 12 month future oil prices and the other is the volatility index derived from 1 month future oil prices. In order to convert

[13] Guo and Kliesen(2005) argue that "the volatility measure seems to be plausible because change in daily crude oil futures prices have a sample average close to zero and negligible serial correlation."

quarterly oil price variance into annual variance, I average four quarterly variances in each year.

For the spot oil price volatility, I create an additional oil price volatility measure using daily OK WTI (the West Texas Intermediate) Cushing spot oil prices downloaded from the U.S. Department of Energy following Guo and Kliesen (2005). I compute the monthly realized oil price variance and average them over each year. The monthly realized oil price variance is the sum of squared daily price changes in a month (RV_O): $RV\_O_t = \sum_{d=1}^{D_t} (RET\_O_d)^2$, where RET_O_d is the change in daily spot prices in day d of month t.

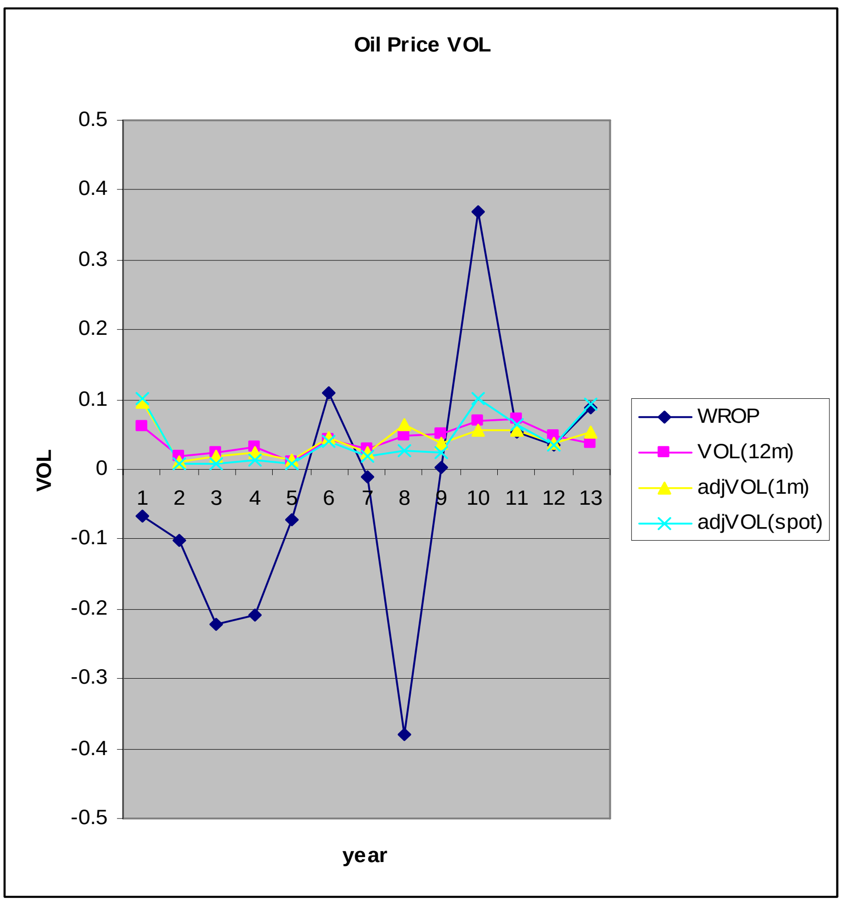
To construct an index for relative oil price change, I compute weighted real oil prices similarly with Davis and Haltiwanger (2001)[14]. Since my data on crude oil (UK Brent) price and consumer price index (the U.S.) have monthly frequencies, I first construct a monthly oil shock index, which equals log of weighted real oil price. And weighted real oil prices equal real oil price divide by weighted average of real prices in the prior 60 months, with weights that sum to one and decline linearly to zero. Please see the appendix for the computed weights. And real oil price equals nominal price of UK Brent crude petroleum divided by the U.S. consumer price index. I get an annual oil shock index by averaging twelve monthly oil shock indices in each year.

Since the mean values of oil price volatility from future oil prices and spot oil prices are different very much in size, we need to adjust the mean values of oil price

[14] Davis and Haltiwanger (2001) construct quarterly Oil shock index, which equals log (real oil price/weighted average of real prices in the prior 20 quarters), with weights that sum to one and decline linearly to zero. And the real oil price equals nominal price of crude petroleum divided by producer price index.

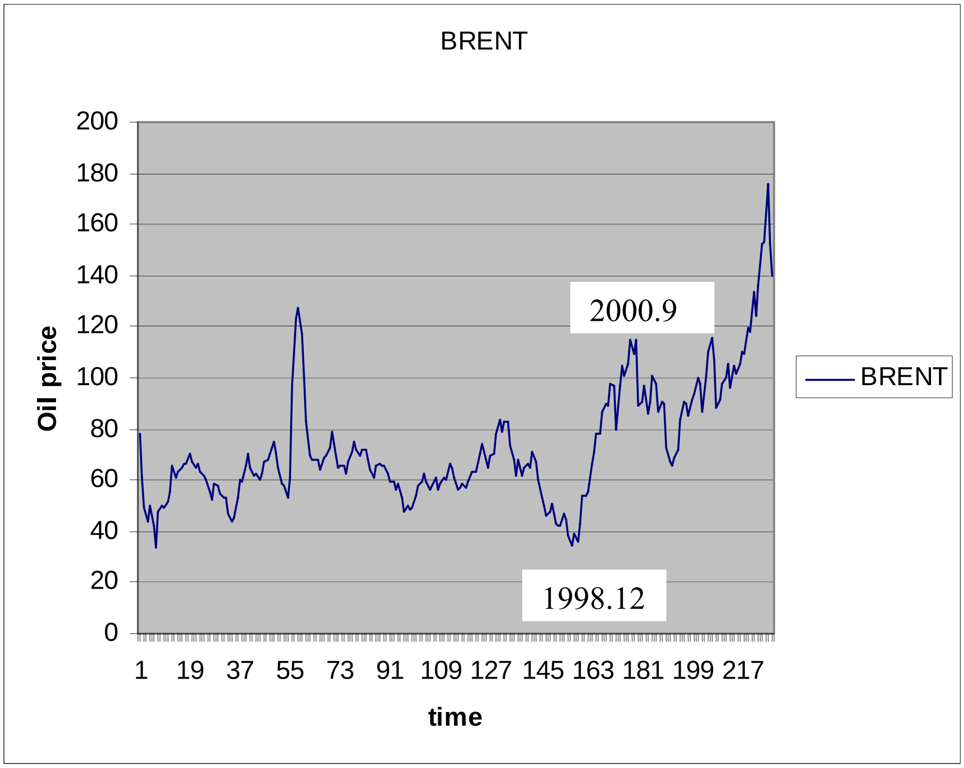
volatilities from 1 month future oil prices and spot oil prices in order to compare the estimation results from the three different volatility measures. Adjusted oil price volatility from 1 month future prices, adjVOL(1m), equals VOL(1m) times mean(VOL(12m) divided by mean((VOL(1m), which is VOL(1m)*0.29547. Adjusted oil price volatility from spot prices, adjusted VOL(spot), equals VOL(spot) times mean(VOL(12m) divided by mean(VOL(spot)), which is VOL(spot)*0.0061.

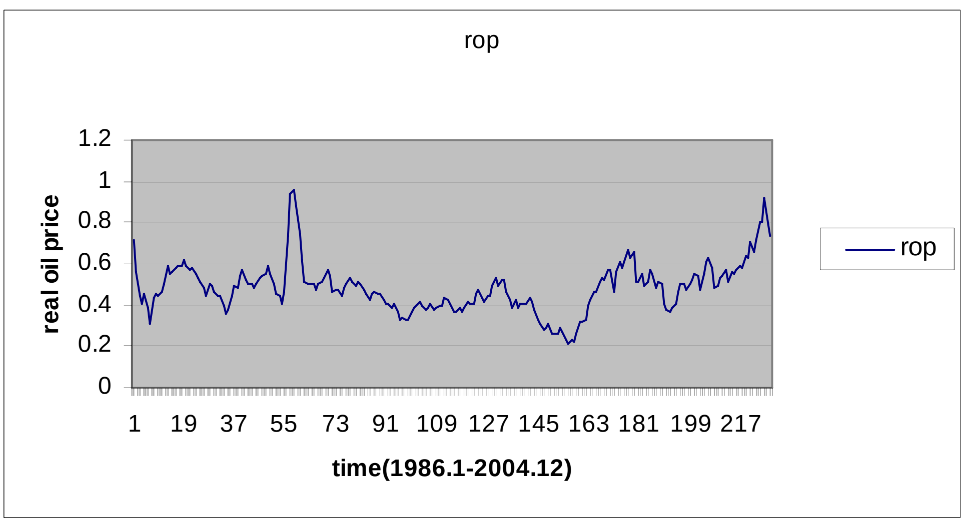
Figure 6-1
Measures of Oil Price Changes after Adjustment in Magnitudes
(Year: 1991-2003)



WROP: weighted real oil prices computed similarly to Davis and Haltiwanger (2001)

Figure 6.2
Monthly Crude Oil Prices (UK Brent) and Real Oil prices
(Period: JAN 1986 – DEC 2004)





* rop, real oil price equals nominal prices divided by the U.S. CPI.

Table 6-1
Correlation Analysis on different Measures of Oil Price Changes

	VOL(12m)	VOL(1m)	VOL(spot)	WROP
VOL(12m)		0.79	0.74	0.46
		0.0001	0.004	0.11
VOL(1m)	0.79		0.81	0.17
	0.0001		0.0007	0.58
VOL(spot)	0.74	0.81		0.6
	0.004	0.0007		0.03
WROP	0.46	0.17	0.6	
	0.11	0.58	0.03	

WROP: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

Overall, I can describe my estimation framework as in Table 6-2. I estimate my empirical equation mainly using oil price volatility derived from 12 month future oil prices. I also compare the estimation results from different measures of oil price changes, while splitting my samples into industrial sub-secotors.

