EFFECTS OF EXCHANGE RATE CHANGES ON INVESTMENT : A STUDY WITH U.S. FIRM LEVEL PANEL DATA

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SEUNG WON LEE
Dr. Ronald A. Ratti, Dissertation Supervisor

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

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Presented by Seung-Won Lee,
a candidate for the degree of Doctor of Philosophy,
and hereby certify that, in their opinion, it is worthy of acceptance.

Professor Ronald A. Ratti

Professor Shawn Ni

Professor Douglas J. Miller

Professor Dong Pil Yoon

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Seung-Won Lee

Dr. Ronald A. Ratti, Dissertation Supervisor

ABSTRACT

In this paper I investigate the effects of exchange rate changes on firm investment through the export channel and imported input channel using U.S. manufacturing firm level data for 1998 ~ 2007. For this study, I create a ‘small’ sample, where the export ratio is ‘export to sales ratio’ obtained from financial statements, and a ‘large’ sample using industry level ‘export to shipment ratio’ as a proxy for the ‘export to sales ratio’. Considering the possible dynamic panel bias problem in the empirical model, I use the ‘difference’ GMM and the ‘system’ GMM for the econometric methods.

The findings of my study are as follows: appreciation (depreciation) of domestic currency reduces (increases) firm investment through the exports channel. Also appreciation (depreciation) of the domestic currency increases (reduces) firm investment through the imported input channel.

Firms with low markup rates are more sensitive in their investment responses to the movement in exchange rate changes both in terms of the exports channel and imported input channel.

Low cash flow firms are more sensitive in terms of investment responses to the exchange rate changes than high cash flow firms. Also smaller firms are more responsive in their investments to exchange rate changes than larger firms. The findings on the role of cash flow and firm size indicate that U.S. firms are exposed to

widespread financial constraints.

With regard to the role of leverage, overall estimation results imply that leverage does not affect the relationship between the exchange rate changes and firm investment.

In most of the results in this paper, the coefficients associated with the export channel are more significant than those of the imported input channel. This suggests that firms' responses to the movement of exchange rates are more sensitive through the export channel than through the imported input channel.

Chapter 1.

INTRODUCTION

1.1. Research Questions

Since the breakdown of the Bretton Woods System in the early 1970s and many countries agreed to allow their exchange rates to float, the world economy has observed fluctuations in exchange rates both in terms of the relative exchange rate levels and the size of volatility. These exchange rate changes have to a great extent influenced macroeconomic environments and have also affected the behaviors of economic agents such as firms and consumers.

Until now, many studies have been conducted on the effects of exchange rate changes on real economy variables such as the prices of goods, firm values and employment. However, only a few studies have been done on the effects of exchange rate changes on business investment.

It has been said that the depreciation of a domestic currency is helpful in raising the competitiveness of domestic firms and stimulating the economy. That is, a depreciation of domestic currency makes firms that export goods and services more competitive, thus raises their profits and sales; although the increase in import prices decreases the benefits to domestic consumers. These increases in firm’s profits and sales will also lead to the increase in investment.

Owing to this conventional wisdom, some countries try to maintain their exchange rate level at lower levels (i.e. depreciation) than competing countries to stimulate their economy. Sometimes this policy inclination toward weak domestic currencies gives rise to international conflicts.

However, as discussed in the paper, the effect of exchange rate changes on an economy may vary according to a country’s industrial structure in terms of its external exposure measured by exports ratio, imports penetration ratio and imported input ratio facing each industry, and this external exposure of each industry also may vary over time. After all, the effects of exchange rate changes on investment will vary from countries to countries according to not only industry structure but also in terms of time, resulting in empirical problems which must be addressed.

The real effective exchange rate (REER) of U.S. was stable from the early 1990s to 1996 after fluctuating wildly during the 1980s. However, from 1996 to 2002, it appreciated for six years by around 25% and then again depreciated from 2002 to 2007 by 20%, which gives us a good environment to investigate the effect of exchange rate changes on firm investment.

As Goldberg (1993) indicates, three routes can be considered in regard to the effects of exchange rate changes on investment. The first route is related to the changes in export and import prices caused by exchange rate changes. These changes in prices affect the demand for goods and services in the domestic and foreign markets and also the cost structures of firms, and hence affect sales and profits of each firm. Another route is related to the effects of exchange rate changes on the relative attractiveness of production location. This route may affect the relative level of foreign direct investment across countries, and affect the overall level of private investment in a country. The last route concerns the effects of exchange rate changes on the financial markets and the movement of capital across countries. This route affects firm investment through the changes in financial and macroeconomic environment. The paper focuses on the first route, where exchange rate changes affect firm investment through exports and imports of goods and services.

My study is to answer the following questions: 1) What influences do the movements of exchange rates have on business investment? 2) Through which channels do exchange rate changes affect business investment? 3) Do firm specific factors such as market power or financial market constraints affect the relationship between exchange rate changes and investment?

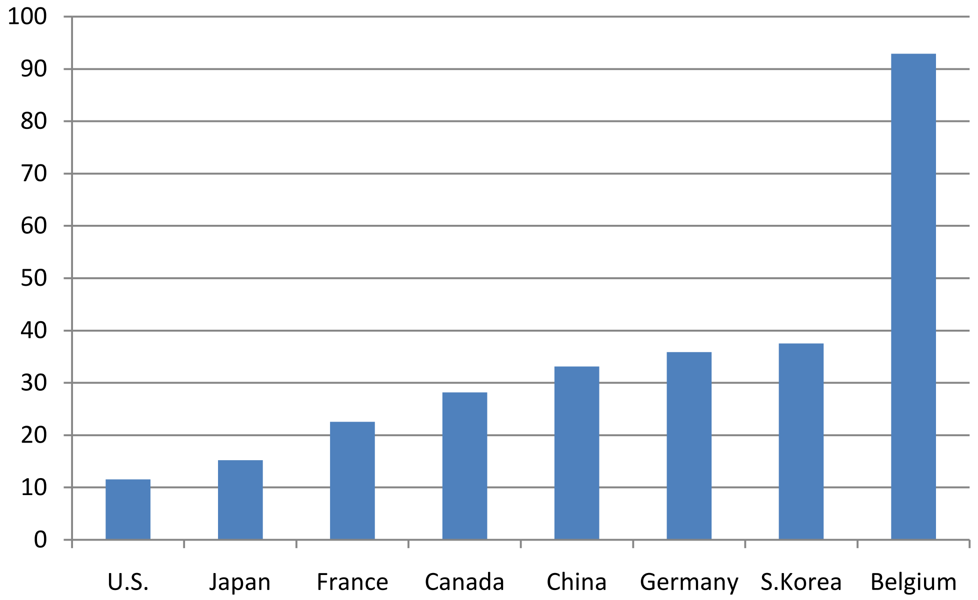
1.2. Trends in U.S. Exports and Imports

As figure 1-1 indicates, the portion of exports and imports in the U.S. economy is very small compared to other countries. This implies that external factors, such as the movement of exchange rates, have less impact on the U.S. economy through trade channel than in other countries.

However, as figure 1-2 shows, the portion of exports and imports in the U.S. economy is increasing continuously. In the early 1970’s, the exports and imports only accounted for approximately 7% of the US economy. Since then, the relative importance of exports and imports in U.S. has increased; as of 2007, exports and imports account for 13.5 percent and 19.3 percent of the U.S. economy, respectively, where imports have grown at a much faster rate.

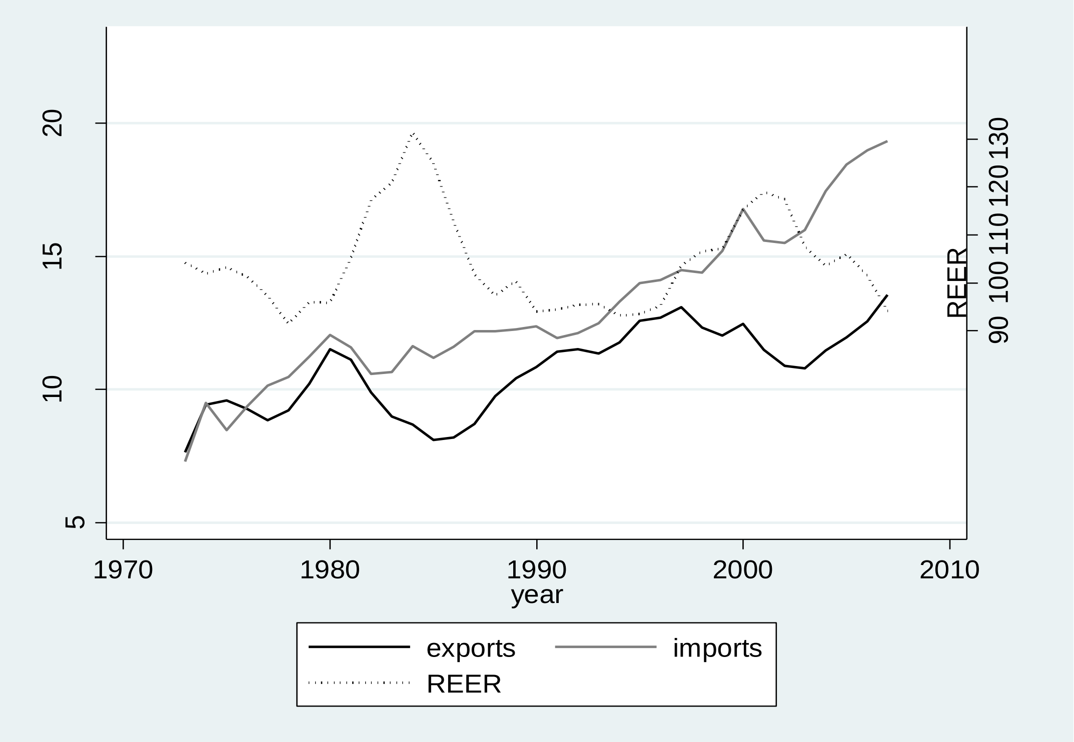
Figure 1-2 presents the trends in exports and imports as percentages of national income as well as the real effective exchange rate. The graph indicates that exports and imports are closely related with the movements of exchange rates as well as they are increasing over time. In particular, exports are more sensitive to exchange rate changes than imports.

Figure 1-1. Exports and Imports as Percentage of GDP (2007)



Note : Data are from 'International Trade Statistics 2008', World Trade Organization, and 'World Economic Out database', IMF; The ratio above is calculated as the average of exports and imports divided by GDP; Exports and imports of service are not included.

Figure 1-2. Exports and Imports of U.S. as Percentages of National Income



Note : Data are from Bureau of Economic Analysis (exports, imports, and national income) and Federal Reserve Bank of New York (real effective exchange rate). Exports and imports include both goods and services.

In the early 1980s, when U.S. dollar rapidly appreciated, U.S. exports as the percentage of national income dropped sharply. Also, from 1997 to 2003, U.S. exports relative to national income dropped with the appreciation of dollar. On the other hand, during periods of depreciation, in the late 1980s and after 2003, exports relative to national income have increased.

1.3. Overview of Previous Research

As I stated earlier, only a few studies have been conducted as to the effects of exchange rate changes on business investment.

Goldberg (1993) investigates the relationship between exchange rate changes and business investment in the U.S. industry, for the first time, using aggregate and two digit disaggregate quarterly data from 1970 : 1 to 1989 : 4. As an empirical model, she regresses the log of investment on the log of the real exchange rate, the log of exchange rate variability, the log of real GDP and real interest rates. In this model, she does not consider any industry specific factors such as the exports ratio or the ratio of imported input in total variable cost.

Her findings are as follows: first, in many cases, the relationship between business investment and exchange rate changes shifted over time. Hence, by dividing the data into two sub-samples, the 1970s and the 1980s, she derives more significant results than when the data of whole periods are analyzed. Second, two digit disaggregate data show more significant results than aggregate data, while the signs of the effects differ by sectors. Third, exchange rate changes have a significant impact on business investment in the manufacturing-durables sectors and in non-manufacturing sectors. This effect is significant mainly for the 1980s. What is interesting is that exchange rate appreciation (depreciation) was associated with expansion (contraction) of business investment in the 1980s, which is contrary to the conventional wisdom concerning the effects of exchange rate changes. Forth, exchange rate volatility has a significant effect on business investment only in the manufacturing-durable sectors, but the sign of this relationship shifts over time and differs by sectors.

These results imply that industry specific factors play an important role in the relationship between exchange rate changes and investment, and those industry specific factors themselves may vary over time.

Campa and Goldberg (1995) address this subject further by including variables for external exposure and the market power of each sector.

For their empirical analysis, they regress the growth rate of business investment on the growth rate of sales, two terms on exposure indices interacted with the change in real exchange rate and the measure of exchange rate variability, respectively, and the growth rate of interest rates. They use aggregate and disaggregate quarterly data on two-digit U.S. manufacturing industries from the 1970s through the 1980s.

With regard to external exposure of the U.S. manufacturing industries, they find some interesting results. During the 1970s and the 1980s, import exposure has increased much more than export exposure, while import exposure already exceeded the export exposure in some sub-sectors in the early 1970s. In addition, manufacturing-durables sectors as a whole face higher import exposure than manufacturing non-durables sectors.

The following are the findings of Campa and Goldberg (1995). First, exchange rate appreciation (depreciation) leads to the contraction (expansion) of business investment as export exposure increases. Exchange rate appreciation (depreciation) shows a positive (negative) effect on business investment when import exposure increases. Second, the effect of exchange rate volatility on business investment is very weak and in most cases insignificant. Third, in the sectors with high price-cost markups, the effects of exchange rate changes on investment are much weaker than in the sectors with low price-cost markups. These results imply that a high markup industry absorbs a lot of the exchange rate changes in its markup rates. As a result, it is less likely to pass the exchange rate changes onto the investment behavior.

Campa and Goldberg (1999) extend their study to the comparison of several countries including the U.S., Japan, The United Kingdom and Canada by using two-digit annual industry data. For their empirical analysis, they investigate the influence of the interaction terms of external exposure, the real exchange rate and markup on investment, controlling for sales, interest rates, and oil prices.

The estimated coefficients with respect to export-share terms and imported-input share terms, both of which are interacted with exchange rate and markup level, were positive and negative[1], respectively, and turned out to be significant in all countries except Canada. Thus, the more export-oriented an industry, the more expansionary (contractive) effect a depreciation (appreciation) has on business investment. Also, the more an industry depends on imported inputs, the stronger the contractive (expansionary) effect a depreciation (appreciation) has on business investment.

Nucci and Pozzolo (2001) investigate the relationship between exchange rate changes and investment using, for the first time, panel data on Italian manufacturing firms for the period 1986-1995.

They regress the changes in the log of investment expenditure on the lagged dependent variable, the changes in the log of sales, and two interaction terms related

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[1] In Campa and Goldberg (1999) the increase in exchange rate implies depreciation.

to exports and imported input exposure, respectively. The terms related to exports exposure are the products of exports ratio and the changes in the log of real exchange rates, while the term related to imported input exposure is the products of imported input to total variable costs and the changes in the log of real exchange rates.

Their findings show that a depreciation of the exchange rate increases business investment through its positive effect on revenue, and decreases business investment through its negative effect on cost; the higher is the export (imported input) exposure, the larger the positive (negative) effect of currency depreciation on business investment. Furthermore, they find that the larger a firm's market power, the weaker the effect of exchange rate changes on business investment.

1.4. Contribution of my paper

My contributions on this subject regarding the relationship between exchange rate changes and business investment are as follows.

(1) U.S. firm level panel data

Studies of the relationship between exchange rate changes and investment using firm level panel data have advantages over studies using aggregate data, in that the former can control for unobservable firm specific effects. However, there is only one study using firm level panel data, an analysis using Italian firm level panel data conducted by Nucci and Pozzolo (2001). Additional studies using panel data method need to be conducted to generalize empirical results. I address this issue using US firm level panel data for the period from 1998 to 2007, which will contribute to the generalization of the empirical results and the comparison of those findings between countries.

(2) Industry Specific Real Effective Exchange Rate

Until now, previous studies on this subject have only used aggregate real effective exchange rates both in terms of exports and imports. However, considering the facts that the distribution of trade counterparts and their weights vary across industry, it is natural to think that industry specific real exchange rates reflect the relative price structure facing each industry better than aggregate real effective exchange rate.

Goldberg (2004) shows that using industry specific real effective exchange rate identifies the effects of dollar movements on profits more precisely compared to using aggregate real effective exchange rate.

In this study, I will use industry specific real effective exchange rates so that the exchange rates more accurately reflect the movements in relative price structure facing each firm.

(3) Adjustment-cost Function

All the literature on the relationship between exchange rate changes and investment specify the adjustment-cost function as only a function of investment, which leads them to use ‘investment’, not ‘investment to capital ratio’ for the dependent variable in their model. However, the tradition in the literature on business investment employs the functional form on the adjustment cost as the function of investment and capital stock (Hayashi, 1982 ; Gilchrist & Himmelberg, 1995; Hubbard, 1998). It is reasonable to expect that firms with different sizes of capital stock may face different adjustment-cost structures when installing new capital stock.