Table 6-2

Estimation Framework for Oil Price Uncertainty

		VOL(12mo)	VOL(1mo)	VOL(spot)	WROP
MFG	All				
	Mfg EI				
	Mfg less EI				
SVC	All				
	S1(hard svc)				
	S2				
	S3				
	S2+S3(soft svc)				

* mfg EI (energy intensive): petroleum refining, paper products, primary metal, stone and concrete, chemical products, lumber & wood
*S1: SIC 40-49, S2: SIC 50-59, S3: SIC 70-89

6.3. Measure of Asset Tangibility

Almeida and Campello (2006) use three types of asset tangibility. The first asset tangibility equals (0.72*Receivables+0.55*Inventory+0.53*Capital)/total assets. [15] The second asset tangibility is "industry-level asset redeployability", which equals used capital acquisitions divided by total capital acquisitions. The third measure of asset tangibility uses a durable/non-durable industry dichotomy. According to Shleifer and Vishny (1992), assets which have alternative uses have high liquidation values. For example, commercial land is used for different purposes. They use the term of asset redeployability as an important determinant of liquidation, and call difference between price in asset liquidation (sale) and the value in best use as "asset illiquidity." When firm(A) has trouble meeting debt payments and sells assets or is liquidated, the highest valuation potential buyers of its assets are likely to be other firms in the same industry. What if shocks to the firm (A) are industry-wide (e.g. declining industry)? Same-industry buyers cannot buy the distressed firm's assets, which leads the price of assets in liquidation to fall below their value in best use. As a proxy for asset tangibility, Almeida and Campello (2006) use industry-level asset reployability, which equals used capital acquisitions divided by total capital acquisitions. Braun (2003) uses net property, plant, and equipment over total assets. Claessens and Laeven (2003) measure the intangible intensity by intangible over fixed assets. In the tangibility and capital structure (leverage) literature, net plant and equipment over total assets is used. Some papers use the sum of inventory, and gross plant, and equipment over total assets.

[15] Almeida and Campello (2006) borrows the expected asset liquidation values from Berger et al (1996) Berger et al (1996) examine data on discontinued firms in COMPUSTAT over 1984 to 1993 and obtain the liquidation values for total receivables, inventory, and fixed assets by regression.

I use Almeida and Campello (2006)'s first measure of asset tangibility by computing (0.72*Receivables+0.55*Inventory+0.53*Capital)/total assets of each firm. The other two measures of Almeida and Campello (2006) are not available to me, and we cannot use tangibility measure of net plant and equipment over total assets which is used in other studies, due to a mathematical problem in our theoretical and empirical equations.

6.4. Key Variables and Summary Statistics

Key variable definitions are in Table 6-3. Table 6-4 provides a list of countries in the sample, with the number of firms and observations per country, which varies widely across the countries. I have 19,263 firm-year observations and 3543 firms in total: for manufacturing, 11,249 observations and 2,120 firms, and for service, 8,014 observations and 1,423 firms. Table 6-5 presents means and standard deviations of key variables of each industry. The key variables are investment, Tobin Q, sales, cash flow, oil price volatility and asset tangibility. We observe that I/K ratio in SIC70-89(narrowly defined service) is higher than any sub-sector, which is consistent with the fact that the narrowly defined service sector is recognized as a fast-growing industry across the world. Tobin Q for the sector is also higher than other sectors. S/K ratio in the service industry is quite higher than manufacturing (6.54 and 4.06, respectively). Table 6-6 reports the means and standard deviations of key variables of each country. Table 6-7 presents the correlation analysis for the key variables.

Table 6-3

Key Variable Definitions

	Name of Variables (# in the COMPUSTAT global DB)
K	Net fixed assets(tangible)(76)
I	Change in net fixed assets (tangible)/K
S	Sales-turnover(1)/K
CF (Cash Flow)	EBIT(14)/K, *earnings before interest and taxes
Cash Stock	cash and short term investments(60)/K
Assets	total assets(89)
Market value	market value of equity =closing price*shares outstanding
Tobin Q	(market value of equity)/total assets (89)
Oil price volatility	Annual realized oil price variance
Asset Tangibility	(0.72*Receivables+0.55*Inventory+0.53*Capital stock + Cash)/ total assets(89) * Receivables: data63, Inventory: data66, Capital stock: data76, Cash: data60

Table 6-4

Firm-Country Observations

	All		MFG		Service	
country	# of obs	# of firms	# of obs	# of firms	# of obs	# of firms
AUS	592	114	292	53	300	61
CAN	1076	213	637	126	439	87
CHN	243	65	183	49	60	16
HKG	262	47	105	22	157	25
IDN	473	92	345	67	128	25
JPN	6784	1315	3906	766	2878	549
KOR	429	95	322	74	107	21
MEX	276	47	167	29	109	18
MYS	1016	206	679	140	337	66
PHL	148	29	73	16	75	13
SGP	589	132	289	68	300	64
THA	585	123	415	86	170	37
TWN	462	102	388	86	74	16
USA	6328	963	3448	538	2880	425
Sum	19263	3543	11249	2120	8014	1423

Table 6-5

Descriptive Statistics for Key Variables each Industry

		I/K		Tobin Q		S/K		CF/K		VOL(12m)		TANG	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
MFG	ALL	0.17	0.22	1.01	0.9	4.06	3.18	0.4	0.53	0.04	0.02	0.55	0.1
	MFG EI	0.17	0.21	0.94	0.87	2.9	2.25	0.31	0.39	0.04	0.02	0.54	0.08
	MFG less EI	0.18	0.22	1.04	0.91	4.55	3.39	0.44	0.58	0.04	0.02	0.55	0.1
SVC	ALL	0.18	0.24	0.96	0.96	6.54	14.3	0.41	0.66	0.04	0.02	0.51	0.11
	SIC 50-89	0.2	0.24	1.06	1.04	8.79	16.74	0.52	0.75	0.04	0.02	0.52	0.11
	SIC 40-49	0.16	0.22	0.76	0.69	1.63	2.39	0.18	0.32	0.04	0.02	0.49	0.1
	SIC 50-59	0.17	0.21	0.87	0.83	9.96	19.41	0.42	0.6	0.04	0.02	0.53	0.1
	SIC 70-89	0.24	0.28	1.43	1.29	6.53	9.27	0.71	0.94	0.04	0.02	0.51	0.14

Mfg EI : energy intensive manufacturing
VOL(12m) : oil price volatility computed on the daily 12 month future oil prices
TANG : asset tangibility computed according to Almeida and Campello (2006)

Table 6-6
Descriptive Statistics for Key Variables each Country

		I/K		TobinQ		S/K		CF/K		VOL12m		TANG	
		Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D	Mean	S.D
AUS	MFG	0.17	0.2	0.99	0.55	4.04	2.44	0.32	0.31	0.04	0.02	0.47	0.11
	SVC	0.21	0.27	1.11	0.76	7.19	8.14	0.45	0.87	0.04	0.02	0.44	0.14
CAN	MFG	0.26	0.29	1.04	0.89	3.91	3.2	0.44	0.54	0.04	0.02	0.54	0.1
	SVC	0.21	0.25	0.78	0.73	4.95	6.06	0.43	0.56	0.04	0.02	0.48	0.13
CHN	MFG	0.23	0.23	1.24	0.89	2.42	1.89	0.25	0.25	0.05	0.01	0.58	0.66
	SVC	0.24	0.28	1.45	0.77	2	5.5	0.17	0.15	0.05	0.01	0.49	0.08
HKG	MFG	0.23	0.32	0.57	0.43	4.18	4.48	0.3	0.3	0.05	0.02	0.54	0.12
	SVC	0.21	0.26	1.48	1.27	2.73	4.41	0.33	0.44	0.04	0.02	0.53	0.14
IDN	MFG	0.29	0.3	0.95	0.98	2.9	2.31	0.56	0.56	0.04	0.02	0.57	0.07
	SVC	0.26	0.28	0.8	0.83	5.79	7.41	0.53	0.63	0.05	0.02	0.57	0.09
JPN	MFG	0.09	0.11	0.64	0.42	3.52	1.86	0.2	0.19	0.04	0.02	0.58	0.06
	SVC	0.12	0.15	0.62	0.55	7.46	11.7	0.24	0.38	0.04	0.02	0.54	0.09
KOR	MFG	0.21	0.27	0.38	0.34	2.33	1.34	0.27	0.24	0.05	0.02	0.52	0.07
	SVC	0.21	0.26	0.47	0.55	20.9	89.9	0.21	0.25	0.05	0.02	0.5	0.07
MEX	MFG	0.19	0.17	0.62	0.46	1.3	0.59	0.24	0.18	0.04	0.02	0.53	0.06
	SVC	0.2	0.17	0.68	0.51	2.83	3.56	0.24	0.21	0.04	0.02	0.54	0.06
MYS	MFG	0.18	0.21	1.11	0.84	2.4	1.72	0.25	0.21	0.04	0.02	0.57	0.09
	SVC	0.19	0.21	1.03	0.96	3.53	5.7	0.32	0.52	0.04	0.02	0.52	0.13
PHL	MFG	0.24	0.28	0.72	0.61	2.16	2.29	0.28	0.28	0.04	0.02	0.53	0.11
	SVC	0.23	0.2	0.88	0.78	1.12	0.99	0.22	0.16	0.05	0.02	0.49	0.1
SGP	MFG	0.22	0.26	0.94	0.65	3.13	3.03	0.28	0.27	0.04	0.02	0.58	0.09
	SVC	0.25	0.28	0.88	0.69	4.17	6.02	0.29	0.41	0.04	0.02	0.53	0.14
THA	MFG	0.19	0.19	0.72	0.52	3.39	2.42	0.3	0.25	0.04	0.02	0.55	0.07
	SVC	0.29	0.34	0.89	0.71	2.3	2.59	0.34	0.56	0.04	0.02	0.49	0.15
TWN	MFG	0.27	0.29	1.37	0.92	4.59	6.13	0.35	0.44	0.05	0.02	0.52	0.1
	SVC	0.2	0.21	1.27	1.09	4.02	5.83	0.23	0.26	0.05	0.01	0.5	0.07
USA	MFG	0.21	0.24	1.49	1.15	5.61	3.79	0.7	0.76	0.04	0.02	0.51	0.12
	SVC	0.22	0.27	1.32	1.19	6.78	9.76	0.64	0.87	0.04	0.02	0.5	0.11
Total	MFG	0.17	0.22	1.01	0.9	4.06	3.18	0.4	0.53	0.04	0.02	0.55	0.1
	SVC	0.18	0.24	0.96	0.96	6.54	14.3	0.41	0.66	0.04	0.02	0.51	0.11

Table 6-7 : Correlation Analysis

Manufacturing

	I_t/K_{t-1}	Q_{t-1}	$(S/K)_{t-1}$	CF_t/K_{t-1}	$VO12m_{t-1}$	$TANG_{t-1}$
I_t/K_{t-1}		0.22	0.16	0.25	-0.06	0.03
		<0.0001	<0.0001	<0.0001	<0.0001	0.0005
Q_{t-1}	0.22		0.19	0.47	-0.08	0.08
	<0.0001		<0.0001	<0.0001	<0.0001	<0.0001
$(S/K)_{t-1}$	0.16	0.19		0.52	-0.05	0.07
	<0.0001	<0.0001		<0.0001	<0.0001	<0.0001
CF_t/K_{t-1}	0.25	0.47	0.52		-0.07	0.03
	<0.0001	<0.0001	<0.0001		<0.0001	0.0003
$VO12m_{t-1}$	-0.06	-0.08	-0.05	-0.07		-0.04
	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001
$TANG_{t-1}$	0.03	0.08	0.07	0.03	-0.04	
	0.0005	<0.0001	<0.0001	0.0003	<0.0001	

Service

	I_t/K_{t-1}	Q_{t-1}	$(S/K)_{t-1}$	CF_t/K_{t-1}	$VO12m_{t-1}$	$TANG_{t-1}$
I_t/K_{t-1}		0.27	0.06	0.25	-0.06	-0.002
		<0.0001	<0.0001	<0.0001	<0.0001	0.85
Q_{t-1}	0.27		0.004	0.42	-0.06	0.11
	<0.0001		0.71	<0.0001	<0.0001	<0.0001
$(S/K)_{t-1}$	0.06	0.004		0.32	-0.0005	0.1
	<0.0001	0.71		<0.0001	0.65	<0.0001
CF_t/K_{t-1}	0.25	0.42	0.32		-0.04	0.07
	<0.0001	<0.0001	<0.0001		0.0002	<0.0001
$VO12m_{t-1}$	-0.06	-0.06	-0.0005	-0.04		-0.05
	<0.0001	<0.0001	0.65	0.0002		<0.0001
$TANG_{t-1}$	-0.002	0.11	0.07	0.07	-0.05	
	0.85	<0.0001	<0.0001	<0.0001	<0.0001	

Chapter 7

Estimation Results

7.1. Uncertainty of Oil Price Changes and Firm Investment

I estimate the models over industry sub-samples, and country sub-samples. In industry sub-samples, I divide manufacturing into the energy-intensive (EI) and the less energy-intensive (EI) industries and also split the service industry into hard service and soft service industries. In country sub-samples, I start the estimation on single countries such as the U.S. and Japan. I also divide countries into several groups according to income level, manufacturing growth, region, and more.

7.1.1. Industry-based Estimation Results

Using oil price volatility from 12 month future prices, I start my estimations without considering observation gaps among countries (estimation without observation weights), and then I move to estimations considering the observation gaps (estimation with observation weights). Next, I report and compare the estimation results using the other three measures of oil price changes: volatility from 1 month future and spot oil prices, and weighted real oil price. I then show how to calculate the effect of oil price volatility on firm-level investment and provide the computed effects of volatility on different industrial sectors.

7.1.1.1. Estimation Results with a Benchmark for Oil Price Volatility

Estimation Results without Observation Weights

Here, I am going to use as the benchmark oil price volatility constructed from 12 month future oil prices, where firm investments are the most responsive in the various estimations. The main results are based on the model given in Equation (10) and are reported in Table 7-1. I start the examination with a standard investment model, which includes the basic explanatory variables for firm-level investment: Tobin Q and cash flow (CF). The results are presented in column 1 and column 3 of Table 7-1. Similar to other studies, the signs of Tobin Q and CF are positive and significant at the 1% level. Firm investments are positively sensitive to investment opportunities as proxied by Tobin Q and are more sensitive to cash flow in both the manufacturing and service industries.

Given the satisfactory results obtained from the standard investment model, I include a measure of lagged oil price volatility interacted with cash flow. Columns 2 and 4 of Table 7-1 present the estimation results. As we predicted, all of the signs in both the manufacturing and service industries are negative and significant at 1% and 5%, respectively. The magnitude of the estimate for manufacturing is much larger than for the service industry (-1.49 and -0.48, respectively). In the test for fixed effects, we easily reject the null hypothesis of no fixed effects in any estimation of this paper at the 1% significance level.

Table 7-1: Results on Oil Price Volatility and Firm Investment without Weights

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	mfg all				svc all			
1) Q model								
Q	0.04	***	0.04	***	0.05	***	0.05	***
CF_t	0.1	***	0.16	***	0.1	***	0.12	***
CF_t*$Volatility_{t-1}$			-1.49	***			-0.48	**
Intercept	0.53	***	0.6	***	0.13		0.14	
R-square	0.38				0.41			
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	11249		11249		8014		8014	
2) Internal funds model								
S	0.02	***	0.02	***	0.0007	**	0.0007	**
CF_t	0.09	***	0.14	**	0.11	***	0.13	***
CF_t*$Volatility_{t-1}$			-1.19				-0.49	**
Intercept	0.34	***	0.41	*	0.19	**	0.2	**
R-square	0.39		0.38		0.4			
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	11249		11249		8014		8014	

Volatility: derived from daily 12 month future oil prices
***, **, * represent significance at 1%, 5%, and 10%, respectively.

We then regress over the six energy-intensive and the other less energy intensive manufacturing sectors. The six energy intensive manufacturing sectors are petroleum refining (SIC 29), paper products (SIC 26), primary metal (SIC 33), stone and concrete (SIC 32), chemical products (SIC 28), lumber & wood (SIC 24). Columns 2 and 3 of Table 7-2 present the estimation results. The estimate for EI manufacturing firms (-1.96) is less than for the less EI manufacturing firms (-1.42), but the difference is not significant (t-value 1.28 with p-value of 0.20). In the service sub-samples, I find significant results only for the svc50-59 sector (wholesale and retail).

Table 7-2: Estimation for Manufacturing Sub-samples without Weights

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Mfg		**mfg EI**		**mfg less EI**		**svc**	
1) Q model								
Q	0.04	***	0.02	***	0.04	***	0.05	***
CF_t	0.16	***	0.25	***	0.15	***	0.12	***
CF_t*$Volatility_{t-1}$	-1.49	***	-1.96	**	-1.42	***	-0.49	**
Intercept	0.6	***	-0.21	**	0.62	***	0.14	
t-value			1.28(0.20)					
Obs	11249		3446		7796		8014	
2) Internal model								
S	0.02	***	0.04	***	0.02	***	0.0007	**
CF_t	0.14	**	0.18	***	0.13	***	0.13	***
CF_t*$Volatility_{t-1}$	-1.19		-1.59	***	-1.18	***	-0.49	**
Intercept	0.41	*	-0.21	**	0.46	***	0.2	**
Obs	11249		3446		7796		8014	

Parenthesis in t-value row is p-value.
Volatility: derived from daily 12 month future oil prices
***, **, * represent significance at 1%, 5%, and 10%, respectively.

Table 7-3: Estimation for Service Sub-samples without Weights

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Svc		**Svc50-89**		**svc40-49**		**svc50-59**		**svc70-89**	
1) Q model										
Q	0.05	***	0.05	***	0.07	***	0.06	***	0.04	***
CF_t	0.12	***	0.11	***	0.12	***	0.17	***	0.08	***
CF_t*$Volatility_{t-1}$	-0.49	**	-0.14		-1.5	*	-0.74	**	0.13	
Intercept	0.14		0.13		0.002		0.38	***	0.15	
Obs	8014		5494		2512		3616		1876	
2) Internal model										
S	0.0007	**	0.0005		0.02	***	0.0004		0	
CF_t	0.13	***	0.12	***	0.11	***	0.18	***	0.09	***
CF_t*$Volatility_{t-1}$	-0.49	**	-0.12		-1.4	*	-0.74	**	0.16	
Intercept	0.2	**	0.19	**	0.03		0.46	***	0.17	
Obs	8014		5494		2512		3616		1876	

Estimation Results with Observation Weights

The number of observations and firms per country varies widely across the countries (Japan 35.2% and 37.1%, U.S. 32.8% and 27.1%). Firms in some countries such as Japan show different cash flow sensitivity in investment behavior with regard to oil price volatility. Thus, I use the weighted regression approach following Love (2003). Weights are equal to a value of one divided by the number of observations per country.

The estimation results are presented in Table 7-4. The signs across the EI manufacturing and less EI manufacturing, and service industries are negative and significant. Firms in the service industry do have a caution effect but less than manufacturing firms. The coefficient of the interaction term of cash flow and oil price volatility in manufacturing shows greater magnitude than in the service industry (-1.72 and -0.8, respectively), as predicted in our hypothesis. Thus, we can say the role of cash flow declines more in importance for the manufacturing industry than for the service industry at heightened oil price volatility. As shown in Table 7-5, EI manufacturing shows the greatest decline in cash flow sensitivity with volatility (-2.35), which tells us that firms in EI manufacturing become the most cautious during the times of heightened oil price volatility. The difference in the estimates between EI and less EI manufacturing is now significant at the 5% level (t-value 2.42). These weighted estimation results are consistent with our expectations. Also we obtain the similar results in the internal funds model, where the sales to capital stock ratio (denoted as S) is used instead of Tobin Q. Declines in cash flow sensitivity are greater in the internal funds model than in the Tobin Q model.