In the study, I specify the adjustment cost function as a function of investment and capital stock, following the previous literature on business investment. As a result, the variable on 'investment' in my paper is not the change in the log of investment but the change in the investment to capital ratio.

(4) 'System' GMM

In analyzing Italian firm level panel data, Nucci and Pozzolo (2001) use 'difference' GMM, developed by Arrelano and Bond (1991), to deal with dynamic panel bias problem. While Blundell and Bond (1998) propose 'system GMM' which is another way to deal with the dynamic panel bias problem. 'System' GMM improves some problems with 'difference' GMM and helps us to prevent data loss that might occur when running 'difference' GMM on unbalanced panel data. In analyzing U.S. panel data I present both "difference" GMM and 'System' GMM estimation results to raise the reliability of the results.

Chapter 2.

LITERATURE REVIEW

2.1. Review on Investment Theory

During the 1960s and the 1970s, the study of business investment was dominated by the neoclassical theory developed by Jorgenson and the ‘q’ theory suggested by Tobin (Hayashi, 1982). Neoclassical theory is based on a firm’s optimizing behavior. A firm determines its investment level in order to maximize the discounted present value of its profits subject to technological constraints such as its production function. However, the earlier approach of Neoclassical theory can only determine the optimal level of capital stock, not the optimal investment level, under constant returns to scale and given an exogenous output level. Later, an idea on the cost of installing new investment goods was introduced, and by employing this idea, Neoclassical theory could derive optimal investment level.

According to ‘q’ theory, developed by Tobin (1969), a firm’s investment rate is an increasing function of Tobin’s ‘q’, where ‘q’ is the ratio of market value from additional capital stock to the replacement cost of the additional capital stock. In ‘q’ theory also, adjustment cost implicitly plays an important role. That is, without considering adjustment cost, firms will increase investment until ‘q’ is equal to one. Tobin’s ‘q’ is basically a ‘marginal’ concept and is not observable from the information in financial markets. Hayashi (1982) shows that under certain conditions,[2] average ‘q’, the ratio of market value from existing capital stock to the replacement

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[2] The four conditions are as follows: first, product and factor markets are competitive, second, production and adjustment cost technologies are linear homogeneous, third, capital is homogeneous and forth, investment decisions are largely separate from other real and financial decisions.(Hayashi, 1982)

cost of the existing capital is equivalent to marginal ‘q’. Based on this theoretical background, many empirical studies of investment have employed average q as a proxy for marginal ‘q’.

Later, Lucas and Prescott (1971), and Abel (1977) etc. find that Tobin’s ‘q’ theory is equivalent to neoclassical investment theory. Hayashi (1982) also shows that a firm’s optimal investment rate can be derived as a function of ‘q’ from a generalized model of a firm’s present value maximization problem.

Adjustment cost is a very important concept in determining the optimal amount of investment in a firm’s profit maximization problem (Chirinko, 1993). Adjustment cost commonly arises from installing new capital stock. Adjustment costs can be divided into external cost, which is related to the upward sloping supply curve of capital goods, and internal cost, an output loss that occurs during the process of installing new capital goods. Economists, in general, pay more attention to internal cost. Internal cost is related to the time needed to make the newly installed capital goods work properly and the cost of retraining employees. Adjustment costs increase at an increasing rate as the amount of newly installed capital goods increases. This convexity of adjustment cost is pivotal in determining optimal amount of investment goods. That is, if a firm invests more than the optimal level, then it faces adjustment costs that increase at an increasing rate, and if it invests less, then the forgone profit will be its opportunity cost.

The adjustment cost function that is included in a model for the optimal investment is a function of investment and capital stock, increasing in investment and decreasing in capital stock. Also it is, in general, described as a quadratic function of investment (Chirinko, 1993).

Hayashi (1982) also describes the adjustment cost function as a function of investment and capital stock, based on the assumption that the cost of installing new capital goods depends not on the absolute amount of the newly installed capital goods, but on the relative value of the investment compared to the size of capital stock. He also describes the adjustment cost function as homogeneous of degree one in both investment and capital stock as this is a crucial condition needed to make average ‘q’ and marginal ‘q’ equal.

Fazzari, Hubbard and Petersen (1988) and Gilchrist and Himmelberg (1995) also follow Hayashi (1982) when specifying their adjustment cost function in their empirical studies.

2.2. Review on Capital Market Imperfection

In the Neoclassical scheme where perfect information is assumed, a firm’s investment decision depends only on a firm’s investment opportunities (expected future profitability of capital) and market real rate of interest. That is, a firm’s investment decision is independent of purely financial factors. Modigliani and Miller (1961) provide a theoretical basis for the ‘neoclassical theory’ by arguing that, in perfect capital markets, a firm’s financial structure will not affect a firm’s market value. Under Neoclassical theory, there is no differences between internal financing and external financing in terms of costs.

However, if capital markets are imperfect, where there is information asymmetry, the cost of external financing is higher than that of internal financing. In this situation, net worth (internal funds) affects investment decisions.[3] Hence, the higher the net

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[3] In regard to capital market imperfection in investment problems, see the survey of Hubbard (1998).

worth, the greater the equilibrium capital stock, which leads to higher investment.

Therefore, if a firm faces high information costs, where the firm has a binding financial constraint, net worth affects investment decisions. On the other hand, if a firm is free from information costs, Neoclassical theory holds; thus, net worth does not affect investment decisions.

Many empirical studies show that uncollateralized external financing is more costly than internal financing and a decrease in net worth reduces investment for firms facing information costs, holding constant investment opportunities. Fazzari, Hubbard and Peterson (1988) investigate the role of net worth on firm investment using data from 421 manufacturing firms over 1970 ~ 1984. Their specification model includes cash flow variable as a proxy for net worth and classifies firms into three groups: low dividend, medium dividend, and high dividend payout groups.

The logic of using the ‘dividend to income ratio’ in their study is as follows; suppose the cost of external financing is higher than that of internal financing. If a firm faces promising investment opportunities, then it is likely that the firm will try to retain their earnings rather than paying dividends to their stockholders. Thus, under the financing constraints, if a firm retains all or most of its earnings then it is likely that its investment expenditure and cash flow have a positive relationship.

What they find is, in the low dividend pay-out group, the coefficient of cash flow was very high and significant, which supports the idea that financing constraints are likely to be important in many firms’ investment decisions.

In addition to Fazzari et al. (1988), many literatures investigate firm level panel data and show that a change in internal funds or net worth affects a firm’s investment decision by using various kinds of criteria to classify firms according to their level of exposure to financial constraints, and presents these as wide spread examples of capital market imperfection.[4]

On the other hand, Gilchrist and Himmelberg (1995) argues that many of these empirical results that show a positive relationship between net worth and firm investment are the result of not controlling for future investment opportunities. That is, they argue that Tobin's 'q', employed in many empirical models, does not perfectly control for future profit opportunities. To solve this problem, they develop 'fundamental q' and use this variable instead of Tobin's 'q'. Then they classify firms in terms of their exposure to capital market imperfections using the criteria such as size, dividend ratio, CP rating, and bond rating, and find that firms that have difficulty in accessing capital markets are more sensitive to fluctuations of cash flow in their investment decisions.

In addition to cash flow, regarding capital market imperfection, I now briefly review on the role of leverage and firm size on investment decisions.

Many literatures find that leverage is negatively related to firm investment. Myers (1977) argues that if we assume that the managers of the firms act in the shareholders interest, higher leveraged firms usually have less incentive to make optimal investment decisions compared to lower leveraged firms, because, in case of higher leveraged firms, greater parts of profits by those investments go to creditors. Eventually these suboptimal investment decisions by higher leveraged firms lower the firms' market value. McConnel and Servaes (1995) investigate using US firm level panel data for 1976 ~ 1988. They find that for the firms with high growth opportunities (high Tobin's q), leverage is negatively correlated with corporate value of a firm. However, for the firms with low growth opportunities (low Tobin's q), it is

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[4] For the criteria, Hosch et al. (1991) use affiliation to industry group or to banks, Devereux and Schiantarelli (1990) use firm size and age, Whited (1992) employs the presence of bond rating, and Onliner and Rudebusch (1992) use degree of shareholder concentration. Regarding the survey on the financial constraints and investment, please see Schiantarelli (1996)

positively correlated with corporate value. These findings imply that leverage induces underinvestment, and, hence a low corporate value, and also reduces overinvestment and, hence raises the corporate value of the firm. Lang et al. (1996) investigate the relationship between leverage and firm investment using US firm level data for 1970 ~ 1989. They find that leverage reduces investment and growth for the firms with low ‘q’. However, they do not find significant results for firms with high ‘q’. Aivazian (2005) studies the issue using Canadian firms for 1982 ~ 1999 and also finds that leverage is negatively related to investment and that this relationship is stronger for firms with low growth opportunities (low Tobin’s ‘q’)

The variable on firm size is used in many literatures as a proxy that indicates the level of financial constraints.[5] That is, smaller firms tend to be more sensitive in their relationship between the fluctuation of cash flow and investment than larger firms are. However, some literatures have conflicting results. Schiantarelli (1990) classifies UK firms according to the size of their capital stock and finds that larger firms are more sensitive to the relationship between cash flow and firm investment. Vogt (1994) classifies US firms by book value and finds that larger firms are more sensitive in the relationship between cash flow and investment than smaller firms. Kadapakkam (1998) classifies firms of six OECD countries including U.S. into large, medium and small size according to market value of equity, total assets and the size of sales. He finds that the large size group is the most sensitive in their relationship between cash flow and investment, and the small size group is lowest in sensitivity. Audretsch and Elston (2002) investigate the relationship between liquidity constraints and investment behavior using German firms for 1970 ~ 1986. They find that medium sized firms are the most sensitive in the relationship between liquidity constraints and

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[5] See Schiantarelli (1990), and Gilchrist & Himmelberg (1995)

investment behavior. They conclude that the policies of German government to support small and medium companies have contributed to easing the financial constraints problem.

2.3. Review on Exchange Rate and Prices

There are two extreme traditional theories concering the exchange rates and prices: the Purchasing Power Parity (PPP) theory and the Keynesian model (Dornbusch, 1987).

In the PPP model, under assumptions of product homogeneity and perfect competition, the ‘law of one price’ holds. This means that the price of a product, adjusted for tariff and transportation costs, should be equal in different locations. In the PPP model, the relative price is independent of exchange rates and exchange rates move to make the prices of the identical goods in different countries equal. This model is useful for analyzing commodity goods such as raw materials and agricultural products.

In the Keynesian model, wage levels are assumed to be fixed and the ratio of the markup rate over labor cost is also constant. Domestic and foreign goods are assumed to be differentiated. The ratio of the relative price level between domestic and foreign goods is expressed as $\lambda = P/eP^*$, where P and P^* represent the GDP deflator of domestic and foreign countries. In this model, exogenous exchange rate changes adjust the relative price level and, again, lead to the change in the demand and employment level within each country. Though the Keynesian model can explain more closely what happens in manufacturing industries, the assumption of a constant markup rate across countries is too strong.

Dornbusch (1987) argues that relative price adjustments to exchange rate changes can be explained more effectively by the industrial organizational approach. He assumes that a representative firm has linear technology and labor is the only input. His model focuses on a relatively short-term horizon. That is, changes in output and profitability do not affect the wage rate, and also they do not affect the number and location of firms in an industry. When the domestic currency appriciates, the labor costs in a foreign country in terms of its domestic currency become cheaper, which gives rise to the disturbance in the market equilibrium of that industry, and an adjustment occurs. The three factors that determine the adjustment process are ⅰ) whether the market is integrated or separated, ⅱ) the extent of substitution between domestic and foreign goods, and ⅲ) market structure.

Dornbusch explains the effect of exchange rate changes on prices using the Cournot model. He assumes that there is perfect substitution between foreign and domestic goods and oligopoly market structure. Also, variation in the markup in response to cost shocks is allowed. From the profit maximization condition of a representative domestic firm and a representative foreign firm, he derives reaction functions and the Cournot-Nash equilibrium. In this process, equilibrium quantities are allocated between representative domestic firm and representative foreign firm, and eventually an equilibrium price is also determined that is common to both foreign and domestic market. The strength of the effect of exchange rate change on the equilibrium price depends on the exchange rate elasticity of price which is determined by two components: share of imports in total sales and the inverse of the markup rate. If we apply the results above to the domestic market, the domestic price is more sensitive to movements in the exchange rate when the industry is competitive (i.e. markup rate is low) and the share of imports in domestic demand is large. Also, in export markets, changes in the exchange rate greatly influence the export prices in terms of the foreign currency, when markup rate is low and the share of exports in the foreign market is high.

Krugman (1987) introduces the concept ‘pricing to market (PTM)’ to explain the difference in the price across foreign markets when the exchange rate changes. In the early 1980s when the U.S. dollar was appreciating, the prices of many imports did not fall as far as the extent that the appreciation suggests. In some cases such as European luxury automobiles, prices actually rose in U.S. dollars during those periods.

PTM does not simply infer that the price change is too little compared to the extent of appreciation. PTM tries to explain what happens when a firm does not change the export price (in the currency of country ‘A’) in a foreign market ‘A’ relative to the level of appreciation, and as a result, its export price in market ‘A’ is much different than the price in the domestic market or other export markets in terms of local currency. That is, PTM focuses on the different responses in terms of price change in different markets to the exchange rate change.

According to Krugman, 35 to 40 percent of the real appreciation of the U.S. dollar during the 1980s has been absorbed by the exporters’ ‘pricing to market’. Evidences of PTM suggest that market structure plays an important role in international trade. Krugman argues that PTM cannot be explained by the traditional perfect competitive market model but can be explained by the imperfect competition model. PTM may be related with both imperfect competition and dynamics, and PTM behavior may vary by industry sector.

There are three strands of empirical literature regarding the relationship between exchange rate movement and product prices: the law of one price(LOP), exchange rate pass-through (‘ERPT’) and pricing to market (‘PTM’) (Goldberg and Knetter, 1997).

If the law of one price holds for some products, then we can consider this as evidences that world market is integrated. However, many estimation results reject the hypothesis of the law of one price (Logoff, 1996).

Exchange rate pass through ('ERPT') measures the percentage of changes in import prices measured in the local currency against a 1% change in the exchange rate. Researchers have focused on the relationship between the elasticity of demand and 'ERPT'. Kreinin (1977), using aggregate data, estimates that 'ERPT' to the US imports is 50 percent, while those to the imports of Germany, Japan and Italy are 60 percent, 70 percent and 100 percent respectively. He explains that incomplete 'ERPT' might occur because either adjustment is not made fully during the period of analysis or 'ERPT' is related to the size of markets. That is, the larger the imports market, the more it could affect the world price and so the lower the 'ERPT'. The studies of 'ERPT' during 1980s focus on U.S. market, and they show the consensus that the 'ERPT' to U.S. market is around 60 percent. As imperfect competition and strategic trade theory are developed, researchers begin to focus on industry level 'ERPT'. Feenstra (1989) analyzes some exports-cars, compact trucks and heavy motorcycles-from Japan to the U.S., and he finds that the range of 'ERPT' is from 63 percent for trucks to 100 percent for motorcycles and most of the pass-through occur in 2 to 3 quarters. Overall, 'ERPT' literature shows that most other countries show higher 'ERPT' than the U.S. and that the larger the economy size, the lower the 'ERPT'.

With regard to 'PTM', Marston (1990) investigates the PTM of Japanese monopolists in 17 industry sectors. The results show that for most goods, except small trucks and camera, there are significant evidences of PTM which range from 30 percent to 100 percent. Overall 'PTM' for transport, equipment and consumer goods industries show around 50 percent.

Gagnon and Kneter (1995) estimates that Japanese auto exporters show 70 percent of ‘PTM’ through markup adjustment.

Knetter (1993) argues that industry-specific factors are more important than country-specific factors in the ‘PTM’ issue. He investigates the extent of PTM across export destinations using the U.S., the U.K., German, and Japanese industry level data. The results are as follows: first, in terms of price discrimination, the importance of the destination market to the foreign exporters does not appear to matter. The U.S. market does not seem to receive different treatment than other markets. Second, the extent of ‘PTM’ does not seem to rely on the different characteristics of the source countries (i.e. exporter countries). Comparisons of source-countries’ behavior within common industries showed remarkably little evidence of differences in the behavior of the source-countries. Finally, when the data is pooled across industries for each source country, the hypothesis that industries show identical behavior within a certain country is rejected both in the U.S. and in the U.K.

Based on these results, Knetter argues that future research on ‘PTM’ should focus on industry heterogeneity rather than on source countries or on destination countries.

Page (1981) finds that Japanese exports show high ‘PTM’ compared to other industrialized countries such as the U.S., the U.K. and Germany. He argues that if exports’ currencies are used as invoice currencies, it might result in a downward bias against ‘PTM’. That is, exporters whose domestic currencies are not invoice currencies tend to change the price measured by domestic currency frequently to make their invoice price stable, which results in high ‘PTM’. According to Page (1981), 98 percent of U.S. exports are invoiced in U.S. dollars, while only 32 percent of Japanese exports are invoiced in Japanese Yen.