Table 7-4: Results of Weighted Estimations

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Mfg				**Service**			
Q	0.08	***	0.08	***	0.07	***	0.06	***
CF_t	0.18	***	0.25	***	0.13	***	0.16	***
CF_t*Volatility$_{t-1}$			-1.72	***			-0.8	**
Intercept	0.001	***	0.0007		0.00002		-0.00003	
R-square	0.55		0.55		0.59		0.59	
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	11249		11249		8014		8014	

Table 7-5: Results of Weighted Estimations for Sub-samples

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Mfg		**Mfg EI**		**mfg less EI**		**svc**	
1) Q model								
Q	0.08	***	0.18	***	0.07	***	0.06	***
CF_t	0.25	***	0.4	***	0.2	***	0.16	***
CF_t*Volatility$_{t-1}$	-1.72	***	-2.35	**	-1.26	***	-0.8	**
Intercept	0.0007		0.0002		0.002	***	0.0001	
t-value				2.42 **				
R-square	0.55		0.64		0.54		0.59	
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	11249		3446		7796		8014	
2) Internal funds model								
S	0.03	***	0.24	***	0.02	***	-0.0002	
CF_t	0.271	***	0.8	***	0.22	***	0.21	***
CF_t*Volatility$_{t-1}$	-2.404	***	-15.9	***	-1.62	***	-1.2	***
Intercept	0.00002		-0.0004		0.002	***	0.001	**
t-value				7.54 ***				
R-square	0.55		0.69		0.54		0.58	
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
obs	11249		3446		7796		8014	

Weights are equal to a value of one divided by the number of observations per country.
***, **, * represent significance at 1%, 5%, and 10%, respectively.

7.1.1.2. Estimation with Different Measures of Oil Price Changes

As I stated in the section on the measure of oil price changes, I constructed three indices of oil price volatility and one index of relative oil price changes. Two oil price volatility indices are computed from 12 month and 1 month future oil prices, and one oil price volatility index is computed from spot oil prices. I call the index of relative oil price changes "weighted real oil prices." So far I have used the volatility measure derived from the 12 month future oil prices. Now I extend my estimations to other measures of oil price change, while splitting the firms into industry-based sub-sectors. The regression results are presented from Table 7-6 to Table 7-9.

When the other two oil price volatilities are used, the signs of the interaction term are mostly negative and significant in manufacturing, which is consistent with the results of the 12 month future oil price volatility estimations. When the volatility from 12 month future prices (VOL(12m)) is used, the negative impact of volatility on cash flow sensitivity is the greatest among the three measures of volatility for any sub-sample, except for the entire manufacturing sample. The negative effect of volatility on cash flow sensitivity decreases with the order of VOL(12m), VOL(1m), and VOL(spot)).

When weighted real oil prices are used, the signs of the interaction term are positive and significant in the sub-samples for all manufacturing, EI manufacturing, and all service industries. Unlike the case of oil price volatility measures, firms become more cash flow sensitive at times of higher oil prices. Thus, we argue in firm investment that the role of cash flow becomes more important when real oil prices go up. As it will, however, be shown in the country-based estimation later, I report that this result does not hold for the single-country regression on the U.S., where cash flow sensitivity declines with weighted real oil prices.

In short, when real oil price rises, firms in the APEC region decide to invest more if they have more income (cash flow). When oil prices fluctuate and uncertainty from the oil price fluctuation (volatility) increases, firms tend to become very cautious and decide not to invest more even if they have more income. In industrial sub-sample estimations, again cash flow sensitivity in EI manufacturing declines most with oil price changes even if other oil price volatility measures are used, and rises most with weighted real oil price. We argue that firms in EI manufacturing are most responsive to oil price changes. On the other hand, service firms show less decline in cash flow sensitivity than manufacturing, which implies service firms are hurt less by oil price changes. This result is consistent with the data on energy intensity and consumption, where the service industry is less energy intensive and less energy consuming than manufacturing.

Table 7-6: Weighted Estimation with Different Volatilities adjusted (mfg)

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Mfg							
	12mo		**1mo[a]**		**spot[a]**		**wrop**	
1) Q model								
Q	0.08	***	0.075	***	0.08	***	0.08	***
CF_t	0.25	***	0.265	***	0.2	***	0.19	***
CF_t*$Volatility_{t-1}$	-1.72	***	-2.07	***	-0.58	***	0.14	***
intercept	0.0007		0.001	***	0.001	***	0.001	***
R-square	0.55		0.55		0.55		0.55	
Obs	11249		11249		11249		11249	
2) Internal funds model								
S	0.03	***	0.03	***	0.03	***	0.03	***
CF_t	0.271	***	0.28	***	0.21	***	0.18	***
CF_t*$Volatility_{t-1}$	-2.404	***	-2.8	***	-1.05	***	0.13	***
intercept	0.00002		0.002	***	0.002	***	0.002	***
R-square	0.55		0.55		0.55		0.55	
Obs	11249		11249		11249		11249	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547

2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot)}=VOL(spot)*0.0061

wrop: Oil price shocks measured similarly to Davis and Haltiwanger(2001)

Table 7-7: Weighted Estimation with Different Volatilities adjusted (mfg EI)

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	mfg EI							
	12mo		**1mo[a]**		**spot[a]**		**wrop**	
1) Q model								
Q	0.18	***	0.19	***	0.2	***	0.2	***
CF_t	0.4	***	0.3	***	0.19	***	0.3	***
CF_t*$Volatility_{t-1}$	-2.35	**	-0.01		2.87	***	0.87	***
intercept	0.0002		-0.0001		-0.0009		-0.001	
R-square	0.64		0.64		0.64		0.65	
Obs	3446		3446		3446		3446	
2) Internal funds model								
S	0.24	***	0.21	***	0.21	***	0.19	***
CF_t	0.8	***	0.55	***	0.36	***	0.3	***
CF_t*$Volatility_{t-1}$	-15.9	***	-8.61	***	-2.78	***	0.23	**
intercept	-0.0004		-0.0002		-0.0002		-0.0005	
R-square	0.69		0.68		0.67			
Obs	3446		3446		3446			

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547

2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061

wrop: Oil price shocks measured similarly to Davis and Haltiwanger(2001)

Table 7-8: Weighted Estimation with Different Volatilities adjusted (svc)

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	svc							
	12mo		1mo[a]		spot[a]		wrop	
1) Q model								
Q	0.06	***	0.06	***	0.07	***	0.07	***
CF_t	0.16	***	0.16	***	0.13	***	0.13	***
CF_t*$Volatility_{t-1}$	-0.8	**	-0.69	**	-0.06		0.08	**
intercept	0.0001		0.0001		0.00002		0.00004	
R-square	0.59		0.59		0.59		0.59	
Obs	8014		8014		8014		8014	
2) Internal funds model								
S	-0.0002		-0.0002		-0.0002		-0.0002	
CF_t	0.21	***	0.2	***	0.17	***	0.15	***
CF_t*$Volatility_{t-1}$	-1.2	***	-1.09	***	-0.31		0.06	*
intercept	0.001	**	0.001		0.001	**	0.001	
R-square	0.58		0.58		0.58		0.58	
Obs	8014		8014		8014		8014	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547

2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061

wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

Table 7-9: Weighted Estimation with Different Volatilities adjusted (svc 50-89)

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	Svc50-89							
	12mo		**1mo[a]**		**spot[a]**		**wrop**	
1) Q model								
Q	0.02	***	0.02	***	0.02	***	0.02	***
CF_t	0.25	***	0.22	***	0.2	***	0.2	***
CF_t*$Volatility_{t-1}$	-1.32	***	-0.52		-0.19		-0.02	
intercept	0.0009		0.0007		0.0006		0.0005	
R-square	0.6		0.6		0.6		0.6	
Obs	5494		5494		5494		5494	
2) Internal funds model								
S	-0.0003	**	-0.0003	*	-0.0003	**	-0.0003	**
CF_t	0.27	***	0.24	***	0.22	***	0.21	***
CF_t*$Volatility_{t-1}$	-1.51	***	-0.72	**	-0.38	**	-0.04	
intercept	0.00003	***	0.002	**	0.002	**	0.001	**
R-square	0.6		0.6		0.6		0.6	
Obs	5494		5494		5494		5494	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547

2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061

wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

I also estimate the model with different measures of oil price changes without weights and report the results in the appendix 3 for comparing the results with weights. Furthermore, I estimate my model with different time variables; lagged cash flow and current-time oil price volatility from 12 month future oil prices. Table 7-10 reports the results. Even though the estimations are not conducted with the country observation weights, the results are consistent with what we have seen.

Table 7-10: Results with Different Time Variables without Weights

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it-1}}{K_{it-1}}) + \beta_3 (\frac{CF_{it-1}}{K_{it-1}}) * VOL_{it} + f_i + d_t + u_{it}$$

	mfg						**mfg EI**					
	12mo		**1mo**		**spot**		**12mo**		**1mo**		**Spot**	
Q model												
Q	0.03	***	0.03	***	0.03	***	0.02	***	0.02	**	0.02	**
CF_{t-1}	0.21	***	0.2	***	18	***	0.32	***	0.26	***	0.3	***
CF_{t-1}*$Volatility_t$	-1.14	***	-0.22	**	-0.003	**	-1.48	**	0.04		-0.006	***
intercept	0.58	***	0.56	***	0.57	***	-0.38	***	-0.43	***	-0.36	***
obs	11249		11249		11249		3446		3446			

	svc						**svc50-89**					
	12mo		**1mo**		**Spot**		**12mo**		**1mo**		**spot**	
Q model												
Q	0.06	***	0.06	***	0.06	***	0.05	***	0.05	***	0.05	***
CF_{t-1}	0.11	***	0.12	***	0.12	**	0.1	***	0.11	***	0.11	***
CF_{t-1}*$Volatility_t$	0.12		-0.03		-0.0003		0.39		0.08		-0.0001	
intercept	0.1		0.1		0.1		0.09		0.1		0.1	
obs	8014		8014		8014		5494		5494		5494	

7.1.1.3. Calculation of the Effect of Oil Price Volatility on Firm Investment

One benefit of our estimation is that we can indirectly compute the effect of oil price uncertainty on firm level investment. Change in investment to capital is equal to the coefficient on the interaction term times one standard deviation of volatility times the level of cash flow to capital (mean value).

Table 7-11 reports the computed effect of one standard deviation of oil price volatility on firm investment. For the entire manufacturing industry, when calculated at the mean of cash flow to capital (0.40), the effect of one-standard deviation in oil price volatility(which is equal to 0.01771) on investment to capital is approximately -0.0122. In percentage terms, the investment to capital decreases by 7.02% when calculated at the mean of investment to capital (0.1736). We can also calculate the oil price volatility elasticity of investment. The oil price volatility elasticity of investment is -0.1632 for the entire manufacturing industry.

Let me extend the computation to other industrial sectors. As shown in columns 2 and 3 of Table 7-11, the effect of one-standard deviation in volatility on investment is -7.7% for the energy intensive manufacturing sector, which shows the largest negative impact on firm investment. For the entire service industry, the effect is -3.18%, which is smaller than the entire manufacturing industry. Thus, we conclude that the EI manufacturing sector is hurt most by oil price volatility, and the service industry is hurt less by the volatility.

Table 7-11
Calculation of the Effect Oil Price Volatility on Investment
(Weighted Estimation Results used)

	mfg all	**EI mfg**	**svc**
Effect of VOL on Investment			
Mean(I/K)	0.1736	0.1659	0.1846
β of CF*VOL(12m)	-1.72	-2.35	-0.8
mean(CF/K)	0.4	0.3059	0.4147
1 std of lag(VOL(12m))	0.01771	0.01771	0.01771
△ I/K	-0.01218	-0.012731099	-0.00588
=β*mean(CF/K)*1 std of lag(VOL(12m))			
$\frac{\Delta(I/K)}{mean(I/K)}$	-0.07019	-0.076739597	-0.03183
	-7.02%	**-7.70%**	**-3.18%**
Elasticity			
mean(VOL(12m))	0.04119	0.04119	0.04119
$\eta = \frac{mean(\sigma)\Delta(I/K)}{mean(I/K)\Delta\sigma}$	**-0.1632**	**-0.1784813**	**-0.074**

7.1.2. Country-based Estimation results

I start with single country estimations on the U.S. and Japan, which are the most developed countries and have the most observations in the dataset. I then extend my work to country-grouping estimations, dividing countries into several groups according to income level, manufacturing growth, region, etc.

7.1.2.1. Single-country Estimations: the U.S. and Japan

Estimations on the U.S. show very stylized signs and magnitudes, which the caution effect theory expects, and we expect in the hypothesis. The coefficients of the interaction term are negative and significant at the 1% level for any manufacturing sub-samples. EI manufacturing shows negative signs and the greatest magnitude in the interaction term of cash flow and oil price volatility, and less EI manufacturing shows negative signs but smaller magnitudes. These results hold for the North American group (Canada, Mexico, and the U.S.) to be shown in Table 7-12. One noticeable thing is that unlike the across-country estimation, the estimates of the interaction term between cash flow and weighted real oil price show significantly negative signs. Thus we say that American manufacturing firms become very cautious and could forgo investment opportunities even if they have more cash flow at times of high uncertainty or high oil prices. In the service industry, I fail to find any significant signs in both all-service and soft service sub-samples when oil price volatility is used. I find significant negative signs in the all-service sample when weighted real oil prices are used. Thus we argue that American service firms tend to forgo or delay investment even if they have more income at times of higher oil prices. Lastly, we notice that American firms are more responsive to oil price volatilities than increase in oil prices, which holds for any of the industrial sub-samples.

Estimations on Japan are reported in Table 7-13. In manufacturing, I fail to find significant results when Tobin Q is used. When the sales to capital stock ratio is used, however, I find significant results in the EI and less EI manufacturing sub-samples. In EI manufacturing, the role of cash flow becomes very important with heightened oil price volatility (3.03). In less EI manufacturing, the role of cash flow diminishes greatly with the heightened oil price volatility (-2.01). In the service industry, we notice that for any model and any sub-sample, cash flow sensitivities increase with weighted real oil prices. Thus, at times of higher oil prices, the role of cash flow becomes more important for Japanese service firms. With regard to these results in service, we need to pay attention to the fact that the contribution of service to value added in Japan has increased by 10% point around the sample period (58.2% in 1990, 68.2% in 2003). The Japanese service sector has substantially grown and demand for investment is potentially high (Japanese I/K ratio: 0.09 for manufacturing and 0.12 for service), which could have led Japanese service firms to invest more at times of higher oil prices if they have more cash flow. It is also important to notice the positive signs when oil price volatility is used even though the estimates are insignificant.

Table 7-12
Estimation Results on the U.S.

	Mfg				**mfg EI**				**mfg Less EI**			
	12mo		**wrop**		**12mo**		**Wrop**		**12mo**		**wrop**	
1) Q model												
Q	0.04	***	0.04	***	0.02	**	0.02	*	0.04	***	0.04	***
CF_t	0.16	***	0.08	***	0.26	***	0.15	***	0.14	***	0.07	***
CF_t*$Volatility_{t-1}$	-1.78	***	-0.1	***	-2.31	***	-0.21	***	-1.65	***	-0.08	***
Intercept	0.65	***	0.62	***	-0.19	*	-0.18		0.67	***	0.63	***
R-square	0.37		0.37		0.36		0.36		0.38		0.38	
2) Internal model												
S	0.02	***	0.02	***	0.02	***	0.02	***	0.01	***	0.02	***
CF_t	0.14	***	0.07	***	0.21	***	0.13	***	0.13	***	0.07	***
CF_t*$Volatility_{t-1}$	-1.5	***	-0.08	***	-1.75	***	-0.16	**	-1.49	***	-0.07	***
Intercept	0.51	***	0.47	***	-0.2	*	-0.2	*	0.56	***	0.52	***
R-square	0.37		0.37		0.36		0.37		0.38		0.38	
Obs	3448		3448		909		909		2535		2535	

wrop: Oil price shocks measured similarly to Davis and Haltiwanger(2001)

	svc				**svc50-89**			
	12mo		**wrop**		**12mo**		**wrop**	
1) Q model								
Q	0.06	***	0.06	***	0.06	***	0.06	***
CF_t	0.11	***	0.1	***	0.09	***	0.09	***
CF_t*$Volatility_{t-1}$	-0.24		-0.06	**	0.16		-0.04	
Intercept	0.1		0.1		0.11		0.12	
R-square	0.43		0.43		0.43		0.43	
2) Internal model								
S	0.004	***	0.004	***	0.004	***	0.004	***
CF_t	0.13	***	0.11	***	0.1	***	0.1	***
CF_t*$Volatility_{t-1}$	-0.36		-0.06	**	0.05		-0.04	
Intercept	0.1		0.11		0.11		0.12	
R-square	0.41		0.42		0.41		0.41	
Obs	2880		2880		1905		1905	

Table 7-13
Estimation Results on Japan

	mfg				**mfg EI**				**mfg Less EI**			
	12mo		**wrop**		**12mo**		**wrop**		**12mo**		**wrop**	
1) Q model												
Q	0.01		0.01		0.02		0.02		0.009		0.007	
CF_t	0.17	***	0.13	***	0.05		0.15	***	0.22	***	0.13	***
CF_t*$Volatility_{t-1}$	-0.84		0.02		2.34	**	0.2	**	-2.26	***	-0.07	
intercept	-0.09		-0.09		-0.07		-0.08		-0.08		-0.08	
R-square	0.28		0.28		0.29		0.29		0.28		0.28	
2) Internal model												
S	0.04	***	0.04	***	0.05	***	0.05	***	0.04	***	0.04	***
CF_t	0.07	**	0.05	***	-0.13	*	0.01		0.14	***	0.05	***
CF_t*$Volatility_{t-1}$	-0.52		0.03		3.03	**	0.25	**	-2.01	***	-0.09	
intercept	-0.17	***	-0.17	***	-0.2	***	-0.21	***	-0.16	***	-0.15	***
R-square	0.31		0.31		0.32		0.32		0.32		0.32	
Obs	3906		3906		1198		1198		2707		2707	

wrop: Oil price shocks measured similarly to Davis and Haltiwanger(2001)

	svc				**svc50-89**			
	12mo		**wrop**		**12mo**		**wrop**	
1) Q model								
Q	0.02	***	0.03	***	0.03	***	0.03	**
CF_t	0.03		0.07	***	0.02		0.06	***
CF_t*$Volatility_{t-1}$	0.71		0.11	**	0.92		0.11	**
intercept	0.48	***	0.49	***	0.48	***	0.48	***
R-square	0.36		0.36		0.37		0.37	
2) Internal model								
S	0.005	***	0.005	***	0.005	***	0.005	***
CF_t	0.01		0.05	***	-0.0008		0.04	***
CF_t*$Volatility_{t-1}$	0.77		0.13	***	0.94		0.12	**
intercept	0.47	***	0.46	***	0.47	***	0.46	***
R-square	0.37		0.37		0.38		0.38	
Obs	2878		2878		2226		2226	

7.1.2.2. Country-grouping Estimations

Given the results on the single-country estimation of the U.S. and Japan, I extend my studies to country-grouping estimations. I split countries with some criteria and examine if there are any differences in investment behavior among country groups. The criteria for country grouping are income, manufacturing growth, region, and more. Here, I focus on the manufacturing industry and its sub-samples.

Country-grouping A-1 and A-2 in Table 7-14 report the results based on income-level criteria. I define countries with per capital GDP of more than US$20,000 as of 2003 as developed countries. For the group of developing countries, the coefficients of the interaction term are negative but insignificant. These results hold for any sub-sectors in manufacturing. The magnitudes of the negative impact are smaller than the U.S. Thus, I argue that firms in developing countries become less cautious in investment if they have more cash flow. When sales to capital ratio is used instead of Tobin Q, we find a marginally significant negative sign in the EI manufacturing sector.

Country-grouping B-1 and B-2 in Table 7-14 present the estimation results based on the manufacturing growth criteria. As shown in Table 2-4, contribution of manufacturing to value added is increasing during the sample period in Indonesia, Malaysia, Singapore, Thailand, and China while the other countries shows decline or little change in the contribution to value added. For the group of manufacturing-growing countries, I fail to find significant results as in developing countries. The coefficients of the interaction term are positive in the entire manufacturing and less EI manufacturing, even though they are insignificant. In EI manufacturing, the coefficient shows a negative but insignificant sign.