With regard to the factors that affect ‘PTM’, both country-specific and industry-specific factors may influence the pricing behavior of a firm; hence, more attention should be given to identify the relevant factors, which may differ by case.

Campa and Goldberg (1999) also propose that country specific institutional factors, such as local capital market condition and industry group activity, be examined in identifying the relationship between exchange rate changes and investment.

Chapter 3.

THEORETICAL MODEL

3.1. The maximization problem of a firm

For the theoretical model of this paper, I closely follow the examples of Campa and Goldberg (1999) and Nucci and Pozzolo (2001).

According to ‘q’ theory, a firm makes investment decisions subject to the firm’s cost adjustment function and traditional capital accumulation equation in order to maximize the expected present values of future profits.

A representative firm’s maximization problem can be expressed as follows:

$$V_t(K_{t-1}) = \max\{[\pi(K_t, e_t) - I_t - H(I_t, K_{t-1})] + \beta E_t[V_{t+1}(K_t)]\}$$

$$\text{s.t. } K_t = K_{t-1} + I_t,\ \ \delta\text{(depreciation rate)=0,} \qquad (1)$$

where, *π( )* is the profit function of the representative firm, K_t is the capital stock at time *t*, and e_t is the real exchange rate expressed as the ratio of domestic currency to foreign currency. I_t is investment at time *t*, and *H( )* is adjustment cost function which is increasing and convex in *I*. For simplicity, we assume that the depreciation rate is zero.

The first order condition of Eq (1) with respect to I_t is:

$$\frac{\partial \pi_t}{\partial K_t} - 1 - \frac{\partial H_t}{\partial I_t} + \frac{\partial H_t}{\partial K_{t-1}} + \beta \frac{\partial V_{t+1}}{\partial K_t} = 0 \qquad (2)$$

According to the envelope condition,

$$\frac{\partial V_t}{\partial K_{t-1}} = -\frac{\partial I_t}{\partial K_{t-1}} - \frac{\partial H_t}{\partial I_t} \cdot \frac{\partial I_t}{\partial K_{t-1}} - \frac{\partial H_t}{\partial K_{t-1}} = 1 + \frac{\partial H_t}{\partial I_t} - \frac{\partial H_t}{\partial K_{t-1}} = q_t \tag{3}$$

By substituting Eq (3) into Eq (2), and solving the equation for q_t, we have:

$$q_t = \frac{\partial \pi_t}{\partial K_t} + \beta \frac{\partial V_{t+1}}{\partial K_t} \tag{4}$$

To express q_t as the accumulated present value of marginal profits on investment at time *t*, I further develop Eq. (4) to derive equation (5):

$$q_t = E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{\partial \pi(K_{t+j}, e_{t+j})}{\partial K_{t+j}} \right], \tag{5}$$

which is the accumulated present value of marginal profits from investment at time *t*.

With regard to the adjustment cost function, previous research of the relationship between exchange rate changes and investment assume that it is only a function of investment. However, the tradition of investment literature considers it to be a function of both investment and capital stock, which implies that the cost of installing one unit of an investment good depends on the relative size of the investment compared to capital stock. Therefore, I follow Chirinko (1993), Hubbard (1998) and Gilchrist & Himmelberg (1998) etc in reference to the adjustment cost function.

$$H(I_t, K_{t-1}) = \frac{b}{2}\left(\frac{I_t}{K_{t-1}} - \lambda_t\right)^2 K_{t-1} \tag{6}$$

where λ_t is a technology shock. From Eq (3) and Eq (6) I obtain:

$$q_t = 1 + \frac{\partial H_t}{\partial I_t} - \frac{\partial H_t}{\partial K_{t-1}} = 1 + b(\frac{I_t}{K_{t-1}} - \lambda_t) - \frac{\partial H_t}{\partial K_{t-1}} \tag{7}$$

By rearranging (7), I obtain a positive relationship between I/K and q_t as follows:

$$\frac{I_t}{K_{t-1}} = \Psi(q_t) = \Psi\left(E_t \sum_{j=0}^{\infty} \beta^j \left[\frac{\partial \pi_{t+j}}{\partial K_{t+j}} \right] \right) \tag{8}$$

where $\Psi(\cdot)$ is increasing and concave in q_t. From Eq (1) ~ Eq (8), we know that a firm's investment decision is made so that the firm's expected present value of marginal profits from the investment equals its marginal costs of the investment.

3.2. Marginal Profit Function

To identify the effects of exchange rate changes on investment, a form of the marginal profit of capital function needs to be specified. In the following model, a representative firm's domestic market and foreign markets are all assumed to be imperfectly competitive. A firm's maximization problem for each time period in these markets is expressed as follows:

$$\pi(K_t, e_t) = \max_{p, p^*, L, L^*} x(p_t) p(e_t) + e_t x^*(p_t^*) p^*(e_t) - w_t L_t - e_t w_t^* L_t^*$$

$$\text{s.t.} \qquad x_t + x_t^* = F(K_t, L_t, L_t^*) \tag{9}$$

where $x(p)$ and $x^*(p^*)$ are the firm's domestic and foreign demand functions, p *and* p^* are prices in domestic and foreign markets, and wL and w^*L^* are expenditures for domestically produced and imported inputs, respectively. *F( )* represents a production function which is homogeneous of degree one.

After rewriting Eq (9) in the Lagrangian functional form, I derive first order conditions as follows:

$$\frac{\partial Z}{\partial p} = x'(p)p(e) + x(p) = -\lambda x'(p) \tag{10}$$

$$\frac{\partial Z}{\partial p^*} = e \cdot x^{*\prime}(p^*)p^*(e) + ex^*(p^*) = -\lambda x^{*\prime}(p^*) \tag{11}$$

$$\frac{\partial Z}{\partial L} = -w - \lambda \cdot \frac{\partial F}{\partial L} = 0 \tag{12}$$

$$\frac{\partial Z}{\partial L^*} = -ew^* - \lambda \frac{\partial F}{\partial L^*} = 0 \tag{13}$$

$$\frac{\partial Z}{\partial \lambda} = F(K, L, L^*) - x - x^* = 0 \tag{14}$$

From Eq (10) and Eq (11), we obtain the two equations below, where ε_x and ε_{x^*} are the price elasticity of domestic and foreign demand, respectively.

$$p(e) + \frac{x(p)}{x'(p)} = -\lambda = p(e) + p \cdot \frac{dp}{dx} \cdot \frac{x}{p} = p(e)(1 + \frac{1}{\varepsilon_x}) \tag{15}$$

$$ep^*(e) + e \cdot \frac{x^*(p^*)}{x^{*\prime}(p^*)} = -\lambda = ep^*(e) + ep^*(e) \cdot \frac{dp^*}{dx^*} \cdot \frac{x^*}{p^*} = ep^*(e)(1 + \frac{1}{\varepsilon_{x^*}}) \tag{16}$$

Again, from Eq (15) and Eq (16), I obtain:

$$p(e) \cdot (1 + \frac{1}{\varepsilon_x}) = ep^* \cdot (e) \cdot (1 + \frac{1}{\varepsilon_{x^*}}) = -\lambda \tag{17}$$

By combining Eq (12), Eq (13) and Eq (17), I further obtain:

$$w = p(e) \cdot (1 + \frac{1}{\varepsilon_x}) \cdot \frac{\partial F}{\partial L} \tag{18}$$

$$ew^* = p(e) \cdot (1 + \frac{1}{\varepsilon_x}) \cdot \frac{\partial F}{\partial L^*} \tag{19}$$

The properties of our production function with ‘homogeneous of degree 1’ from the constraint in Eq. (9) give:

$$Y = \frac{\partial F}{\partial K} \cdot K + \frac{\partial F}{\partial L} \cdot L + \frac{\partial F}{\partial L^*} \cdot L^*$$

$$\Rightarrow \quad \frac{\partial F}{\partial K} = \frac{1}{K}(Y - \frac{\partial F}{\partial L} \cdot L - \frac{\partial F}{\partial L^*} \cdot L^*) \tag{20}$$

Now, by substituting (20) into the envelope condition in Eq (9) I obtain:

$$\frac{\partial Z}{\partial K} = \frac{\partial \pi}{\partial K} = -\lambda \cdot \frac{\partial F}{\partial K} = p(1 + \frac{1}{\varepsilon_x}) \cdot \frac{\partial F}{\partial K}$$

$$= p(1 + \frac{1}{\varepsilon_x}) \frac{1}{K} (Y - \frac{\partial F}{\partial L} L - \frac{\partial F}{\partial L^*} L^*)$$

$$= \frac{1}{K} \left[px(1 + \frac{1}{\varepsilon_x}) + ep^* x^* (1 + \frac{1}{\varepsilon_x^*}) - wL - ew^* L^* \right]$$

$$= \frac{1}{K} \left[px \frac{1}{\mu} + ep^* x^* \frac{1}{\mu^*} - wL - ew^* L^* \right], \tag{21}$$

where $\mu = \frac{p}{MC} = \frac{\varepsilon_x}{\varepsilon_x + 1}$ and $\mu^* = \frac{p^*}{MC} = \frac{\varepsilon_{x^*}}{\varepsilon_{x^*} + 1}$ are the markup rates of the representative firm in the domestic market and foreign markets, respectively.

3.3. Identifying Three Channels

Now, I assume that the exchange rate is the only source of uncertainty for this firm and that this firm admits the variations of exchange rate as permanent movements in exchange rates.

Under those assumptions, Eq (8) becomes

$$\frac{I_t}{K_{t-1}} = \Psi(q_t) = \Psi\left(\frac{1}{1-\beta}\frac{\partial \pi_t}{\partial K_t}\right) \tag{22}$$

I differentiate Eq (22) with respect to exchange rate which gives:

$$\frac{\partial (I_t / K_{t-1})}{\partial e_t} = \Psi_q(q_t)\cdot\frac{1}{1-\beta}\cdot\frac{\partial^2 \pi}{\partial K \partial e} \tag{23}$$

From Eq (21) and Eq (23), the following equation is derived.[6]

$$\begin{aligned}\frac{\partial (I/K)}{\partial e} = \Psi_q(q)\frac{1}{1-\beta}\frac{1}{K}\Bigg[& \frac{dp}{de}x(1+\varepsilon_x^{-1}) + p\frac{dx}{dp}\frac{dp}{de}(1+\varepsilon_x^{-1}) - px\frac{d\varepsilon_x}{de}\frac{1}{\varepsilon_x^2} \\ & + p^*x^*(1+\varepsilon_{x^*}^{-1}) + \frac{dp^*}{de}ex^*(1+\varepsilon_{x^*}^{-1}) + ep^*\frac{dx^*}{dp^*}\frac{dp^*}{de}(1+\varepsilon_{x^*}^{-1}) \\ & - ep^*x^*\frac{d\varepsilon_{x^*}}{de}\frac{1}{\varepsilon_{x^*}^2} - w^*L^* - eL^*\frac{dw^*}{de}\Bigg]\end{aligned} \tag{24}$$

To simplify Eq (24), I introduce several elasticity concepts where $\varepsilon_{\mu,e}$ is the exchange rate elasticity of markup, $\varepsilon_{p,e}$ is the exchange rate elasticity of price and $\varepsilon_{w^*,e}$ is the exchange rate elasticity of imported input price.

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[6] For convenience, I drop all the time subscripts.

$$\varepsilon_{\mu,e} = \frac{d\mu}{de} \cdot \frac{e}{\mu} = \frac{d\varepsilon_x}{de} \cdot \frac{e}{\varepsilon_x} \cdot \frac{1}{\varepsilon_x + 1}$$

$$\varepsilon_{p,e} = \frac{dp}{de} \cdot \frac{e}{p} \quad , \qquad \varepsilon_{w^*,e} = \frac{dw^*}{de} \cdot \frac{e}{w^*}$$

In addition, I introduce following expressions:

- Domestic sales : $px = S(1-\chi)$, S : sales, χ : export ratio
- Export sales : $ep^* x^* = S \cdot \chi$
- Imported input value : $ew^* L^* = \alpha \cdot \frac{S}{\bar{\mu}}$

Where α : imported input to *TVC* ratio

TVC : Total Variable Costs

$\bar{\mu}$: markup rate expressed as *TS/TVC*.

Using the above expressions, I simplify Eq (24) as follows;

$$\frac{\partial (I/K)}{\partial e} = \Psi_q(q) \cdot \frac{1}{1-\beta} \cdot \frac{S}{e \cdot K} \cdot$$

$$\left\{ \frac{\chi}{\mu^*}\left[1 + \varepsilon_{p^*,e}(1+\varepsilon_{x^*}) - \varepsilon_{\mu^*,e}\right] + \frac{1-\chi}{\mu}\left[\varepsilon_{p,e}(1+\varepsilon_x) - \varepsilon_{\mu,e}\right] - \frac{\alpha}{\bar{\mu}}(1+\varepsilon_{w^*,e}) \right\} \qquad (25)$$

3.4. Three Channels

Eq (25) identifies three channels through which the effects of exchange rate changes influence firm investment. The three channels are the export channel, the domestic sales channel, and the imported input channel.

The first channel works through export sales. Under the appreciation[7] of domestic currency, exports prices in terms of foreign currency are forced to increase through the process of exchange rate pass-through (ERPT).[8] The size of the exchange rate pass-through depends on the exchange rate elasticity of export price in terms of foreign currency, $\varepsilon_{p^*,e}$, which ranges from zero to one. The increases in export prices affect foreign demand through the price elasticity of demand, ε_{x^*}, the sign of which is negative. A firm's markup rate is also affected by changes in the exchange rate through exchange rate pass-through. For example, if an export good has 60 percent of exchange rate pass-through, then 40 percent of exchange rate changes are absorbed through the decrease in markup rate, under the assumption of fixed marginal cost (Goldberg and Knetter, 1997). Hence, the exchange rate elasticity of markup rate, $\varepsilon_{\mu^*,e}$, will be negative, and ranges from minus one to zero. After all, the role of the export sales channel on the relationship between exchange rate changes and firm investment depends on these three types of elasticity. As long as the absolute value of the price elasticity of foreign demand, ε_{x^*}, is greater than one, and the product of exchange rate elasticity of export price and one plus price elastic of foreign demand, $\varepsilon_{p^*,e}(1+ \varepsilon_{x^*})$, is

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[7] In deriving the theoretical model, exchange rate is expressed as the ratio of domestic currency to foreign currency. However, from now on, I will use exchange rate, e, as the ratio of foreign currency to domestic currency, which is consistent with the real effective exchange rate data used in the paper.

[8] 'ERPT' means "the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing countries."(Goldberg and Knetter, 1997)

greater than one minus exchange rate elasticity of markup rate in the foreign market, $1- \varepsilon_{\mu^*,e}$, then there will be negative relationship between exchange rate changes and firm investment through the export channel. Also, the higher the export ratio, the exchange rate pass-through, and the absolute value of price elastic of foreign demand, the more sensitive the relationship is between exchange rate changes and firm investment through the export sales channel.

The influence of exchange rate changes on firm investment also works through the domestic sales channel. When the domestic currency appreciates, the import prices in terms of domestic currency will decrease, and it is likely to lower the price of domestic goods competing with imports. The size of this decrease in price depends on the exchange rate elasticity of domestic price, which is negative and ranges from negative one to zero. Again, this price adjustment will force the markup rate of a firm to decrease with the assumption of fixed marginal cost. Therefore, exchange rate elasticity of markup rate in the domestic market is negative in sign and ranges from minus one to zero. Hence, as long as the absolute value of price elasticity of the domestic demand is greater than one, there will be a positive relationship between exchange rate changes and firm investment through the domestic sales channel. Also, this relationship will be more sensitive if a firm depends more on domestic market, faces a large absolute value of exchange rate elasticity of domestic price, and, has large absolute value of price elasticity of domestic demand.

The last channel is the imported input channel. Under the appreciation of domestic currency, the prices of imported inputs are expected to decrease, and the size of these price decreases depend on the exchange rate elasticity of imported input price in terms of the foreign currency. Again, the value of the exchange rate elasticity of imported input prices in terms of foreign currency depends on the size of the exchange rate pass-through. If a foreign producer of imported inputs passes through the change in exchange rate by 100 percent, then the elasticity will be zero. However, if it does not pass through at all (i.e. ERPT = 0), then the elasticity will be one. Therefore the exchange rate elasticity of imported input price will be positive and range from zero to one. The higher the elasticity, $\varepsilon_{w*,e}$, and, the larger the imported input ratio, α, the larger the effect of exchange rate changes on firm investment through the imported input channel.

3.5. Market Power

A firm's market power plays an important role in all three of the channels above. From Eq (25), we know that markup rate is inversely related to the effects of exchange rate changes on firm investment. That is, as a markup rate decreases, implying that a firm faces a more competitive environment, it amplifies the effects of exchange rate changes on firm investment in all three channels.