Overall, unlike in the U.S., firms in developing countries and manufacturing-growing countries become less cautious in investment if they have more cash flow. Especially firms in manufacturing-growing countries become little cautious if they have more cash flow and are likely to increase investment because investment demands in manufacturing-growing countries are higher than other countries, and the problem of investment irreversibility becomes less important.

Country-grouping D-1 and D-2 in Table 7-14 report present the estimation results based on region criteria. For North American countries such as Canada, Mexico and the U.S., the coefficients of the interaction term are negative and significant, which implies firms in the region become very cautious at times of heightened oil price volatility and forgo investment even with more cash flow.

Finally, we find again that for most of the country-groupings, EI manufacturing firms become more cautious than any other industrial sub-sectors, and the role of cash flow diminishes the most with oil price volatilities. In the Asian country group including Japan, EI manufacturing firms show a positive but insignificant sign in the interaction term, which is because Japanese firms showing a large positive sign are included.

Table 7-14: Results of Country-grouping Estimations

Country-grouping A-1

Developing countries: CHN, IDN, KOR, MEX, MYS, PHL, THA, TWN

	mfg		mfg EI		mfg less EI	
1) Q model						
Q	0.02	*	-0.004		0.03	**
CF_t	0.24	***	0.28	***	0.22	***
CF_t*$Volatility_{t-1}$	-0.78		-1.33		-0.48	
Intercept	0.22	*	0.08		0.21	
Obs	2572		912		1659	
2) Internal model						
S			0.09	***		
CF_t			0.18	*		
CF_t*$Volatility_{t-1}$			-3.35	*		
Obs			912			

Developing countries: less than US$20,000 in per capital GDP as of 2003

Volatility: derived from daily 12 month future oil prices

Country-grouping A-2

Other developed countries: AUS, CAN, SGP, HKG

	mfg		mfg EI		mfg less EI	
1) Q model						
Q	0.11	***	0.13	***	0.11	***
CF_t	0.15	***	0.32	***	0.11	**
CF_t*$Volatility_{t-1}$	-0.13		-4.43	**	1.19	
intercept	0.17		-0.04		0.13	
obs	1323		427		895	
2) Internal model						
S			0.07	***		
CF_t			0.26	**		
CF_t*$Volatility_{t-1}$			-4.38	**		
intercept			-0.1			
obs			427			

Developed countries: more than US$20,000 in per capital GDP as of 2003

Table 7-14 (*continued*)

Country-grouping B-1

Manufacturing-growing countries: CHN, IND, MYS, SGP, THA

	mfg		mfg EI		mfg less EI	
Q	0.008		-0.004		0.01	**
CF_t	0.15	***	0.24	**	0.1	***
CF_t*$Volatility_{t-1}$	0.28		-1.73		1.59	
Intercept	0.17	*	0.03		0.17	
Obs	1911		630		1281	

Country-grouping B-2

mfg non-growing countries: AUS, CAN, KOR, HKG, TWN, MEX, PHL except USA and JPN

	mfg		mfg EI		mfg less EI	
Q	0.09	***	0.11	***	0.08	***
CF_t	0.21	***	0.37	***	0.18	***
CF_t*$Volatility_{t-1}$	-0.78		-4.19	*	-0.02	
Intercept	0.12		0.09		0.14	
Obs	1984		709		1273	

Country-grouping C-1

Others except USA and JPN

	mfg		mfg EI		mfg less EI	
Q	0.05	***	0.02		0.05	***
CF_t	0.19	***	0.29	***	0.16	***
CF_t*$Volatility_{t-1}$	-0.26		-0.26		0.51	
Intercept	0.18		0.11		0.17	
Obs	3895		1339		2554	

Table 7-14 (*continued*)

Country-grouping D-1

North America: USA, CAN, MEX

	mfg		mfg EI		mfg less EI	
Q	0.05	***	0.04	***	0.05	***
CF_t	0.16	***	0.26	***	0.14	***
CF_t*$Volatility_{t-1}$	-1.72	***	-2.62	***	-1.6	***
Intercept	0.6	***	-0.19	*	0.64	***
Obs	4252		1245		3003	

Country-grouping D-2

Asian including AUS

	mfg		mfg EI		mfg less EI	
Q	0.03	***	0.02		0.03	***
CF_t	0.22	***	0.18	***	0.23	***
CF_t*$Volatility_{t-1}$	-0.73		0.19		-1.04	*
Intercept	0.22	**	0.16		0.21	**
Obs	6997		2201		4793	

Volatility: derived from daily 12 month future oil prices

In the previous estimations, we observed that cash flow sensitivity increases with weighted real oil prices across the APEC countries, while cash flow sensitivity declines with weighted real oil prices in the U.S. Thus, I need to examine the effect of relative oil price changes on firm investments over the other countries except for the U.S. and Japan. Table 7-15 reports the estimation results. For the country group that excludes the U.S. and Japan, the estimate of the interaction term of cash flow and weighted real oil price shows a greater positive magnitude than for the all country group (0.21 and 0.14, respectively), which implies the role of cash flow becomes more important with oil prices for all countries except the U.S. and Japan. For the country group of China, Hong Kong, Indonesia, Malaysia, and the Philippines, the positive magnitude becomes much larger.

Table 7-15: Weighted Estimation Results with Weighted Real Oil Prices
(Manufacturing only)

Country group	**All countries**		**USA**		**Other Countries except USA and JPN**		**CHN, HKG, IND, MYS, PHL**	
	Wrop		**wrop**		**wrop**		**wrop**	
1) Q model								
Q	0.08	***	0.04	***	0.07	***	0.08	***
CF_t	0.19	***	0.08	***	0.19	***	0.27	***
CF_t*$Volatility_{t-1}$	0.14	***	-0.1	***	0.21	***	0.45	***
Intercept	0.001	***	0.62	***	0.002	**	0.001	
R-square	0.55		0.37		0.5		0.52	
2) Internal model								
S	0.03	***	0.02	***	0.03	***	0.03	***
CF_t	0.18	***	0.07	***	0.17	***	0.27	***
CF_t*$Volatility_{t-1}$	0.13	***	-0.08	***	0.22	***	0.49	***
Intercept	0.002	***	0.47	***	0.001	***	0.001	***
R-square	0.55				0.46		0.46	
Obs	11249		3448		3895			

7.2. Asset tangibility and Firm Investment

The effect of asset tangibility on cash flow sensitivity is presented in row 4 of Tables 7-16 Part 1 and Part 2. The estimation uses pre-determined firm selection with "financially constrained (FC)" and "not financially constrained (NFC)" categories. Almeida and Campello (2006) use dividends, firm size, and bond ratings for financial constraints criteria in their standard regressions, and additionally they include the level of asset tangibility for financial constraints selection in their switching regression model. Here, my constraint categories are assigned by two criteria: the level of asset tangibility and the size of total assets in U.S. dollars. I define firms above the mean value of asset tangibility or the mean value of total asset as financially unconstrained. First, I find the credit multiplier effect of asset tangibility only for the entire service firm sample when the constraints criteria of asset tangibility are used. The 4^{th} and 8^{th} rows in column 3 of Table 7-16 show positive and significant signs. When the constraints criteria of total assets in U.S. dollars are used, all of the signs in the interaction terms are negative regardless of the type of financial constraints and the type of industries, which implies that there is not any credit multiplier effect of asset tangibility. Overall, I fail to find the credit multiplier effect in manufacturing. Second, it is noticeable that in manufacturing, the signs of the interaction term are significantly negative and greater in magnitude for financially unconstrained firms. Table 7-17 reports the results of weighted estimations. In the weighted estimations, the signs of the interaction term are negative and significant for both financially constrained and unconstrained groups in manufacturing. The magnitude of the estimate is greater in financially unconstrained group. In the entire service sample, the signs of the interaction term are insignificantly negative. Thus, we argue that the role of cash flow declines or does little in importance with asset tangibility for both manufacturing and service, and the higher level of asset tangibility reduces the level of financial frictions faced by firms.

Similar to the estimations of oil price volatility, sales show very little impact on investment (0.00004-0.003) in the service industry. In the manufacturing firms, the estimates on sales showed relatively greater magnitudes (0.01-0.03).

I also conduct alternative tests for the credit multiplier effect of asset tangibility and use the explanatory variable of asset tangibility at the current period instead of the lagged asset tangibility. The effect of asset tangibility on cash flow sensitivity is presented in row 4 of Table 7-18. The estimation results show that it is very hard to find the credit multiplier effect of tangible assets in any industry and any financial constraint regimes because we cannot find significantly positive signs on the interaction term except for the financially constrained group of the entire service industry. Rather, it is noticeable in the service industry that we see significant and strong negative signs in the financially unconstrained regime. This holds for the entire service sample and soft service sample. In the internal funds model, we observe similar results. This result can be interpreted, in financially unconstrained regime of the service industry, as the level of financial friction declining much more with the rise in asset tangibility, leading firms to be much less sensitive to internal funds (cash flow) in their investment decisions.

Table 7-16: Main results on Asset Tangibility

Part 1 - Financial constraints criteria: Mean of asset tangibility

	Mfg				**svc**				**svc50-89**			
	FC		NFC		FC		NFC		FC		NFC	
1) Q model												
Q	0.04	***	0.02	***	0.06	***	0.05	***	0.05	***	0.05	***
CF_t	0.1	***	0.27	***	0.06	***	0.15	***	0.2	***	0.12	***
$TANG_{t-1}$	0.11		0.38	***	-0.1		0.32	***	0.17	*	0.33	***
CF_t*TANG_{t-1}	0.06		-0.27	***	0.11	**	-0.09		-0.15	**	-0.06	
Intercept	0.21	**	0.07		0.02		-0.07		-0.08		-0.08	
2) Internal funds model												
S	0.03	***	0.02	***	0.0001		0.003	***	0.00004		0.003	***
CF_t	0.08	**	0.22	***	0.07	***	0.15	***	0.22	***	0.13	***
$TANG_{t-1}$	0.15	**	0.3	***	-0.07		0.38	***	0.20	**	0.4	***
CF_t*TANG_{t-1}	0.09		-0.23	***	0.14	***	-0.1	*	-0.14	*	-0.07	
Intercept	0.08		0.12		0.05		-0.12		-0.06		-0.14	

Part 2 - Financial constraints criteria: Mean of log of total assets in US dollars

	Mfg				**svc**				**svc50-89**			
	FC		NFC		FC		NFC		FC		NFC	
1) Q model												
Q	0.04	***	0.02	***	0.06	***	0.04	***	0.05	***	0.04	***
CF_t	0.16	***	0.28	***	0.15	***	0.07	***	0.17	***	0.24	***
$TANG_{t-1}$	0.37	***	0.15	**	0.17	**	0.06		0.3	***	0.27	***
CF_t*TANG_{t-1}	-0.1	***	-0.14	**	-0.07		-0.007		-0.09	*	-0.28	***
intercept	0.04		0.28	***	0.005		-0.02		-0.08		-0.12	
2) Internal funds model												
S	0.03	***	0.01	***	0.003	***	0.0004		0.003	**	0.0003	
CF_t	0.12	***	0.27	***	0.16	***	0.08	***	0.17	***	0.27	***
$TANG_{t-1}$	0.35	***	0.16	**	0.23	***	0.1		0.35	***	0.34	***
CF_t*TANG_{t-1}	-0.1	*	-0.16	***	-0.07		-0.005		-0.09	*	-0.31	***
Intercept	0.08		0.27	**	-0.04		-0.01		-0.11		-0.13	

FC: financially constrained, NFC: financially unconstrained

Table 7-17
Weighted Estimations on Asset Tangibility and Investment

Financial constraint criteria: total asset in US$

	mfg				svc			
	FC		NFC		FC		NFC	
1) Q model								
Q	0.13	***	0.04	***	0.01		-0.02	*
CFt	0.36	***	1.55	***	0.61	***	-0.33	***
TANGt-1	0.32	**	6.13	***	2.23	***	-0.87	***
CFt*TANGt-1	-0.64	***	-3.59	***	-1.15	***	1.06	***
Intercept	0.0005		-0.02	***	-0.01	***	0.02	***
R-square	0.62		0.72		0.67		0.68	
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	2416		3178		1630		2294	
2) Internal funds model								
S	0.05	***	-0.009		0.01	***	-0.002	
CFt	0.4	***	1.5	***	0.56	***	-0.29	***
TANGt-1	0.8	***	6.14	***	2.29	***	-0.88	***
CFt*TANGt-1	-0.62	***	-3.4	***	-1.1	***	0.97	***
Intercept	0.001		-0.02	***	-0.01	***	0.02	***
R-square	0.61		0.72		0.67		0.68	
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	2416		3178		1630			

FC: financially constrained, NFC: Not financially constrained
I rank firms based on their total assets and assign to the financially constrained (unconstrained) group those firms in the bottom (top) 25% of the average asset size distribution.

* Almedia and Campello (2006): bottom (top) 3 deciles of the annual asset size distribution

Table 7-18: Main results on Asset Tangibility with different time variables

Financial constraints criteria: Mean of asset tangibility

	Mfg				**Svc**				**svc50-89**			
	FC		NFC		FC		NFC		FC		NFC	
1) Q model												
Q	0.04	***	0.04	***	0.06	***	0.05	***	0.06	***	0.04	***
CF_t	0.1	***	0.07	*	0.07	***	0.2	***	0.18	***	0.16	***
$TANG_t$	-0.3	***	-0.45	***	-0.16	**	-0.15	*	0.03		-0.18	*
CF_t*$TANG_t$	0.11		0.04		0.13	**	-0.17	***	-0.08		-0.13	**
intercept	0.43	***	0.55	***	0.04		0.27		0.31		0.4	

FC: financially constrained, NFC: Not financially constrained
***, **, * represent significance at 1%, 5%, and 10%, respectively.

	Mfg				**Svc**			
	FC		NFC		FC		NFC	
2) internal funds model								
S	0.03	***	0.02	***	0.00001		0.004	***
CF_t	0.08	**	0.07	*	0.07	***	0.2	***
$TANG_t$	-0.3	***	-0.44	***	-0.17	**	-0.11	
CF_t*$TANG_t$	0.14	*	0.004		0.18	***	-0.19	***
intercept	0.32		0.57		0.09		0.22	

FC: financially constrained, NFC: Not financially constrained
***, **, * represent significance at 1%, 5%, and 10%, respectively.

Chapter 8

Conclusion

In this article, I investigate how the role of cash flow changes with the uncertainty coming from oil price fluctuations. I construct three measures of oil price volatility and one measure of relative oil price change. The three measures of oil price volatility are built on daily 12 month future prices and 1 month future prices, and daily spot prices. One measure of relative oil price change is built on monthly oil prices. Using the annual data obtained from COMPUSTAT global during the period of 1991 to 2004, I investigate the relationship between uncertainty and firm-level investment.

I find that the role of cash flow diminishes with higher oil price volatility from 12 month future oil prices in both manufacturing and service industries. I also provide evidence that cash flow sensitivity declines more with volatility in more energy intensive (EI) industries. Firms in more energy intensive industries become more cautious at times of heightened oil price volatility, and do not increase investment even if they have more cash flows, which leaves the role of cash flow to diminish more than firms in less energy-intensive industries. Thus, firm investments in energy intensive manufacturing are hurt the most by oil price fluctuations, and firms in the service industry are hurt less in their investment decision than firms in manufacturing.

When I use different measures of oil price volatility from 1 month future and spot oil prices, I observe similar results: a decrease in cash flow sensitivity with oil price volatility. I also find that firm investments respond most adversely to the volatility from

12 month future oil prices. Then, firm investments respond more to the volatility from 1 month future oil prices than the volatility from spot oil prices. When real oil prices are used for the measure of oil price changes, most APEC countries except the U.S. show the role of cash flow increasing during times of higher oil prices. Firms in the most APEC countries become less cautious if they have more cash flow and are likely to invest more.

In the country-grouping analysis, we find that oil price volatility affects firm investments in the U.S. and Canadian manufacturing negatively and significantly. For the low income countries and manufacturing-growing countries, however, we fail to find significantly negative effects of oil price volatility on cash flow sensitivity. Manufacturing firms in low income countries and manufacturing-growing countries are less hurt by oil price volatility, which implies that they become less cautious in investment if they have more cash flow. My interpretation of these results is that firms in developing countries are managerially less risk-averse, and firms in the U.S and Canada are managerially more risk-averse.

This article makes contributions to the literature in several ways. First, it provides the evidence that uncertainty coming from oil price volatility decreases firm-level investment even if firms have more income, and has a greater negative impact on firm investment than a rise in oil price. Our policy recommendation is that governments should make more efforts to reduce oil price fluctuations for economic growth than to decrease oil prices. Second, this article shows the differences in manufacturing and service firms in response to oil price shocks. The service industry is less hurt by oil price volatility, which implies that it is on the right track for governments to pursue polices to develop service industries in order to reduce negative shocks of oil price on investment. Third, this article shows the managerial differences between firms in developed countries such as the U.S. and Canada and firms in developing countries. Firms in more developed countries such as the U.S. and Canada show more managerial risk-aversion, and firms in developing countries show less managerial risk-aversion.

For future work, we will consider the impact of volatility over the business cycle. We will also study the different impacts of oil price volatility and oil price changes in detail using more alternative measures of relative oil price changes. It will be interesting to see whether or not the caution effect with regard to oil price volatility exists dominantly across other developed countries in Europe as it did in Canada and the U.S. More studies on the service sub-sectors are required.

In the analysis of the effect of asset tangibility on investment, I fail to find the credit multiplier effect in manufacturing. I find that the role of cash flow declines or does little in importance with tangible assets in manufacturing and service industries, and the higher level of asset tangibility reduces the level of financial frictions faced by the firms. My last finding is that sales show slight impact on investment in the service industry unlike in manufacturing.

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Appendix 1. Derivations for the Euler Equation

Firm value is given by:

$$V_t(K_t,\xi_t) = \max_{\{I_{t+s}\}_{s=0}^{\infty}} D_t + E_t\left[\sum_{s=1}^{\infty} \beta_{t+s-1} D_{t+s}\right] \qquad (1)$$

subject to

$$D_t = \Pi(K_t,\xi_t) - C(I_t,K_t) - I_t \qquad (2)$$

$$K_{t+1} = (1-\delta)K_t + I_t \qquad (3)$$

$$D_t \geq 0 \qquad (4)$$

D_t : the dividend paid to shareholders

β_{t+s-1} : a discounter factor from the period t+s to period t

K_t : capital stock, I_t : investment expenditure, δ : the depreciation rate

$\Pi(K_t,\xi_t)$: restricted profit function, $C(I_t,K_t)$: the adjustment cost of investment

The financial frictions are introduced via a non-negativity constraint on dividends (equation (4)), and the multiplier on this constraint is denoted λ_t. λ_t is the shadow cost associated with raising new equity, which implies external (equity) financing is costly due to information or contracting costs.

We can conveniently rewrite the dynamic optimization problem in equation (1) in a Bellman equation form.

$$V_t(K_t,\xi_t) = \max_{I_t} D_t + \beta_{t+1} E_t\left[V_{t+1}(K_{t+1},\xi_{t+1})\right] + \lambda_t D_t \qquad \text{(a1)}$$

The first order condition of the problem in (a1) is:

$$(1+\lambda_t)\left(\frac{\partial D}{\partial I}\right)_t + \frac{\partial \beta_{t+1} E_t\left[V_{t+1}(K_{t+1}, \xi_{t+1})\right]}{\partial I_t} = 0$$

And recall the equation (3): $K_{t+1} = (1-\delta)K_t + I_t$

$$\frac{\partial \beta_{t+1} E_t\left[V_{t+1}(K_{t+1}, \xi_{t+1})\right]}{\partial I_t} = \frac{\partial \beta_{t+1} E_t\left[V_{t+1}((1-\delta)K_t + I_t, \xi_{t+1})\right]}{\partial K_{t+1}}$$

$$(1+\lambda_t)\left(\frac{\partial D}{\partial I}\right)_t + \beta_{t+1} E_t\left[q_{t+1}\right] = 0, \qquad \text{(a2)}$$

where $q_{t+1} = \left(\frac{\partial V}{\partial K}\right)_{t+1}$ and q is the "marginal q."