The markup rate is also related to the elasticity concepts illustrated in Eq (25). We know that as the markup rate decreases, the absolute value of price elasticity of demand, ε_{x*} or ε_x, increases.[9] Also, as Dornbusch (1987) argues, the lower the markup rate, the higher the exchange rate pass-through. In other words, when the markup rate is low, the absolute value of the exchange rate elasticity of price both in terms of foreign currency and domestic currency, $\varepsilon_{p*,e}$ or $\varepsilon_{p,e}$, is high. Furthermore, if the exchange rate elasticity of exports price in terms of foreign currency, $\varepsilon_{p*,e}$, is high, then the absolute value of exchange rate elasticity of markup rate in the foreign

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[9] From Lerner index of monopoly power, we can derive $\mu = \frac{p}{MC} = \frac{\varepsilon_x}{\varepsilon_x + 1}$

market, $\varepsilon_{\mu*,e}$, is low. Lastly, if the absolute value of exchange rate elasticity of price in terms of the domestic currency, $\varepsilon_{p,e}$, is high, then the absolute value of the exchange rate elasticity of markup rate in the domestic market, $\varepsilon_{\mu,e}$, is also high.

All factors listed above work toward amplifying the existing effect of exchange rate changes on firm investment through the three channels when markup rate is low.

Chapter 4.

DATA

4.1. Data Sources

To investigate the effects of exchange rate changes on business investment, I use firm level financial statement data of U.S manufacturing firms, real effective exchange rates (REER) and U.S. Input-output tables, from several data sources.

Firm Level Financial Statement Data

First, I use firm level financial statement data from the ‘COMPUSTAT North America’ database, provided by WRDS.[10] This database provides data of firms which are publicly traded in U.S. stock market. For this study, I only extract the data of U.S manufacturing firms.

One important variable in my study is the ‘export to sales ratio’ which is not available from the ‘COMPUSTAT North America’ database. Fortunately, the ‘COMPUSTAT segment’ database, a supplementary database to ‘COMPUSTAT North America’, contains ‘export sales’ item. However, only approximately 30 percent of all observations report valid export sales including small number of observations with “zero” exports sales. Thus the remaining 70 percent of observations have missing values for the export sales, which results in a huge data loss.

While, to check the sample selection problem, I compare the means and variances of the two groups, one with valid (i.e. positive or zero) export sales and the other with

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[10] Wharton Research Data Services

missing export sales values. The F-test results show that the two groups are different in means and variances in key variables used in the study.

The Small Sample and The Large Sample

To solve the data loss problem caused by observations with missing export sales and to deal with a possible sample selection problem, I create another dataset, called the ‘large sample’ in the paper. Thus I use two datasets for my study, the ‘small sample’ and the ‘large sample’. The small sample and the large sample are distinguished by what kinds of data are used for the ‘export ratio’.

The small sample uses firm level export sales and total sales data that are available from ‘COMPUSTAT North America’ and ‘COMPUSTAT Segment’. That is, I merge ‘COMPUSTAT North America’ which contains general firm level financial statement data, with ‘COMPUSTAT Segment’ data which contains export sales item. I obtain the export ratio by dividing ‘export sales’ by ‘sales’ of each firm. Even though ‘small sample’ has problems on huge data loss and possible sample selection, it has the advantage of using firm level data to obtain export ratio.

On the other hand, the large sample uses industry level exports to shipment ratio[11] as a proxy for each firm’s export ratio. In this way, I am able to use all the observations including those with missing export sales values and avoid possible sample selection problem. However, using the large sample has a limitation in that the ‘export ratio’ is not calculated from firm level financial statement data but a proxy.

By analyzing the two samples and comparing their empirical results, I can present more reliable outputs for this study. The ‘small sample’ is composed of 881 firms and

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[11] I use industry level export to shipment ratio on the website of Federal Reserve Bank of New York, http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html.

6,142 observations for the period 1998 ~ 2007, while the 'large' sample includes 2,653 firms and 16,951 observations for the period 1999~2007.[12] One thing to note about the small sample is that only around 3,800 of the 6,142 observations have valid export sales values. I keep observations with missing export sales values of firms that have at least two observations with valid export sales. This is done since GMM for dynamic panel data, an econometric method used in my study, requires lagged variables as instruments. For both the small sample and the large sample, older observations from 1993 are also used as instruments for this study. My datasets are unbalanced panel data sets and include both active and inactive firms as of 2007.

Real Effective Exchange Rate (REER)

For the real effective exchange rate (REER), I use 'industry specific export REER' and 'aggregate import REER', both of which are calculated by Goldberg (2004).[13] 'Industry specific export REER' is calculated with respect to 20 manufacturing sectors (three digit NAICS[14]).

Until now, previous literatures on this subject have only used aggregate REER for both in terms of exports and imports. However, considering that the trade structure and the distribution of trade counterparts may vary across industries, it is natural to think that one might obtain more accurate results regarding the effects of exchange rate change on firms' behavior by using industry specific REER. Goldberg (2004)

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[12] BEA provides industry level shipment data with NAICS from 1998, and the lagged value of export ratio is included in my model. Therefore the period for large sample starts with 1999.

[13] I also obtain the exchange rate data from http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html

[14] North American Industry Classification System

shows that using industry specific REER identifies the effects of dollar movements on profits effect more precisely compared to the case using aggregate REER.

While using industry specific REER with respect to exports channel, I use aggregate import REER with respect to imported inputs channel since imported inputs that are used to produce a certain goods in an industry span various industries.

Firm Level Ratio of Imported Input to Total Variable Cost

The financial statement data does not directly provide the ratio of imported inputs to total variable costs (TVC). Therefore, following the methodology of Nucci and Pozzolo (2001), I estimate the data by multiplying the ratio of imported inputs to total intermediate inputs, which is industry specific, by the ratio of total intermediate input to TVC ratio, which is firm specific information.

To derive the industry specific ratio of imported inputs to total intermediate inputs, I use the “import matrix” and the “use table”[15] provided by the U.S. Bureau of Economic Analysis (BEA). The method I use is as follows: I obtain the total amount of imported inputs that are attributed to each industry, and divide those numbers by the corresponding total intermediate inputs which are available from the ‘use table’. Our problem here is that the BEA does not release the ‘import matrix’ for the period 1998 - 2001. That is, it provides only the tables for 1997 and 2002~2006. On the other hand, ‘Use Table’ is available for the period 1997-2006. Thus I estimate imported input values of each industry for 1998-2001 using the ‘import matrix’ of 1997 and 2002 and the ‘use table’ of each year, based on the assumption that the portions of imported input that are assigned to each industry move smoothly between 1997 and

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[15] “Imports matrix” shows the value of imported input that are attributed to each commodity or industry. “use table” says about intermediate input that are attributed to each commodity or industry.

2002. Then, I divide the estimated imported input of each industry by the corresponding total intermediate input that are available from the ‘use tables’ of those years, and thus, obtain the industry specific ‘imported inputs to total intermediate inputs ratio’. It is classified by three digit NAICS and calculated for the period 1997 ~ 2006. I, then, multiply the ‘imported inputs to total intermediate inputs ratio’ by firm level ‘ratio of total intermediate inputs to total variable costs’, available from firms’ financial statement data. Thus I obtain firm level ‘ratio of imported inputs to TVC’ .

Data Management

Individuals that have less than three observations are deleted. If there are missing values for investment (CAPX), net fixed asset (PPENT), sale (SALE) or capital stock (K), those observations are deleted. Observations with zero or negative values in any of the variables on investment, net fixed asset, sale or capital stock are also deleted. Observations that have negative values for cost of goods sold (COGS) or selling, general and administrative expense (XSGA) are deleted. If markup rate shows higher than one, then those observations are deleted. To control for the events such as M&A’s and breakups, I delete observations where growth rate of capital stock is either greater than 2 or less than -0.7. I also exclude outliers in key variables from the data. I exclude 1percent on each side of key variables, the change in investment to capital ratio ($\Delta(I/K)$), and the change in sales to capital ratio ($\Delta(S/K)$). I delete 2 percent from left tail of markup (MKUP) and 1percent from the right tail of leverage (LT/AT). For the ratio of cash flow to capital, I exclude 2 percent from each side considering its longer tails in the distribution.

4.2. Description of Key Variables

Table 4-1 describes the definition of key variables in my empirical study.

Table 4-1. Description of key variables

Abbreviation	**Description [Mnemonic of COMPUSTAT]**
Firm-level variables (from COMPUSTAT North America or COMPUSTAT Segment)	
CAPX	Capital expenditure on the cash flow statement [CAPX]
PPENT	Property, plant and equipment (net tangible fixed asset) [PPENT]
SALE	Net sales on the income statement [SALE]
DA	Depreciation and Amortization [DA]
K	Capital stock at the beginning of the period [PPENT – CAPX + DA]
I/K	Investment to capital stock ratio [CAPX/K]
S/K	Sales to capital stock ratio [SALE/K]
COGS	Cost of goods sold on the income statement [COGS]
XSGA	Selling, general and administrative expense on the income statement [XSGA]
INVCH	Inventory change on the cash flow statement [INVCH]
MKUP	Markup rate [(SALE-INVCH-COGS-XSGA)/(SALE-INVCH)][16]
AT	Assets – Total [AT]
LT	Liabilities – Total [LT]
DR	The ratio of Total Debt to Total Assets [LT/AT]
CF	Earnings before interest and taxes [EBIT]
CF/K	Cash flow to capital stock ratio [EBIT/K]
EXPORT	Export sales [EXPORT] – for the small sample
XRATIO	Export to sales ratio [EXPORT/SALE] – for the small sample
IIRATIO	The ratio of intermediate input to total variable cost [COGS/(COGS+XSGA)]
MIRATIO	The ratio of imported input to total variable cost [IIRATIO*MI_RATIO]
Industry level data or aggregate data (from BEA or N.Y. Fed)	
MI_RATIO	The ratio of imported input to total intermediate input, industry level
XRATIO	The ratio of exports to shipment, industry level – for the large sample
XER	Industry specific real effective exchange rate(REER) in terms of export
AMER	Aggregate REER in terms of import

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[16] When inventory increases, ‘INVCH’ is expressed with negative sign in COMPUSTAT

In regard to the definition of ‘investment’ and ‘capital stock’, I follow the example of Love (2003), where capital expenditure is used as ‘investment’ and capital stock (K_{it}) is measured as the capital stock at the beginning of time t. The markup rate, which stands for a firm’s market power is calculated based on the methods of Nucci and Pozzolo (2001) who also followed the suggestion of Domowitz et al (1989). The definition of ‘XRATIO’ is slightly different in small sample and large sample. In the small sample it means the ‘ratio of export to sales’ from firm level financial statement data, while in the large sample, it indicates the ‘export to shipment ratio’ which is classified by three digit NAICS.

4.3. Data Description

Real Effective Exchange Rate

Figure 4-1 shows the export REER of sectors 325, 333, 334, which have the largest portion of the observation, and aggregate import REER since 1990. All of them are quarterly indices (1990:1=100). Though the trends are similar across these various REERs, they are slightly different.[17]

U.S. REER, which was stable from 1990 to 1995, began to appreciate in 1996 and peaked in 2002. After 2002, it depreciated until 2007, when, in the 4th quarter of 2007, the REER returned to the levels of mid-1990’s. U.S dollar appreciated by more than 25% in the six year period from the 1st quarter of 1996 to the 1st quarter of 2002 (1996:1-2002:1), and then depreciated by approximately 20% in six years from the 2nd quarter of 1996 to the last quarter of 2007 (1996:2-2007:4).

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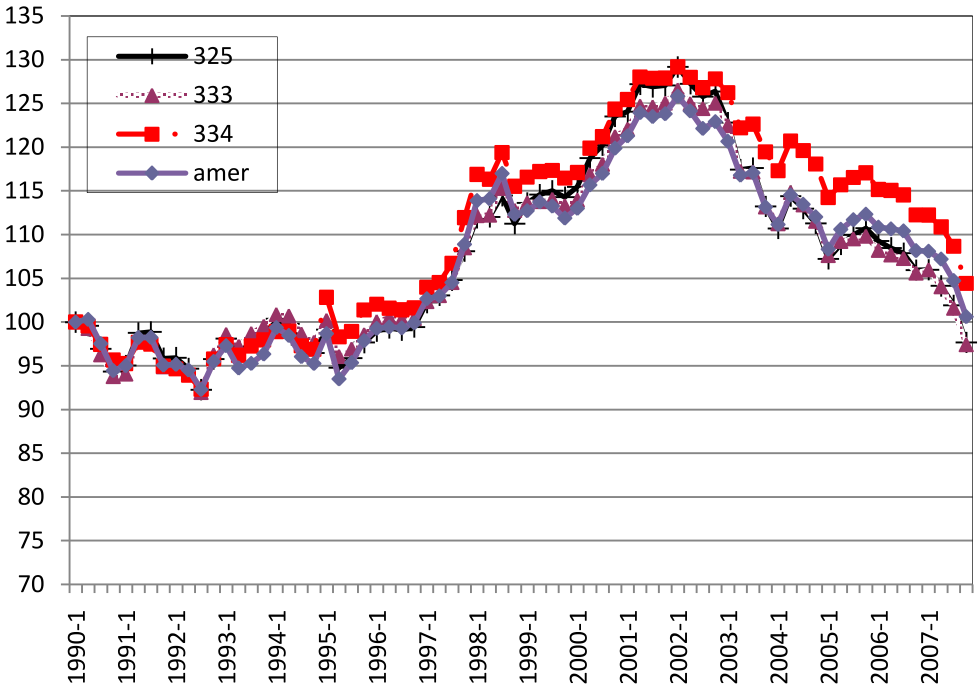
[17] The REERs calculated by Goldberg (2004) are quarterly data, while I use annual data for my study. Therefore I use the data of 4th quarter as the REER of the year.

Figure 4-1. Comparison of U.S. Industry Specific Export REER



Note : Data are from N.Y. FRB.
http://www.newyorkfed.org/research/global_economy/industry_specific_exrates.html

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Description of the Large Sample

Tables 4-2 through 4-6 show the descriptive statistics of the large sample. The distribution of the large sample across industry sector shows that ‘Computer and electronic products’ (three digit NAICS: 334) comprises 30.6 percent of the total observations, followed by ‘Chemical products’ (325) which is 13.1 percent and ‘Machinery’ (333) which is 9.7 percent. Table 4-3 shows exports ratio (XRATIO) and imported inputs ratio (MIRATIO) across industries. The sectors that have high export ratios are ‘Computer and electronic products (334)’, followed by ‘Machinery (333)’ and ‘Electrical Equipment (335)’. On the other hand, ‘Petroleum and coal products (324)’, ‘Primary metal (15.7)’ and ‘Transportation equipment (336)’ are sectors that are highly dependent on imported inputs. When comparing export ratio and imported input ratio across industries, ‘Computer and electronic products (334)’ has the largest export ratio relative to imported input ratio, implying that the sector is likely to benefit the most in a period of depreciation. While, ‘Petroleum and coal products (324)’, which has highest imported input ratio relative to export ratio, is expected to benefit the most from exchange rate appreciation and also suffer the most under the exchange rate depreciation.

Table 4-2. Summary Statistics for the Large Sample : 1999 ~ 2007

Obs : 16,951	Mean	Median	S.D.	Min	Max
$\Delta(I_{it}/K_{it})$	-0.013	-0.002	0.281	-2.383	2.016
$\Delta(S_{it}/K_{it})$	0.289	0.167	4.020	-37.015	31.980
I_{it}/K_{it}	0.244	0.166	0.266	0.000	4.035
S_{it}/K_{it}	8.085	5.374	9.160	0.006	186.023
SALE	1,992.50	198.07	10,154.16	0.01	358,600.00
K	581.26	34.92	3,541.21	0.01	117,732.00
XRATIO	0.229	0.204	0.126	0.027	0.453
MIRATIO	0.102	0.095	0.057	0.000	0.577
MKUP	0.003	0.102	0.452	-5.121	0.785
CF_{it}/K_{it}	-0.030	0.256	2.054	-18.121	6.076
LT/AT	0.521	0.480	0.344	0.015	3.124

Note : Data are from COMPUSTAT North America and Bureau of Economic Analysis. Variables are defined in the ‘Description of Key variables’. XRATIO, MIRATIO, MKUP, CF_{it}/K_{it}, and LT/AT are for 1998~2006. Δ(I/K), changes in the ratio of investment to capital (beginning of the period); Δ(S/K), changes in the ratio of sales to capital; SALE and K, in million U.S. dollar units; K, beginning of the period capital stock; XRATIO, the ratio of export to shipment by industries; MIRATIO, the ratio of imported input to total variable cost, CF/K; the ratio of cash flow to capital stock, LT/AT, the ratio of Liability total to Asset Total.

Table 4-4 shows the trends in export ratio and imported input ratio during the period from 1998 to 2006. We can see that both export ratio and imported input ratio increased for the industries as a whole during 1998 ~ 2006, while export ratio grew faster than imported input ratio.

Table 4-5 shows the mean values of key variables across industries. ‘Petroleum and coal products (324)' has the largest average firm size in terms of the sales, followed by 'Paper products (322)' and 'Textile product mills (314). 'Beverage and tobacco (312)' has the highest markup rate. 'Plastic and rubber (326)', 'Transportation equipment (336) and 'Paper products (322)' have the highest leverages, while 'Leather manufacturing (316)' has the highest Cash flow ratio (CF/K).