That is, the shadow value of capital equals the increase in the value of the firm after increase in one unit of capital.

Using the envelope theorem, we obtain;

$$\begin{aligned} q_t = \left(\frac{\partial V}{\partial K}\right)_t &= \left(\frac{\partial D}{\partial K}\right)_t + \frac{\partial \beta_{t+1} E_t\left[V_{t+1}(K_{t+1}, \xi_{t+1})\right]}{\partial K_{t+1}}(1-\delta) + \lambda_t\left(\frac{\partial D}{\partial K}\right)_t \\ &= (1+\lambda_t)\left(\frac{\partial D}{\partial K}\right)_t + \beta_{t+1} E_t\left[q_{t+1}\right](1-\delta) \end{aligned} \qquad \text{(a3)}$$

Combining the first order condition and the envelope theorem to eliminate q_t *and* q_{t+1} yields;

From (a3), $q_{t+1} = \left(\frac{\partial V}{\partial K}\right)_{tz=1} = (1+\lambda_{t+1})\left(\frac{\partial D}{\partial K}\right)_{t+1} + \beta_{t+2} E_{t+1}\left[q_{t+2}\right](1-\delta)$ (a4)

and $\beta_{t+2} E_{t+1}\left[q_{t+2}\right] = -(1+\lambda_{t+1})\left(\frac{\partial D}{\partial I}\right)_{t+1}$ from (a2). (a5)

(a4) + (a5); $q_{t+1} = \left(\frac{\partial V}{\partial K}\right)_{tz=1} = (1+\lambda_{t+1})\left(\frac{\partial D}{\partial K}\right)_{t+1} - (1+\lambda_{t+1})\left(\frac{\partial D}{\partial I}\right)_{t+1}(1-\delta)$

From (a2);

$$(1+\lambda_t)\left(\frac{\partial D}{\partial I}\right)_t + \beta_{t+1}E_t\left[(1+\lambda_{t+1})\left(\frac{\partial D}{\partial K}\right)_{t+1} - (1+\lambda_{t+1})\left(\frac{\partial D}{\partial I}\right)_{t+1}(1-\delta)\right] = 0$$

$$-\left(\frac{\partial D}{\partial I}\right)_t = \beta_{t+1}E_t\left[\left(\frac{1+\lambda_{t+1}}{1+\lambda_t}\right)\left\{\left(\frac{\partial D}{\partial K}\right)_{t+1} - \left(\frac{\partial D}{\partial I}\right)_{t+1}(1-\delta)\right\}\right] = 0$$

$$\left(\frac{\partial D}{\partial I}\right)_t = -\left(\frac{\partial C}{\partial I}\right)_t - 1$$

$$\left(\frac{\partial D}{\partial K}\right)_t = \left(\frac{\partial \Pi}{\partial K}\right)_t - \left(\frac{\partial C}{\partial K}\right)_t$$

For simplicity, I ignore the derivative of the adjustment cost function with regard to capital, $\left(\frac{\partial C}{\partial K}\right)_t$.

Finally we get the Euler equation.

$$1+\left(\frac{\partial C}{\partial I}\right)_t = E_t\left[\beta_{t+1}\left(\frac{1+\lambda_{t+1}}{1+\lambda_t}\right)\left\{\left(\frac{\partial \Pi}{\partial K}\right)_{t+1} + \left(\left(\frac{\partial C}{\partial I}\right)_{t+1} + 1\right)(1-\delta)\right\}\right] = 0\text{, or}$$

$$1+\left(\frac{\partial C}{\partial I}\right)_t = \beta_t E_t\left[\Theta_t\left\{\left(\frac{\partial \Pi}{\partial K}\right)_{t+1} + (1-\delta)\left(1+\left(\frac{\partial C}{\partial I}\right)_{t+1}\right)\right\}\right]$$

where $\Theta_t = \frac{1+\lambda_{t+1}}{1+\lambda_t}$.

"LHS means the marginal cost of investment of today (= the price of investment goods, normalized to one + the adjustment cost).

RHS means the discounted marginal cost of postponing investment until tomorrow (equals the foregone marginal benefit of an extra unit in capital (MPK) plus the adjustment cost plus price of investment goods tomorrow)."

By solving the profit maximization problem, MPK is a function of the sales to capital ratio (MPK= f(S/K)). $\Theta_t = \frac{1+\lambda_{t+1}}{1+\lambda_t}$ is the relative cost of external finance in periods t and t+1, and Love (2003) parameterizes it as a linear function of the cash stock. Financial development decreases financing constraints.

Thus $\Theta_t = a_0 + (a_1 + a_2 FD_c) Cash_{t-1}$,

where FD_c is the country-level measure of financial development.

Appendix 2. Weights for weighted average of real prices in the prior 60 months

Weight Number	Weight
w1	0.0333
w2	0.0328
w3	0.0322
w4	0.0316
w5	0.0311
w6	0.0305
w7	0.0299
w8	0.0294
w9	0.0288
w10	0.0282
w11	0.0277
w12	0.0271
w13	0.0266
w14	0.0260
w15	0.0254
w16	0.0249
w17	0.0243
w18	0.0237
w19	0.0232
w20	0.0226
w21	0.0220
w22	0.0215
w23	0.0209
w24	0.0203
w25	0.0198
w26	0.0192
w27	0.0186
w28	0.0181
w29	0.0175
w30	0.0169

Weight Number	Weight
w31	0.0164
w32	0.0158
w33	0.0153
w34	0.0147
w35	0.0141
w36	0.0136
w37	0.0130
w38	0.0124
w39	0.0119
w40	0.0113
w41	0.0107
w42	0.0102
w43	0.0096
w44	0.0090
w45	0.0085
w46	0.0079
w47	0.0073
w48	0.0068
w49	0.0062
w50	0.0056
w51	0.0051
w52	0.0045
w53	0.0040
w54	0.0034
w55	0.0028
w56	0.0023
w57	0.0017
w58	0.0011
w59	0.0006
w60	0.0000

Appendix 3. Results with Different Measures of Volatility without Weights

Table A3-1: Estimation with Different Measures of Volatilities without Weights

$$Model: \frac{I_{it}}{K_{it-1}} = \beta_1 Q_{it-1} + \beta_2 (\frac{CF_{it}}{K_{it-1}}) + \beta_3 (\frac{CF_{it}}{K_{it-1}}) * VOL_{it-1} + f_i + d_t + u_{it}$$

	mfg						mfg EI					
	12mo		1mo		spot		12mo		1mo		Spot	
Q model												
Q	0.04	***	0.04	***	0.04	***	0.02	***	0.02	***	0.02	***
CF_t	0.16	***	0.14	***	0.13	***	0.25	***	0.24	***	0.22	***
CF_t*$Volatility_{t-1}$	-1.49	***	-0.27	***	-0.004	***	-1.96	***	-0.47	***	-0.006	***
Intercept	0.6	***	0.56	***	0.59	***	-0.20	**	-0.23	**	-0.20	**
R-square	0.38											
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001		0.0001			
Obs	11249		11249		11249		3446		3446			

	svc						svc50-89					
	12mo		1mo		spot		12mo		1mo		spot	
Q model												
Q	0.05	***	0.05	***	0.05	***	0.05	***	0.05	***	0.05	***
CF_t	0.12	***	0.1	***	0.09	**	0.11	***	0.1	***	0.1	***
CF_t*$Volatility_{t-1}$	-0.49	**	-0.01		0.0003		-0.14		0.06		0.0004	
Intercept	0.14		0.13		0.12		0.13		0.12		0.12	
R-square												
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001		0.0001			
Obs	8014		8014		8014		5494		5494		5494	

Table A3-2
Estimation with Different Measures of Volatility adjusted without Weights

	Mfg							
	12mo		**1mo[a]**		**spot[a]**		**wrop**	
1) Q model								
Q	0.04	***	0.04	***	0.04	***	0.04	***
CF_t	0.16	***	0.14	***	0.13	***	0.1	***
CF_t*$Volatility_{t-1}$	-1.49	***	-0.91	***	-0.71	***	-0.07	***
Intercept	0.6	***	0.56	***	0.59	***	0.56	***
R-square	0.38							
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	11249		11249		11249		11249	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547
2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061
wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

	mfg EI							
	12mo		**1mo[a]**		**spot[a]**		**wrop**	
Q model								
Q	0.02	***	0.02	***	0.02	***	0.02	**
CF_t	0.25	***	0.24	***	0.22	***	0.17	***
CF_t*$Volatility_{t-1}$	-1.96	***	-1.59	***	-1.06	***	-0.1	**
Intercept	-0.2	**	-0.23	**	-0.2	**	-0.23	**
R-square								
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
Obs	3446		3446		3446		3446	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547
2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061
wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

Table A-2 (*continued*)

	Svc							
	12mo		**1mo**[a]		**spot**[a]		**wrop**	
Q model								
Q	0.05	***	0.05	***	0.05	***	0.05	***
CF_t	0.12	***	0.1	***	0.09	**	0.1	***
CF_t*$Volatility_{t-1}$	-0.49	**	-0.05		0.05		0.008	
intercept	0.14		0.13		0.12		0.13	
R-square								
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
obs	8014		8014		8014		8014	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean(VOL(1m))}=VOL(1m)*0.29547
2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot))}=VOL(spot)*0.0061
wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

	svc50-89							
	12mo		**1mo**[a]		**spot**[a]		**wrop**	
Q model								
Q	0.05	***	0.05	***	0.05	***	0.05	***
CF_t	0.11	***	0.1	***	0.1	***	0.1	***
CF_t*$Volatility_{t-1}$	-0.14		0.22		0.08		-0.004	
intercept	0.13		0.12		0.12		0.13	
R-square								
F-test for fixed effects	0.0001		0.0001		0.0001		0.0001	
obs	5494		5494		5494		5494	

a: adjusted VOL measures

1) adjusted VOL(1m)=VOL(1m)*{mean(VOL(12m)/mean (VOL(1m))}=VOL(1m)*0.29547
2) adjusted VOL(spot)=VOL(spot)*{mean(VOL(12m)/mean(VOL(spot)}=VOL(spot)*0.0061
wrop: Oil price shocks measured similarly to Davis and Haltiwanger (2001)

VITA

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