Table 4-3. Mean Values by Industries in the Large Sample (XRATIO and MIRATIO) : 1998 ~ 2006

naics3	industry	# of Obs	# of Firms	XRATIO (b)	MIRATIO (a)	b-a
311	Food mfg	731	113	4.5	4.5	0.0
312	Beverage and tobacco	240	37	4.5	3.6	0.9
313	Textile mills	136	23	9.7	9.9	-0.3
314	Textile product mills	45	6	9.8	9.3	0.5
315	Apparel mfg	412	66	12.6	7.3	5.3
316	Leather manufacturing	202	30	12.6	6.9	5.7
321	Wood products	179	28	4.3	10.2	-5.9
322	Paper products	362	56	9.0	10.0	-1.0
323	Printing	235	37	5.0	7.2	-2.2
324	Petroleum and coal products	229	40	3.2	42.7	-39.5
325	Chemical products	2,226	363	18.1	6.8	11.3
326	Plastic and rubber	523	78	9.2	9.0	0.2
327	Nonmetalic mineral products	228	36	6.7	6.8	-0.1
331	Primary metal	506	80	13.1	15.7	-2.6
332	Fabricated metal products	698	106	7.9	8.2	-0.3
333	Machinery	1,651	249	28.8	10.2	18.6
334	Computer and electronic products	5,178	814	38.5	11.6	26.9
335	Electrical equipment	705	104	22.0	9.9	12.1
336	Transportation equipment	978	142	19.8	15.1	4.7
337	Furniture	256	37	3.2	8.6	-5.4
339	Miscellaneous manufacturing	1,231	208	20.9	7.2	13.8
	Total	16,951	2,653	22.9	10.2	12.7

Note : Data are from COMPUSTAT North America and Bureau of Economic Analysis. The number of observations and firms are for 1999~2007. The units for 'EXRATIO', 'MIRATIO' and 'b-a' are percentage and percentage point respectively. XARATIO and MIRATIO are included in the model as lagged values. Therefore, this table shows mean values for 1998 ~ 2006.

Table 4-4. Mean Values by Years in the Large Sample (XRATIO and MIRATIO) : 1998 ~ 2006

Year	1998	1999	2000	2001	2002	2003	2004	2005	2006
# of Obs	1,894	2,025	2,108	2,034	2,019	1,966	1,886	1,791	1,664
XRATIO	19.6	19.8	22.0	22.2	22.4	23.2	25.3	25.5	28.3
MIRATIO	9.6	9.5	9.9	9.4	9.7	9.9	11.0	11.3	11.9

Note : Data are from COMPUSTAT North America and Bureau of Economic Analysis. The units for 'EXRATIO' and 'MIRATIO are percentages.

Table 4-5. Mean (Median) Values by Industries in the Large Sample (key variables) : 1999 ~ 2007

naics3	I/K	S/K	SALE	MKUP	DT/AT	CF/K
311	0.181	5.29	438.8	0.104	0.571	0.255
312	0.160	4.89	343.4	0.153	0.601	0.285
313	0.126	5.47	287.8	0.087	0.599	0.126
314	0.150	4.68	985.8	0.107	0.620	0.296
315	0.249	16.40	403.3	0.104	0.468	0.738
316	0.296	17.37	250.8	0.097	0.364	0.861
321	0.133	6.55	337.0	0.096	0.544	0.164
322	0.131	2.90	1,000.5	0.129	0.638	0.124
323	0.186	5.68	297.3	0.116	0.529	0.293
324	0.186	5.07	4,466.8	0.085	0.614	0.195
325	0.224	6.40	266.6	0.114	0.522	0.221
326	0.171	5.00	279.8	0.106	0.687	0.208
327	0.201	4.40	397.5	0.117	0.494	0.217
331	0.132	3.96	683.3	0.090	0.619	0.136
332	0.175	5.64	241.4	0.121	0.560	0.324
333	0.220	7.93	185.2	0.101	0.485	0.329
334	0.319	10.32	86.0	0.074	0.341	0.149
335	0.202	7.83	160.0	0.104	0.467	0.339
336	0.223	7.55	558.3	0.103	0.639	0.334
337	0.198	7.89	446.5	0.115	0.457	0.468
339	0.306	8.77	74.9	0.119	0.377	0.400

Note : Data are from COMPUSTAT North America. I/K and S/K are mean values and SALE, MKUP, DT/AT and CF/K are median values. MKUP, DT/AT and CF/K are for 1998~2006; SALE, current prices in million U.S. dollar units.

Table 4-6 shows the trends of key variables for the period 1999 ~ 2007. Overall, mean values of key variables decreased from 2001 to 2003 and then recovered from 2004, which reflects the economic downturn in 2001 and 2002.[18]

Table 4-6. Mean (median) Values by Years in the Large Sample (key variables) : 1999 ~ 2007

year	I/K	S/K	SALE	MKUP	LT/AT	CF/K
1999	0.276	7.36	151.3	0.109	0.517	0.261
2000	0.284	7.61	167.0	0.115	0.497	0.280
2001	0.231	6.97	161.8	0.080	0.499	0.161
2002	0.198	7.15	161.1	0.082	0.478	0.172
2003	0.192	7.59	180.1	0.087	0.468	0.183
2004	0.237	8.46	214.0	0.112	0.455	0.303
2005	0.263	9.31	254.9	0.107	0.450	0.352
2006	0.269	9.87	286.4	0.115	0.447	0.393
2007	0.256	9.27	350.7	.	.	.

Note : Data are from COMPUSTAT North America. The data period for this study on the large sample is 1999 ~ 2007, where lagged values of MKUP, DT/AT and CF/K are used. I/K and S/K are mean values; SALE, MKUP, DT/AT and CF/K are median values; SALE, current prices in million U.S. dollar units.

Description of the Small Sample

Tables 4-7 through 4-11 show the statistics of key variables of the small sample. The descriptive statistics of the small sample show slightly different results from those of the large sample. In the small sample, ‘Computer and electronic products’ (NAICS: 334), ‘Machinery (333)’ and ‘Chemical products (325)’ account for the largest portions in the sample; these three industries occupy 61.7 percent of the small sample. Export ratios across industries and over time are shown in tables 4-8 and 4-9, respectively. ‘Computer and electronic products (334)’ has the highest export ratio

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[18] U.S. real GDP growth rate in 2001 and 2002 showed 0.8% and 1.6%, the lowest growth rate during 1998 ~ 2007.

followed by ‘Machinery (333)’ and ‘Electrical Equipment (335); the same order as in the large sample. Also, the sectors that have the highest imported input ratio are the same as the large sample, ‘Petroleum and coal products (324)’, ‘Primary metal (331)’ and ‘Transportation equipment (336)’.

Table 4-7. Summary Statistics for the Small Sample : 1998 ~ 2007

Obs : 6,142	Mean	Median	S.D.	Min.	Max.
$\Delta(I_{it}/K_{it})$	-0.016	-0.002	0.278	-2.218	1.852
$\Delta(S_{it}/K_{it})$	0.118	0.133	3.826	-36.282	28.287
I_{it}/K_{it}	0.253	0.176	0.256	0.001	4.035
S_{it}/K_{it}	8.076	5.558	7.850	0.330	80.557
SALE	1,386.64	152.68	5,452.03	0.23	101,407.00
K	366.66	26.19	1,493.71	0.02	22,541.00
XRATIO	0.203	0.139	0.189	0.000	1.000
MIRATIO	0.106	0.103	0.042	0.000	0.566
MKUP	0.065	0.109	0.254	-3.136	0.609
CF_{it}/K_{it}	0.217	0.289	1.613	-13.198	6.134
LT/AT	0.464	0.435	0.277	0.020	2.344

Note : Data are from COMPUSTAT North America. Variables are defined in the ‘Description of Key variables’. XRATIO, MIRATIO, MKUP, CF_{it}/K_{it}, and LT/AT are for 1997~2006. Δ(I/K), changes in the ratio of investment to capital(beginning of the period); Δ(S/K), changes in the ratio of sales to capital; SALE and K, in million U.S. dollar units; K, beginning of the period capital stock; XRATIO, the ratio of export to sales; MIRATIO, the ratio of imported input to total variable cost, CF/K; the ratio of cash flow to capital stock, LT/AT, the ratio of Liability total to Asset Total.

When examining ‘export ratio minus imported input ratio’ across industries, ‘Computer and electronic products (334)’, ‘Machinery (333)’ and ‘Miscellaneous manufacturing (339)’ have the highest exports ratio relative to imported inputs ratio. While, ‘Petroleum and coal products (324)’ and ‘Primary metal (331)’ has higher imported inputs ratio relative to their exports ratio. In particular, ‘Petroleum and coal products (324)’ has an overwhelmingly high imported input ratio, which implies that this industry is heavily dependent on oil for their input. Table 4-9 shows the changes in exports ratio and imported inputs ratio across time from 1997 to 2006. One thing to note is that export ratio did not change much during that period, which is different from the large sample where export ratios have increased during that period. It is likely that export ratio and imported input ratio in the large sample are more close to the developments of real U.S. industries than those in the small sample, considering the limitations in the small sample stated earlier in the paper.

Table 4-8. Mean Values by Industries in the Small Sample (XRATIO and MIRATIO) : 1997 ~ 2006

naics3	Industry	# of Obs	# of Firms	XRATIO (b)	MIRATIO (a)	b-a
311	Food manufacturing	173	24	12.5	5.0	7.5
312	Beverage and tobacco	45	8	7.2	4.0	3.2
313	Textile mills	70	12	11.9	9.7	2.3
314	Textile product mills	4	1	6.9	9.6	-2.7
315	Apparel manufacturing	42	6	10.4	6.4	4.0
316	Leather manufacturing	49	7	12.2	6.8	5.3
321	Wood products	36	6	8.3	10.4	-2.2
322	Paper products	110	16	12.0	9.8	2.2
323	Printing	23	4	16.4	7.6	8.8
324	Petroleum and coal products	23	3	11.0	36.9	-25.9
325	Chemical product	536	73	13.9	7.7	6.2
326	Plastic and rubber	154	20	9.7	9.1	0.6
327	Nonmetalic mineral products	85	10	14.7	6.3	8.4
331	Primary metal	165	24	8.7	15.7	-7.0
332	Fabricated metal products	169	26	12.7	7.9	4.8
333	Machinery	819	114	23.5	9.8	13.7
334	Computer and electronic products	2,432	349	28.2	12.2	16.0
335	Electrical equipment	362	44	16.7	10.0	6.7
336	Transportation equipment	387	54	13.4	14.8	-1.3
337	Furniture	99	14	7.8	8.7	-1.0
339	Miscellaneous manufacturing	394	66	16.3	6.8	9.5
	Total	6142	881	20.3	10.6	9.7

Note : Data are from COMPUSTAT North America and Bureau of Economic Analysis. The number of observations and firms are for 1998~2007. XRATIO and MIRATIO are included in the model as lagged values. The units for the 'XRATIO', 'MIRATIO' and 'b-a' are percent and percentage point respectively. For XRATIO, only around 3,900 observations out of 6,151 show valid export values. Therefore observations with missing export sales are excluded from calculating XRATIO.

Table 4-9. Mean Values by Years in the Small Sample (XRATIO and MIRATIO) : 1997 ~ 2006

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
# of Obs	762	799	788	713	669	633	601	547	507	468
XRATIO	21.8	20.4	19.4	18.9	18.2	19.3	20.4	21.2	22.7	21.4
MIRATIO	10.0	9.9	9.8	10.3	9.9	10.4	10.5	12.0	12.2	12.9

Note : Data are from COMPUSTAT North America and Bureau of Economic Analysis. The units for the 'EXRATIO', 'MIRATIO' and 'b-a' are % and %p respectively.

Table 4-10. Mean (Median) Values by Industries in the Small Sample (key variables) : 1998 ~ 2007

naics3	I/K	S/K	SALE	MKUP	LT/AT	CF/K
311	0.160	5.21	579.6	0.082	0.585	0.173
312	0.157	2.69	318.4	0.255	0.534	0.270
313	0.137	2.78	614.6	0.095	0.583	0.108
314	0.118	2.43	1,429.7	0.091	0.825	0.098
315	0.278	12.20	336.5	0.113	0.645	0.474
316	0.326	19.88	101.1	0.076	0.381	0.766
321	0.120	2.04	2,089.0	0.121	0.620	0.101
322	0.131	3.18	1,136.0	0.118	0.624	0.093
323	0.235	5.22	196.2	0.192	0.343	0.530
324	0.206	6.93	1,775.8	0.108	0.538	0.230
325	0.211	6.48	183.7	0.127	0.488	0.272
326	0.166	4.66	235.3	0.105	0.634	0.218
327	0.249	4.63	238.7	0.105	0.487	0.247
331	0.129	3.14	854.1	0.107	0.616	0.156
332	0.159	3.82	180.1	0.122	0.519	0.275
333	0.234	8.15	161.1	0.106	0.463	0.361
334	0.311	10.20	74.8	0.097	0.321	0.297
335	0.214	7.07	253.9	0.118	0.450	0.404
336	0.213	7.26	649.4	0.119	0.644	0.403
337	0.200	6.13	394.4	0.116	0.486	0.428
339	0.320	8.30	60.3	0.135	0.309	0.436

Note : Data are from COMPUSTAT North America. MKUP, DT/AT and CF/K are for 1997~2006. The data period for this study on the small sample is 1998 ~ 2007, where lagged values of MKUP, DT/AT and CF/K are used. I/K and S/K are mean values; SALE, MKUP, DT/AT and CF/K are median values; SALE, current prices in million U.S. dollar units.

Table 4-10 shows mean values of key variables across industries. ‘Wood products (321)’ and ‘Petroleum and coal products (324)’ have the largest firm size in terms of firm average sales, while ‘Beverage and tobacco (312)’ has the highest markup rate as is the case in the large sample. ‘Textile product mills (314)’ and ‘Apparel manufacturing (315)’ have the highest leverage. Lastly, ‘Apparel manufacturing (315)’ also has the highest Cash flow (CF/K).

Table 4-11 shows the trends in key variables for the period 1998 ~ 2007. As discussed in the large sample, mean values of key variables decreased from 2001 to 2003 and then recovered from 2004.

Table 4-11. Mean (median) Values by Years in the Small Sample (key variables) : 1998 ~ 2007

Year	I/K	S/K	SALE	MKUP	LT/AT	CF/K
1998	0.313	7.70	103.4	0.117	0.458	0.319
1999	0.275	7.55	112.4	0.113	0.469	0.243
2000	0.285	7.66	128.2	0.122	0.468	0.287
2001	0.239	7.21	122.2	0.084	0.442	0.174
2002	0.194	7.11	131.9	0.084	0.422	0.204
2003	0.185	7.71	146.9	0.092	0.415	0.209
2004	0.231	8.89	195.6	0.119	0.406	0.375
2005	0.268	9.64	211.3	0.114	0.400	0.427
2006	0.273	9.71	261.2	0.121	0.415	0.426
2007	0.244	9.09	307.6	.	.	.

Note : Data are from COMPUSTAT North America. I/K and S/K are mean values; SALE, MKUP, DT/AT and CF/K are median values; SALE, current prices in million U.S. dollar units.

Chapter 5.

EMPIRICAL MODEL

5.1. Empirical Model

Based on the theoretical model presented earlier in the paper, I derive my empirical model as follows:

$$\Delta(I/K)_{it}=\beta_1\Delta(I/K)_{it-1}+\beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER_{jt-1}) \\ +\beta_4 MIRATIO_{it-1}*\Delta log(AMER_{t-1})+yr_t+c_i+\upsilon_{it} \qquad (5\text{-}1)$$

$\Delta(I/k)_{it}$: change in the investment to capital ratio of a firm at time t

$\Delta(S/k)_{it}$: change in the sales to capital ratio of a firm at time t

$XRATIO_{it-1}$: export to sales ratio of a firm (lagged)[19]

$MIRATIO_{it-1}$: imported input to TVC ratio of a firm (lagged)

XER_{jt-1} : industry specific export REER (lagged)

$AMER_{t-1}$: aggregate import REER (lagged)

I regress the change in the investment to capital ratio on: the lagged dependent variable, the change in the sales to capital ratio, two interaction terms related to export channel and imported input channel, respectively, and year dummies.

The lagged dependent variable is included in regressors to control for autocorrelation. I also include lagged variables on export ratio (XRATIO), imported input ratio (MIRATIO), and exchange rates (XER, AMER) in the model under the

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[19] For large sample, industry level export to shipment ratio is used as a proxy.

assumption of ‘one time to build’ on investment. That is, a firm’s investment decision is assumed to be made based on the information acquired one period earlier. The change in the sales to capital ratio is included to control for future investment opportunities. The two important coefficients in the model are β_3 and β_4.

I also include a time-variant year dummy yr_t, which affects all firms equally, to control macroeconomic factors such as interest rate and oil price. Also the model include c_i as unobservable fixed effects, and idiosyncratic error, υ_{it}, which is assumed to be $E(\upsilon_{ti})=0$.

5.2. Econometric Issues

The empirical model in the paper uses dynamic panel data, where the lagged dependent variable is included in regressors. Hence, lagged dependent variable might be correlated with unobservable fixed effects, which may lead to dynamic panel biases. Here, I briefly explain dynamic panel bias.[20]

My empirical model can be expressed in the following form:

$$y_{it} = \alpha y_{it-1} + X_{it}^{'}\beta + \varepsilon_{it},$$

$$\text{Where} \quad \varepsilon_{it} = c_i + u_{it}, \qquad E(c_i) = E(u_{it}) = E(c_i u_{it}) = 0$$

Suppose a firm faces a shock in 1998, unexplained by the model above, and its dependent variable, y, greatly decreases in that year. Then the effect of the shock is captured by error term, and the fixed effects of this firm during the period 1998~2007 will also decrease because of this shock. Here, fixed effects capture the difference

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[20] I refer to Roodman (2006) for the explanation of this part.

between the whole sample and this firm in the average variations that are not explained by the regressors in this model. In 1999, both lagged ‘y’ and the fixed effects of this firm will be low in values, which results in correlation between lagged dependent variable and the error term.

To solve this problem, several alternatives might be considered. As the first alternative, fixed effect method can be employed to remove unobservable fixed effects. However, the possible correlation between idiosyncratic error term and the lagged dependent variable will not be removed with fixed effect method.[21]

In addition to ‘within estimator’ explained above, another way to remove dynamic panel bias directly is to transform the data either by first differencing or forward orthogonal deviation[22]. That is, for example, fixed effect, c_i, can be removed by first-differencing the data. However, in this case, the first-differenced lagged dependent variable, $\Delta y_{it} = y_{it-1} - y_{it-2}$, is correlated with first-differenced error term, $\Delta u_{it} = u_{it} - u_{it-1}$. Fortunately, deeper lags of regressors can be used as instruments for the transformed lagged dependent variable because they are, unlike the within-estimator case above, uncorrelated with error term. Our second possible alternative is to follow this method and run 2SLS (Two Stage Least Square). That is, by first-differencing the data and using dipper lags (y_{t-2}) as instruments for the transformed lagged dependent variable (Δy_{t-1}), one can remove dynamic panel biases and get consistent estimators. However, this method may require more dipper lags than just ‘y_{t-2}’ to increase efficiency. Requiring deeper lags as instruments results in data loss for an unbalanced panel data since individuals that do not have enough lags

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[21] Within transformation of lagged dependent variable and idiosyncratic error term are expressed as $y^*_{i,t-1} = y_{i,t-1} - \frac{1}{T-1}(y_{i2} + \cdots + y_{iT})$, and $u^*_{it} = u_{it} - \frac{1}{T}(u_{i2} + \cdots + u_{iT})$. Here, $y_{i,t-1}$ in $y^*_{i,t-1}$ and $-\frac{1}{T}u_{it-1}$ in u^*_{it} move together. That is, $y^*_{i,t-1}$ and u^*_{it} have negative correlation.(Roodman, 2006)

[22] Forward orthogonal deviation transforms the data by subtracting the average of future available observations from current observation.

should be deleted. Thus, there is a trade-off problem between efficiency and the sample size. In addition, idiosyncratic error terms of first differenced data may not satisfy the homoskedasticity assumption required for the validity of 2SLS.

'Difference GMM method' developed by Arrelano and Bond (1991) provides a solution for the problem on trade-off between the need for deeper lags for instruments and sample size as well as the problem concerning the assumptions on the error term stated above. While Blundell and Bond (1998) propose another way to solve the dynamic panel bias problem, 'system' GMM which improves some problems with 'difference' GMM. In investigating my empirical model, I use both "difference" GMM and 'System' GMM, where lagged dependent variable and the change in the sales to capital ratio ($\Delta(S/K)$) are instrumented with deeper lags.

5.3. Generalized Method of Moment

In this section, I briefly review GMM (Generalized Method of Mement). Suppose we have a panel data model as follows:[23]

$$y_i = X_i\beta + u_i$$

Where, y_i is T x 1 vector, X_i is T x K matrix, u_i=T x 1 vector, and i=1……N.

The following orthogonality conditions are required to estimate β:

Assumption 1 : $E(Z_i'u_i) = 0$, where Z_i is T x L matrix of instrumental variables.

Assumption 2 : rank $E(Z_i'X_i) = K$, where $L \geq K$.

Under the two assumptions above, estimates of β, a unique K x 1 vector, can be derived from the following population moment condition and corresponding sample

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[23] For the explanation in this section, I closely follow Wooldridge (2002)

moment condition.

Population moment : $\mathrm{E}\left[Z_i'(y_i - X_i\beta)\right] = 0$

Sample moment : $N^{-1}\sum_{i=1}^{N} Z_i'\left(y_i - X_i\hat{\beta}\right) = 0$

This vector of moments is composed of L linear equations from which K unknown estimates of β can be derived.

If L=K and $\sum_{i=1}^{N} Z_i' X_i$ is non singular, then the estimates of β derived from the sample moment above are consistent. However, if L is greater than K, then we cannot obtain the estimates of β using the method above, and instead of that, we can get the estimate of β which minimizes the sample moment above. This is the basic idea of Generalized Method of Moments (GMM), and by adding weighting matrix which is positive semi-definite, we can obtain the GMM estimator of β. That is, we can obtain the GMM estimator of β by solving the following equation.

$$\min_b \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b)\right]' \hat{W} \left[\sum_{i=1}^{N} Z_i'(y_i - X_i b)\right]$$

The GMM estimator $\hat{\beta}$ is expressed as follows;

$$\hat{\beta} = (X'Z\hat{W}Z'X)'(X'Z\hat{W}Z'Y)$$

which is a consistent GMM estimator of β.

We can obtain a consistent GMM estimator with whatever positive semi definite weighting matrix, $\hat{W}$. The optimal weighting matrix that gives us an efficient GMM estimator is as follows;

$$W = \Lambda^{-1}, \text{where } \Lambda \equiv E\left(Z_i'u_iu_i'Z_i\right) = Var(Z_i'u_i)$$

The process of obtaining an efficient GMM estimator through estimating an optimal weighting matrix is composed of two steps. First, we obtain a one-step GMM estimator by using a certain arbitrary weighting matrix, where $\widehat{\mathrm{W}} = (\mathrm{Z}^{-1}\mathrm{Z}/\mathrm{N})^{-1}$ is usually used under the homoskedasticity assumption on the error term. In this case, the one-step GMM estimator is the same as the 2SLS estimator. The next step is to obtain a general consistent estimator of the weighting matrix from residuals that are acquired by estimating the dependent variable with one-step GMM estimator. Finally, we get a second-step GMM estimator, using the general consistent estimator of weighting matrix. This is the asymptotically optimal GMM estimator, and it is robust to heteroskedasticity and autocorrelation in the error term.

GMM estimator for dynamic panel data, developed by Arellano-Bond (1991), Arellano-Bover (1995) and Blundell-Bond (1998), can be used in the following situation; 1) small time period and large sample size 2) a linear functional relationship 3) lagged dependent variable is included in regressors 4) other independent variables also are not strictly exogenous 5) fixed individual effect 6) heteroskedasticity and autocorrelation within individual, but not across them.[24]

Arrelano-Bond (1991) proposes to transform all variables by first differencing and use untransformed lags as instruments, which is called ‘difference’ GMM. With regard to the method of transforming, forward orthogonal deviation, proposed by Arellano and Bover (1995), is also used as well as first-differencing.

While, Blundell and Bond (1998) proposes ‘system’ GMM which improves ‘difference’ GMM. If a dependent variable moves close to a random walk, ‘difference’ GMM may not work successfully because the untransformed (level) lags may not provide much information about the transformed variable which is instrumented. Blundell and Bond (1998) propose to use transformed lags as instruments for the untransformed variables, in addition to using untransformed lags as instruments for

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[24] Regarding the explanation on dynamic panel estimator using GMM, I closely refer to Roodman (2006).

transformed variables. This method requires that idiosyncratic error, u_{it}, be serially uncorrelated. Otherwise, the instruments and errors will be correlated. As a result, ‘system GMM estimator’ uses transformed data and untransformed data at the same time. In actual GMM estimation, this stacked data is treated as a single-equation estimation problem because the same linear functional relationship is applied to both transformed and untransformed data. Blundell and Bond (1998) show that ‘system’ GMM shows improved results compared to ‘difference’ GMM by running Monte Carlo simulation with a simple AR(1) model.

A problem of GMM estimator discussed above is that if there are too many instruments, standard error may be downward biased (Arrelano and Bond, 1991). Windmeijer (2005) proposes a way to correct such a downward bias of standard error in a small sample, which is used in this paper in producing standard errors. By running ‘difference’ GMM on a simulated panel data, Windmeijer shows that the two-step standard error corrected by his method is superior to one-step estimation or uncorrected two-step standard errors.

The most important assumption regarding the validity of GMM estimation is that instruments are exogenous. Under the assumption of joint validity, the vector of sample moments, $N^{-1}\sum_{i=1}^{N} Z_i' \left(y_i - X_i\hat{\beta}\right)$, is randomly distributed around zero. We can check this with Wald test. That is, if the null hypothesis that instruments are jointly exogenous is true, the distribution of Wald statistic derived from the sample moment follows a Chi-square distribution with (L-K) degrees of freedom.[25] With regard to the test for over-identification, it is known that Hansen J-test (1982) is superior to Sargan test (1958) in that the former is robust to heteroskedasticity and autocorrelation of error term.

[2525] L is the number of instruments and K is the number of regressors.

5.4. Hypotheses

Based on the conclusions of the theoretical model stated earlier in the paper and the findings of relevant previous literature, I establish hypotheses concerning my empirical study.

(1) Hypothesis 1: $\beta_3 < 0$. The coefficient $\beta_{3,}$ associated with export exposure, the interaction term of export ratio and exchange rate changes, is negative. This implies that appreciation (depreciation) contracts (expands) firm investment through export channel.

(2) Hypothesis 2: $\beta_4 > 0$. The coefficient $\beta_{4,}$ associated with imported input exposure, the interaction term of imported input ratio and exchange rate changes, is positive. This implies that appreciation (depreciation) expands (contracts) firm investment through imported input channel.

(3) Hypothesis 3: $|\beta_3^{\text{low mkup}}| > |\beta_3^{\text{high mkup}}|$, $|\beta_4^{\text{low mkup}}| > |\beta_4^{\text{high mkup}}|$. The absolute values of the coefficients β_3 and β_4 are greater for low markup firms than high markup firms. This implies that firms with low market power are more responsive, in the investment decision, to exchange rate changes.

(4) Hypothesis 4 : $|\beta_3^{\text{low cashflow}}|>|\beta_3^{\text{hig h cashflow}}|$, $|\beta_4^{\text{low cashflow}}|>|\beta_4^{\text{high cashflow}}|$. The absolute values of the coefficients β_3 and β_4 are greater for low cash flow (CF/K) firms than high cash flow (CF/K) firms. This suggests that firms with low cash flow are more sensitive, in terms of investment decisions, to exchange rate changes under the environment of capital market imperfection.

(5) Hypothesis5 : $|\beta_3^{\text{low levered}}|>|\beta_3^{\text{high levered}}|$, $|\beta_4^{\text{low levered}}|>|\beta_4^{\text{high levered}}|$. The absolute values of the coefficients β_3 and β4 are greater for low leveraged firms than high leveraged firms. This implies that low leveraged firms are more sensitive in their

investment decisions to exchange rate changes. As I mentioned earlier in the paper, some literature indicate the there is negative relation between firm investment and leverage. That is, high leverage lowers firm investment in terms of the ratio of investment to capital. Hence, firms with low investment to capital ratio also are likely to have small changes in investment to capital ratio.

(6) Hypothesis 6: $|\beta_3^{\text{small}}| > |\beta_3^{\text{large}}|$, $|\beta_4^{\text{small}}| > |\beta_4^{\text{large}}|$. The absolute values of the coefficients β_3 and β_4 are greater for smaller firms than larger firms. This indicates that smaller firms are more sensitive in their investment decisions to exchange rate changes under the environment of capital market imperfection.

Chapter 6.

ESTIMATION RESULTS

I run my empirical models using both the large sample and the small sample. First of all, I investigate the effects of exchange rate changes on firm level investment through export and imported input channels, which is my base model. After that, I estimate the effects that market power, represented by markup rate, has on the exchange rate-investment relationship. Then, to check robustness, I allow for differences in cash flow (CF/K), leverage (LT/AT) and firm size in terms of sales (SALE), respectively, in the following models and then analyze the impact of those variables on the relationship between exchange rate changes and firm investment. In estimating all of the models, I run pooled OLS, the fixed effect method (or random effect method) and 2SLS as well as GMM. The results of pooled OLS, the fixed effect method (or random effect method) and 2SLS are included in the appendix. With regard to GMM[26], I run both 'difference GMM' and 'system' GMM; the results of which are reported in this chapter.

6.1. Results with the Large Sample

6.1.1. External Exposure

Table 6-1 shows the results of GMM estimation on the effects of exchange rate changes on firm investment. β_1, associated with the lagged dependent variable, is

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[26] Estimations are conducted using 'xtabond2' commandment in STATA developed by Roodman (2006).

negative and statistically significant. The change in the ratio of sales to capital stock, $\Delta(S/K)$, which controls for a firm's future investment opportunities, is positive and significant at the 1% level. I also present the Wald-test results of year dummies which are employed to control for time-varying macroeconomic environment.

The results of β_3 and β_4, two critical coefficients in this model, are consistent with the hypotheses. In the results for both 'difference GMM' and 'system GMM', β_3 is negative and significant at the 1 percent level, also β_4 is positive and significant at the 5 percent level.

The estimation results are a little hard to interpret since both the dependent variable and key independent variables are expressed as first-differenced terms, not level terms. If we assume the export ratio (XRATIO) is 20 percent, the estimates of β_3 implies that a 1 percentage point increase in the appreciation (depreciation) rate of the domestic currency lowers (raises) the change in I/K by 0.32 to 0.38 percentage point. Also, if imported input ratio (MIRATIO) is 20 percent, the estimation results of β_4 suggest that a 1 percentage point increase in the appreciation (depreciation) rate of domestic currency increases (decreases) the change in I/K by 0.34 to 0.40 percentage point. In other words, appreciation (depreciation) decreases firm investment through the export channel, while it increases firm investment through imported input channel, and the size of a firm's investment response to the change in exchange rate depends on the magnitude of the export ratio and the imported input ratio facing each firm.

These results are consistent with the results of the theoretical model presented earlier in this paper, and are also consistent with previous studies such as Campa and Goldberg (1995, 1999) and Nucci and Pozzolo (2001).

Table 6-1. GMM Estimations over the Large Sample : External Exposure

$$\text{Model : } \Delta(I/K)_{it}=\beta_1\Delta\,(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}$$
$$+\ \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + yr_t + \ c_i + \upsilon_{it}$$

Dep. Var : Δ(I/K)$_{it}$	**‘Difference’ GMM2)**	**‘System’ GMM3)**
Δ(I/K)$_{it-1}$	-0.317***	-0.312***
	(0.107)1)	(0.103)
Δ(S/K)$_{it}$	0.023***	0.022***
	(0.006)	(0.006)
XRATIO$_{it-1}$*Δlog(XER)$_{it-1}$	-1.900***	-1.618***
	(0.490)	(0.405)
MIRATIO$_{it-1}$*Δlog(AMER)$_{it-1}$	2.018**	1.709**
	(0.842)	(0.689)
Intercept	.	-0.014*
		(0.008)
Year dummies	Chi2(8)=36.86	chi2(8) = 42.85
(Wald test)	(0.000)	(0.000)
Arellano-Bond	z = -1.87	z = -1.91
AR(2) test	(0.061)	(0.057)
Hansen test of overidentification	chi2(94) = 107.07	chi2(112) = 120.37
	(0.168)	(0.277)
# of observation	13,400	16,388

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

6.1.2. Market Power

I will now discuss the influence of market power on the relationship between exchange rate changes and firm investment. I deal with the issue of market power in two ways, first by using a markup dummy, and second, by interacting the lag of the markup rate with each of two external exposures. Market power is represented by the markup rate, the definition of which is stated earlier in the paper. A firm’s markup rate is derived without distinguishing between the domestic market and export market. That is, a firm has only one time-varying markup rate which combines the domestic and all the export markets facing the firm.

First, I include a markup dummy in the base model. That is, I create two interaction terms by multiplying each of the two terms on export and imported input by the markup dummy. Table 6-2 shows the estimation results. β_3 and β_4, which are associated with export exposure and imported input exposure, respectively, represent the coefficients of the low markup group, while $\beta_3 + \beta_5$ and $\beta_4 + \beta_6$ represent coefficients of the high markup group.

In both the ‘difference’ GMM and ‘system’ GMM, most of the coefficients reported are statistically significant. If we see the estimation results on export exposure, β_5, the coefficient of the interaction term with export exposure and markup dummy, is positive, while β_3 is negative. As a result, $\beta_3 + \beta_5$, which stands for the coefficient of export exposure for the large markup group, is smaller in absolute value than β_3. With regard to imported input exposure, the coefficients have positive signs in both groups, where the coefficients in the low markup group are larger than those in the high markup group.

Table 6-2. GMM Estimations over the Large Sample : Including Markup Dummy

$$
\begin{aligned}
\textit{Model} : \Delta(I/K)_{it} = {} & \beta_1\, \Delta\,(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1} \\
& + \beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}{*}D^{mkup} \\
& + \beta_6 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1}{*}\, D^{mkup} + D^{mkup} + yr_t + c_i + \upsilon_{it}
\end{aligned}
$$

Dep. Var : $\Delta(I/K)_{it}$	**‘Difference’ GMM2)**	**‘System’ GMM3)**
$\Delta(I/K)_{it-1}$	-0.319***	-0.310***
	(0.107)1)	(0.103)
$\Delta(S/K)_{it}$	0.023***	0.022***
	(0.006)	(0.006)
$XRATIO_{it-1}{*}\Delta\log(XER)_{it-1}$	-2.601***	-2.211***
	(0.651)	(0.529)
$MIRATIO_{it-1}{*}\Delta\log(AMER)_{it-1}$	2.752**	2.345**
	(1.125)	(0.917)
$XRATIO_{it-1}{*}\Delta\log(XER)_{it-1}{*}D^{mkup}$ 4)	1.678**	1.464***
	(0.739)	(0.568)
$MIRATIO_{it-1}{*}\Delta\log(AMER)_{it-1}{*}D^{mkup}$ 4)	-1.841	-1.650*
	(1.218)	(0.976)
D^{mkup} 4)	.	0.025***
		(0.004)
Intercept	.	-0.027***
		(0.008)
Year dummies	Chi2(8)=36.64	chi2(8) = 41.84
(Wald test)	(p-value : 0.000)	(p-value : 0.000)
Arellano-Bond	z = -1.89	z = -1.89
AR(2) test	(p-value : 0.058)	(p-value : 0.058)
Hansen test of overidentification	chi2(94) = 106.90	chi2(112) = 120.77
	(p-value : 0.171)	(p-value : 0.269)
# of observation	13,400	16,388

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

4) D^{mkup} =0 (1), when average markup rate of a firm is below (above) median value.

I now include the lag of the markup rate by creating two interaction terms by multiplying each of two terms on export and imported input by ‘one minus lag of markup rate’. I use ‘one minus markup rate’ in order to be consistent with the theoretical model, which indicates that the markup rate is negatively correlated with the size of effects of exchange rate changes on investment. One advantage of using this model over the former model which employs a markup dummy is that this model allows for the changes in the markup rate within a firm over time, while the model with markup dummy does not. However, one possible limitation with this model is that the role of the markup rate may not be clearly captured if the variations in external exposure and exchange rates overwhelm the variation in the markup rate. This discussion of the advantages and limitations can also be applied to other models on cash flow and leverage in the paper where relevant variables are interacted with the terms on external exposures.

The results are reported in table 6-3. In both GMM estimations, β_3 and β_4 have the same sign as those in the base model. This implies that at a certain level of export ratio, imported input ratio and appreciation (depreciation) path of domestic currency, if a firm has a lower mark up rate, then its investment response to the exchange rate changes will be more sensitive. β_3 is statistically significant at the 1 percent level, β_4, however, is not significant.

Overall, the estimation results of the two models, one using a markup dummy and the other using the lag of markup rate, are consistent with the hypothesis and the theoretical model presented in this paper, thus confirm the findings of the previous literature. That is, as a firm’s markup rate increases, the relationship between exchange rate changes and firm investment becomes more sensitive to both in terms of export channel and imported input channel.

Table 6-3. GMM Estimations over the Large Sample : Including the Lag of Markup

$$Model : \Delta(I/K)_{it}=\beta_1\Delta(I/K)_{it-1}+\beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-mkup_{it-1})$$
$$+\beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-mkup_{it-1}) + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM**[2]	**'System' GMM**[3]
$\Delta(I/K)_{it-1}$	-0.309***	-0.294***
	(0.105)[1]	(0.100)
$\Delta(S/K)_{it}$	0.024***	0.023***
	(0.006)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*(1-MKUP_{it-1})$	-2.059***	-1.729***
	(0.555)	(0.426)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*(1-MKUP_{it-1})$	1.316	1.094
	(1.059)	(0.831)
Intercept	.	-0.017**
		(0.008)
Year dummies	Chi2(8)=38.13	chi2(8) = 41.84
(Wald test)	(p-value : 0.000)	(p-value : 0.000)
Arellano-Bond	z = -1.84	z = -1.78
AR(2) test	(p-value : 0.065)	(p-value : 0.074)
Hansen test of overidentification	chi2(94) = 109.93	chi2(112) = 123.23
	(p-value : 0.125)	(p-value : 0.220)
# of observation	13,055	16,007

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and $\Delta(S/K)$ dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and $\Delta(S/K)$ dated t-5 and earlier.

6.1.3. Robustness Check

I now investigate the roles of cash flow, leverage and firm size in the relationship between the movement of domestic currency and firm investment.

6.1.3.1. Cash Flow

To analyze the role of cash flow in the relationship between exchange rate changes and firm investment, I use a dummy variable for cash flow (CF/K). I create interaction terms by multiplying each of two terms on external exposures by dummy variable on cash flow. In this model I include the lag of the markup rate to control for the possible correlation between the cash flow and the markup rate, considering that a firm with high markup rate also is likely to have high cash flow. The results of this model are reported in table 6-4. The coefficients associated with export and imported input exposure are respectively β_3 and β_4 for the low cash flow group, while the coefficients corresponding to those of high cash flow group are $\beta_3 + \beta_5$ and $\beta_4 + \beta_6$. The estimates for the low cash flow group are larger for both export exposure and imported input exposure in absolute values compared to the high cash flow group. All the coefficients are statistically significant except β_6, the interaction term with imported input exposure and cash flow dummy.

As an alternative way to investigate the role of cash flow, I interact 'one minus the lag of cash flow'[27] with each of the two external exposures terms. This model also employs the lag of the markup rate to control for the possible correlation between cash flow and the markup rate. The estimation results are presented in table 6-5. All the signs of the coefficients are as expected, which is consistent with the results of the model with the cash flow dummy. The coefficient associated with the export channel is more significant than the coefficient associated with imported input exposure.

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[27] I use (1-CF/K) instead of CF/K to make interpretation of coefficients easy, considering the hypothesis that low cash flow firm will be more sensitive in their investment decision to the movement of exchange rate.

Table 6-4. GMM Estimations over the Large Sample : Including Cash Flow Dummy

$$\text{Model : } \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta\log(XER)_{jt-1} \\ + \beta_4 MIRATIO_{it-1}*\Delta\log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta\log(XER)_{jt-1}*D^{cfk} \\ + \beta_6 MIRATIO_{it-1}*\Delta\log(AMER)_{t-1}*D^{cfk} + D^{cfk} + MKUP_{it-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM2)**	**'System' GMM3)**
$\Delta(I/K)_{it-1}$	-0.325*** (0.102)1)	-0.304*** (0.099)
$\Delta(S/K)_{it}$	0.024*** (0.006)	0.023*** (0.006)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	-2.795*** (0.685)	-2.455*** (0.538)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	2.181** (0.919)	2.059*** (0.758)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}*D^{cfk}$ 4)	1.860** (0.835)	1.943*** (0.633)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}*D^{cfk}$ 4)	-1.282 (1.442)	-1.885 (1.165)
D^{cfk} 4)	.	0.003 (0.003)
$MKUP_{it-1}$	0.105*** (0.023)	0.075*** (0.013)
Intercept	.	-0.020** (0.008)
Year dummies (Wald test)	Chi2(8)=31.14 (p-value : 0.000)	chi2(8) = 37.15 (p-value : 0.000)
Arellano-Bond AR(2) test	z = -2.03 (p-value : 0.043)	z = -1.90 (p-value : 0.057)
Hansen test of overidentification	chi2(94) = 108.91 (p-value : 0.139)	chi2(112) = 123.73 (p-value : 0.211)
# of observation	13,055	16,007

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

4) If D^{cfk} =0(1), when firm average 'CF/K' is below (above) median.

Table 6-5. GMM Estimations over the Large Sample : Including the Lag of Cash Flow

$$\textit{Model}: \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}(1\text{-}CFK_{it-1}) \\ + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}(1\text{-}CFK_{it-1}) + MKUP_{it-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.317***	-0.298***
	(0.104)[1)]	(0.100)
$\Delta(S/K)_{it}$	0.025***	0.023***
	(0.006)	(0.006)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}{*}(1\text{-}CF/K_{it-1})$	-1.017***	-0.929***
	(0.375)	(0.275)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}{*}(1\text{-}CF/K_{it-1})$	1.940	1.834*
	(1.292)	(0.991)
$MKUP_{it-1}$	0.099***	0.071***
	(0.023)	(0.012)
Intercept	.	-0.011*
		(0.006)
Year dummies	Chi2(8)=44.76	chi2(8) = 53.89
(Wald test)	(p-value : 0.000)	(p-value : 0.000)
Arellano-Bond	z = -1.95	z = -1.84
AR(2) test	(p-value : 0.052)	(p-value : 0.066)
Hansen test of overidentification	chi2(94) = 111.53	chi2(112) = 124.92
	(p-value : 0.105)	(p-value : 0.191)
# of observation	13,055	16,007

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

6.1.3.2. Leverage

I now analyze the role of leverage in the relationship between exchange rate changes and firm investment. Following the cases of the markup rate and the cash flow, I address this issue on leverage using two methods: one using a leverage dummy and the other by employing the lag of leverage.

I first create two interaction terms on export exposure and imported input exposure by multiplying each of them by a leverage dummy, and then run the model. The estimation results are presented in table 6-6. As in the cases of the markup rate and the cash flow, β_3 and β_4 are the coefficients associated with export exposure and imported input exposure for the low levered group, while $\beta_3 + \beta_5$ and $\beta_4 + \beta_6$ are the coefficients corresponding to the two external exposures for the high levered group. β_3 is negative and β_4 is positive, which is as expected. However, both β_5 and β_6 are positive, which is not consistent with the hypotheses. Thus the coefficients associated with export channel in the low markup group are larger in absolute value than the coefficients in the high markup group, while the coefficients associated with imported input channel in the low markup group are smaller than the coefficients in the high markup group. However, only β_3 is statistically significant at the 1 percent level, while β_4, β_5 and β_6 are not significant.

Next, instead of a leverage dummy, I include ‘one minus lag of leverage’ in the model, with which I interact each of two external exposure terms. The estimation results are presented in table 6-7. With this model, the signs of β_3 and β_4 are consistent with the hypotheses. However, only β_3 is statistically significant.

Table 6-6. GMM Estimations over the Large Sample : Including Leverage Dummy

Model : $$\Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^{lev} + \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}* D^{lev} + D^{lev} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**‘Difference’ GMM**[2]	**‘System’ GMM**[3]
$\Delta(I/K)_{it-1}$	-0.316***	-0.313***
	(0.107)[1]	(0.103)
$\Delta(S/K)_{it}$	0.023***	0.022***
	(0.006)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-2.055***	-1.623***
	(0.756)	(0.602)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	1.513	1.062
	(1.999)	(1.631)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*D^{lev}$[4]	0.701	0.307
	(0.917)	(0.708)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*D^{lev}$[4]	0.435	0.682
	(1.903)	(1.546)
D^{lev}[4]	.	0.016***
		(0.004)
Intercept	.	-0.022***
		(0.008)
Year dummies	Chi2(8)=37.32	chi2(8) = 43.14
(Wald test)	(p-value : 0.000)	(p-value : 0.000)
Arellano-Bond	z = -1.86	z = -1.92
AR(2) test	(p-value : 0.063)	(p-value : 0.055)
Hansen test of overidentification	chi2(94) = 106.70	chi2(112) = 119.39
	(p-value : 0.175)	(p-value : 0.299)
# of observation	13,400	16,388

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

4) D^{dr} =0(1), when the firm average ‘LT/AT’ is below (above) median value.

Table 6-7. GMM Estimations over the Large Sample : Including the Lag of Leverage

Model : $\Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-LT/AT_{it-1})$
$+\beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-LT/AT_{it-1}) + yr_t + c_i + v_{it}$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.308***	-0.310***
	(0.108)[1)]	(0.103)
$\Delta(S/K)_{it}$	0.023***	0.021***
	(0.006)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*(LT/AT)_{it-1}$	-2.157**	-1.796***
	(0.886)	(0.689)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*(LT/AT)_{it-1}$	1.552	0.862
	(1.876)	(1.552)
Intercept	.	-0.013**
		(0.006)
Year dummies	Chi2(8)=39.36	chi2(8) = 49.77
(Wald test)	(p-value : 0.000)	(p-value : 0.000)
Arellano-Bond	z = -1.75	z = -1.85
AR(2) test	(p-value : 0.080)	(p-value : 0.065)
Hansen test of overidentification	chi2(94) = 104.91	chi2(112) = 117.82
	(p-value : 0.208)	(p-value : 0.335)
# of observation	13,354	16,344

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and Δ(S/K) dated t-5 and earlier.

6.1.3.3. Firm Size

Lastly, I examine whether firm size affects the relationship between exchange rate changes and firm investment. This time, I do not run the model using the lag of firm size because firm size is unlikely to change much over time. I use ‘average sale’ of a firm for the firm size variable. As in the previous models, I create interaction terms of export exposure and imported input exposure by multiplying each by a firm size dummy. For the small sized group, the coefficients associated with export exposure and imported input exposure are β_3 and β_4, respectively, while the corresponding coefficients for the large sized group, are $\beta_3 + \beta_5$ and $\beta_4 + \beta_6$.

Table 6-8 shows the results of the model with a firm size dummy. The two coefficients of the small sized group, corresponding to export exposure and imported input exposure, are both larger than those of the large sized group in absolute values. All the coefficients are statistically significant except β_6 in ‘difference’ GMM.

These results are consistent with the findings of Nucci and Pozzolo (2001). They find that the coefficients of two exposure terms are larger in absolute value for the small sized group. According to Gilchrist and Himmelberg (1995), a firm size variable can be used as an indicator to show the extent of financial constraints of a firm. That is, smaller firms tend to be exposed to financial constraints more than larger firms because they do not have enough assets that can be used as collateral and might have more difficulties adapting to the changing environments than larger firms.[28]

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[28] The findings of some literature are contrary to those of Gilchrist and Himmelberg (1995). That is, Kadapakkam et al. (1998) and Vogt (1994) show that large firms are more sensitive in the effects of cash flow on firm investment.

Table 6-8. GMM Estimations over the Large Sample : Including Firm Size Dummy

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^s \\ & + \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\, D^s + D^s + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.320***	-0.313***
	(0.107)[1)]	(0.103)
$\Delta(S/K)_{it}$	0.023***	0.022***
	(0.006)	(0.006)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-2.885***	-2.573***
	(0.851)	(0.680)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	3.734*	3.644**
	(2.174)	(1.766)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}{*}D^{s}$ [4)]	2.054**	1.994***
	(0.924)	(0.713)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}{*}D^{s}$ [4)]	-2.561	-2.852*
	(2.120)	(1.721)
D^{s} [4)]	.	0.028***
		(0.004)
Intercept	.	-0.028***
		(0.008)
Year dummies	Chi2(8)=37.95	chi2(8) = 43.28
(Wald test)	(0.000)	(0.000)
Arellano-Bond	z = -1.91	z = -1.92
AR(2) test	(0.057)	(0.055)
Hansen test of overidentification	chi2(94) = 107.01	chi2(112) = 120.85
	(0.169)	(0.267)
# of observation	13,400	16,388

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and $\Delta(S/K)$ dated t-5 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-6 and earlier and $\Delta(S/K)$ dated t-5 and earlier.

4) D^s =0(1), when the firm average sales is below (above) median value.

6.2. Results with the Small Sample

In analyzing the small sample, I run the same empirical models that are used for the large sample.

6.2.1. External Exposure

Table 6-9 shows the results of the GMM estimation on the base model over the small sample. The signs of β_3 and β_4, the coefficients associated with export exposure and imported input exposure, are respectively negative and positive, which is consistent with the results of the estimation using the large sample and the hypothesis. However, β_3 and β_4 are statistically significant only using the ‘system’ GMM.

I compare the estimation results of the small sample with those of the large sample. The estimates of β_3, corresponding to export exposure, are similar between the two samples. However, the estimates of β_4, associated with imported input exposure, are quite different between the two samples. The estimates of β_4 in the small sample are approximately 4.3, while those in the large sample are between 1.7 and 2.0, which are much lower than those in the small sample.

The estimation results of the small sample also confirm the results of the theoretical model and the findings of previous literatures on this subject, which say that appreciation (depreciation) of domestic currency reduces (increases) firm investment through the export channel, while it increases (reduces) firm investment through the imported input channel. However, the significance levels of key coefficients in the small are much weaker than those in the large sample.

Table 6-9. GMM Estimations over the Small Sample : External Exposure

$$\text{Model} : \Delta(I/K)_{it}=\beta_1\Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta \log(XER)_{jt-1}$$
$$+ \beta_4 MIRATIO_{it-1}*\Delta \log(AMER)_{t-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM**[2]	**'System' GMM**[3]
$\Delta(I/K)_{it-1}$	-0.275***	-0.246***
	(0.097)[1]	(0.090)
$\Delta(S/K)_{it}$	0.024***	0.024***
	(0.007)	(0.006)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	-1.364	-1.305*
	(1.117)	(0.787)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	4.272	4.306**
	(3.073)	(2.052)
Intercept	.	-0.001
		(0.020)
Year dummies	Chi2(9)=20.05	chi2(9) = 27.24
(Wald test)	(0.018)	(0.001)
Arellano-Bond	z = -1.65	z = -1.50
AR(2) test	(0.100)	(0.133)
Hansen test of	chi2(133) = 144.16	chi2(153) = 157.38
overidentification	(0.240)	(0.387)
# of observation	2,514	3,749

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

6.2.2. Market Power

Estimation results from the model with the markup dummy using the small sample are presented in table 6-10. The coefficients associated with export exposure and imported input exposure for the low markup group are β_3 and β_4, respectively, and those for the high markup group are $\beta_3 + \beta_5$ and $\beta_4 + \beta_6$, respectively. The estimates of the coefficients for the low markup group associated with export exposure are between -1.522 and -1.277, while those for the high markup group are between -0.73 to -0.406. Also, the estimates of the coefficients for the low markup group associated with imported input exposure are 3.953 to 4.451, and those for the high markup group are 2.291 to 3.339. However, β_3, β_4, β_5 and β_6, key coefficients in this model, are not statistically significant, with the exception of β_4 in 'system' GMM.

Table 6-11 presents the estimation results from the model including the lag of markup rate. The estimates of β_3 and β_4, corresponding to external exposures interacted with (1-MKUP), are negative and positive in sign, respectively. This implies that at a given level of export ratio, imported input ratio and appreciation (depreciation) path of the exchange rate, as the markup rate decreases, the relationship between exchange rate changes and firm investment becomes more sensitive. However, β_3 and β_4 in this model are not significant with the exception of β_3 in 'system' GMM.

In both models examining the role of markup, the results are consistent with the theoretical model and the findings of previous literature.

Table 6-10. GMM Estimations over the Small Sample : Including Markup Dummy

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1 \Delta (I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * D^{mkup} \\ & + \beta_6 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * D^{mkup} + D^{mkup} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.276***	-0.246***
	(0.096)[1)]	(0.088)
$\Delta(S/K)_{it}$	0.025***	0.024***
	(0.007)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-1.277	-1.522
	(1.604)	(1.149)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	3.953	4.451*
	(3.831)	(2.368)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*D^{mkup}$ 4)	0.547	1.116
	(2.041)	(1.456)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1} *D^{mkup}$ 4)	-0.614	-1.530
	(3.411)	(2.246)
D^{mkup} 4)	.	0.021**
		(0.009)
Intercept	.	-0.015
		(0.021)
Year dummies	Chi2(9)=20.10	chi2(9) = 26.66
(Wald test)	(p-value : 0.017)	(p-value : 0.002)
Arellano-Bond	z = -1.64	z = -1.49
AR(2) test	(P-value : 0.102)	(p-value : 0.136)
Hansen test of overidentification	chi2(133) = 146.62	chi2(153) = 159.00
	(p-value : 0.198)	(p-value : 0.353)
# of observation	2,514	3,749

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

4) D^{mkup} =0(1), when firm average markup rate is below (above) median.

Table 6-11. GMM Estimations over the Small Sample : Including the Lag of Markup

$$\text{Model : } \Delta(I/K)_{it}=\beta_1 \Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-mkup_{it-1}) \\ +\beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-mkup_{it-1}) + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.277***	-0.246***
	(0.094)[1)]	(0.087)
$\Delta(S/K)_{it}$	0.023***	0.023***
	(0.006)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*(1-MKUP_{it-1})$	-1.865	-1.586*
	(1.218)	(0.880)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*(1-MKUP_{it-1})$	0.946	1.403
	(3.598)	(2.240)
Intercept	.	-0.017
		(0.020)
Year dummies	Chi2(9)=20.33	chi2(9) = 23.89
(Wald test)	(p-value : 0.016)	(p-value : 0.005)
Arellano-Bond	z = -1.68	z = -1.52
AR(2) test	(p-value : 0.093)	(p-value : 0.129)
Hansen test of overidentification	chi2(133) = 145.30	chi2(153) = 158.54
	(p-value : 0.220)	(p-value : 0.363)
# of observation	2,448	3,650

***, **, * represent significance at 1%, 5% and 10%, respectively

1) (   ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-3 and earlier.

6.2.3. Robustness Check

I investigate the roles of cash flow (CF/K), leverage (LT/AT) and firm size with the small sample, using the same models that are used for the large sample.

6.2.3.1. Cash Flow

I examine whether the cash flow, (CF/K), affects the relationship between exchange rate changes on firm investment using two models, one using a dummy variable and the other by interacting ‘one minus lag of cash flow’ with each of the two terms on external exposures. To control for the possible correlation between cash flow and the markup rate, I include the lag of markup rate in both models.

The estimation results of the model with the dummy variable on cash flow are presented in table 6-12. The estimates of the coefficients regarding export exposure for the low cash flow group and the high cash flow group are -1.892 and -1.747, respectively, using the ‘difference’ GMM. Also the coefficients of imported input exposure for low cash flow group and high cash flow group are 6.032 and 4.352, respectively, in ‘difference’ GMM. That is, the absolute values of coefficients associated with export and imported input are larger in the low cash flow group than those in the high cash flow group. However, the sign of β_5 in the ‘system’ GMM is not consistent with the hypothesis. All the key coefficients-β_3, β_4, β_5, and β_6-in this model are not statistically significant with the exception of β_6 in the ‘difference’ GMM.

The results of the model allowing for the differences in the lag of cash flow are presented in table 6-13. The signs of β_3 and β_4, associated with export exposure and imported input exposure, are not consistent with the hypothesis. Also, they are not statistically significant.

Table 6-12. GMM Estimations over the Small Sample : Including Cash Flow Dummy

$$\begin{aligned} \textit{Model} : \Delta(I/K)_{it} = {} & \beta_1 \Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^{cfk} \\ & + \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\, D^{cfk} + D^{cfk} + MKUP_{it-1} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.295***	-0.266***
	(0.099)[1)]	(0.094)
$\Delta(S/K)_{it}$	0.025***	0.025***
	(0.007)	(0.006)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-1.892	-0.911
	(1.720)	(0.962)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	6.032*	2.755
	(3.606)	(2.416)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}{*}D^{cfk}$ [4)]	0.145	-0.788
	(2.246)	(1.214)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}{*}D^{cfk}$ [4)]	-1.680	-0.361
	(3.292)	(2.015)
D^{cfk} [4)]	.	-0.009
		(0.008)
$MKUP_{it-1}$	0.118**	0.148***
	(0.060)	(0.047)
Intercept	.	-0.007
		(0.024)
Year dummies	Chi2(9)=18.92	chi2(9) = 23.67
(Wald test)	(p-value : 0.026)	(p-value : 0.005)
Arellano-Bond	z = -1.73	z = -1.57
AR(2) test	(p-value : 0.083)	(p-value : 0.116)
Hansen test of overidentification	chi2(133) = 142.75	chi2(153) = 157.74
	(p-value : 0.266)	(p-value : 0.380)
# of observation	2,448	3,650

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-3 earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-1 through t-5.

4) D^{CFK} =0 (1), when firm average cash flow rate is below (above) median.

Table 6-13. GMM Estimations over the Small Sample : Including the Lag of Cash Flow

$$\textit{Model}: \Delta(I/K)_{it} = \beta_1 \Delta(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * (1-CFK_{it-1}) \\ + \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * (1-CFK_{it-1}) + MKUP_{it-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM$^{2)}$**	**'System' GMM$^{3)}$**
$\Delta(I/K)_{it-1}$	-0.282***	-0.255***
	(0.099)$^{1)}$	(0.092)
$\Delta(S/K)_{it}$	0.025***	0.025***
	(0.006)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*(1-CFK_{it-1})$	-0.132	0.081
	(0.825)	(0.504)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*(1-CFK_{it-1})$	-2.060	-1.751
	(2.537)	(1.654)
$MKUP_{it-1}$	0.108*	0.126***
	(0.061)	(0.040)
Intercept	.	-0.027
		(0.019)
Year dummies	Chi2(9)=17.80	chi2(9) = 15.33
(Wald test)	(p-value : 0.038)	(p-value : 0.082)
Arellano-Bond	z = -1.63	z = -1.51
AR(2) test	(p-value : 0.104)	(p-value : 0.130)
Hansen test of overidentification	chi2(133) = 146.46	chi2(153) = 157.89
	(p-value : 0.201)	(p-value : 0.376)
# of observation	2,448	3,650

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

6.2.3.2. Leverage

I next analyze the role of leverage in the relationship between exchange rates and firm investment using the small sample.

Table 6-14 shows the estimation results from the model using a dummy variable on leverage. The signs of β_5 and β_6 are not consistent in the two GMM estimations, and none of the key coefficients are statistically significant except β_3 and β_4 in the 'system' GMM.

Estimation results from the model including the lag of leverage are presented in table 6-15. β_3 and β_4 are negative and positive in their signs, respectively. However neither of them are statistically significant.

The results of the two models examining the role of leverage are basically similar in the large sample and the small sample. That is, using either sample, the model using a leverage dummy does not have significant results for many of the coefficients associated with external exposure, hence the role of leverage in the relationship between firm investment and the exchange rate changes is not clear. On the other hand, the model using the lag of leverage yields significant results only for the export channel in the large sample.

Table 6-14. GMM Estimations over the Small Sample : Including Leverage Dummy

Model : $$\Delta(I/K)_{it} = \beta_1 \Delta(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1}$$
$$+ \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * D^{lev}$$
$$+ \beta_6 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * D^{lev} + D^{lev} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM$^{2)}$**	**'System' GMM$^{3)}$**
$\Delta(I/K)_{it-1}$	-0.265***	-0.239***
	(0.099)$^{1)}$	(0.092)
$\Delta(S/K)_{it}$	0.024***	0.024***
	(0.007)	(0.006)
$XRATIO_{it-1} * \Delta log(XER)_{it-1}$	-1.781	-1.289*
	(1.161)	(0.667)
$MIRATIO_{it-1} * \Delta log(AMER)_{it-1}$	5.167	3.949*
	(3.379)	(2.211)
$XRATIO_{it-1} * \Delta log(XER)_{it-1} * D^{lev\ 4)}$	0.634	-0.479
	(2.675)	(1.389)
$MIRATIO_{it-1} * \Delta log(AMER)_{it-1} * D^{lev\ 4)}$	-0.833	0.796
	(3.690)	(2.205)
$D^{lev\ 4)}$	.	0.009
		(0.008)
Intercept	.	0.002
		(0.023)
Year dummies	Chi2(9)=18.97	chi2(9) = 31.40
(Wald test)	(p-value : 0.026)	(p-value : 0.000)
Arellano-Bond	z = -1.56	z = -1.43
AR(2) test	(p-value : 0.118)	(p-value : 0.154)
Hansen test of overidentification	chi2(133) = 145.26	chi2(153) = 156.16
	(p-value : 0.221)	(p-value : 0.414)
# of observation	2,514	3,749

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

4) D^{LEV} =0 (1), when firm average leverage (LT/AT) is below (above) median value.

Table 6-15. GMM Estimations over the Small Sample : Including the Lag of Leverage

$$\text{Model}: \Delta(I/K)_{it} = \beta_1 \Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}{*}(1-LT/AT_{it-1})$$
$$+\beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1}{*}(1-LT/AT_{it-1}) + yr_t + c_i + v_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM**[2]	**'System' GMM**[3]
$\Delta(I/K)_{it-1}$	-0.272*** (0.101)[1]	-0.240*** (0.091)
$\Delta(S/K)_{it}$	0.024*** (0.007)	0.024*** (0.006)
$XRATIO_{it-1}{*}\Delta\log(XER)_{it-1}$ $*(1-LT/AT_{it-1})$	-0.941 (1.820)	-1.168 (1.289)
$MIRATIO_{it-1}{*}\Delta\log(AMER)_{it-1}$ $*(1-LT/AT_{it-1})$	5.544 (5.078)	3.767 (3.679)
Intercept	.	-0.007 (0.020)
Year dummies (Wald test)	Chi2(9)=24.21 (p-value : 0.004)	chi2(9) = 28.49 (p-value : 0.001)
Arellano-Bond AR(2) test	z = -1.60 (p-value : 0.110)	z = -1.46 (p-value : 0.144)
Hansen test of overidentification	chi2(133) = 145.01 (p-value : 0.225)	chi2(153) = 159.51 (p-value : 0.343)
# of observation	2,509	3,744

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and Δ(S/K) dated t-3 and earlier.

6.2.3.3. Firm Size

Lastly, I analyze the role of firm size on the effects of exchange rate changes on investment. To examine this, I run only the model using a firm size dummy, the results of which are presented in table 6-16.

The estimation results from the ‘system’ GMM are statistically significant and consistent with the hypothesis. The coefficients associated with the export channel in the smaller firms group and larger firms group are -1.511 and -0.913. Also, the coefficients corresponding to the imported input channel in the smaller firms group and larger firms group are 5.899 and 2.04, respectively. The absolute values of those coefficients for the smaller firms group are larger than those for the larger firms group. However, the results from the ‘difference’ GMM are not statistically significant.

On balance, based on the results on this model, I conclude that smaller firms tend to be more sensitive in their investment response to the movements in exchange rate changes through both export channel and imported input channel.

As I explained in the section concerning the results for the small sample, considering that firm size can be considered as an indicator of financial constraints, the results confirm that a firm facing financial constraints is more sensitive to the movements of domestic currency when making investment decisions.

Table 6-16. GMM Estimations over the Small Sample : Including Firm Size Dummy

$$Model : \Delta(I/K)_{it} = \beta_1\Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}$$
$$+ \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^s$$
$$+ \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}* D^s + D^s + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	**'Difference' GMM[2)]**	**'System' GMM[3)]**
$\Delta(I/K)_{it-1}$	-0.276***	-0.249***
	(0.096)[1)]	(0.092)
$\Delta(S/K)_{it}$	0.024***	0.024***
	(0.007)	(0.006)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-1.156	-1.511*
	(1.529)	(0.886)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	4.934	5.899**
	(3.952)	(2.633)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}*D^s$ 4)	-0.772	0.598
	(2.046)	(1.058)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}*D^s$ 4)	-0.778	-3.859*
	(3.383)	(2.205)
D^s 4)	.	0.036***
		(0.009)
Intercept	.	-0.020
		(0.024)
Year dummies	Chi2(9)=19.81	chi2(9) = 29.49
(Wald test)	(p-value : 0.019)	(p-value : 0.001)
Arellano-Bond	z = -1.66	z = -1.50
AR(2) test	(p-value : 0.097)	(p-value : 0.135)
Hansen test of overidentification	chi2(133) = 144.20	chi2(153) = 154.82
	(p-value : 0.239)	(p-value : 0.444)
# of observation	2,514	3,749

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : standard error with Windmeijer (2005) correction

2) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

3) The instrument set includes lagged values of the dependent variable dated t-4 and earlier, and $\Delta(S/K)$ dated t-3 and earlier.

4) If D^s =0(1), when 'average sales' is below (above) median value.

6.3. Comparison of the Results between the Two Samples

Tables 6-17 through 6-24 present the comparisons of GMM estimates of the coefficients associated with export and imported input exposure from all the models investigated in the paper using both the large sample and the small sample.

In all the models, the results for the large sample are more significant than those for the small sample. This may result from the limitations in the small sample, that is, huge data loss and the possible sample selection bias.

In the base model, the estimates of β_3 are negative while those of β_4 are positive and both are statistically significant; this is presented in table 6-17. That is, firm investment decreases (increases) with the appreciation (depreciation) of domestic currency through the export channel, and increases (decreases) with the appreciation (depreciation) of the exchange rate. However, the size of β_4, associated with imported input exposure, in the small sample is much greater than in the large sample, while the size of β_3, associated with export exposure, is not much different between the two samples. Similar results on the size of β_4 over the two samples are observed in all the models that uses dummy variables on the markup rate, cash flow, leverage and firm size.

With regard to the analysis of the role of the markup rate, both samples yield similar results overall. The results confirm that the lower the markup rate, the more sensitive the relationship between firm investment and exchange rate changes both in terms of the export channel and the imported input channel. The results from the large sample are much more significant in both the two models than those from the small sample.

The results from the two models with regard to the role of cash flow are statistically significant using the large sample. However, the results from the two models over the small sample are not significant. Also in the small sample, the signs of some coefficients are not consistent with the hypotheses.

In regard to the analysis of the role of leverage, the model employing a leverage dummy does not produce significant results, which implies that the role of leverage is not clear in the model using either of the two samples. Even though the coefficient associated with the export channel in the model using the lag of leverage over the large sample is significant, the role of leverage in the relationship between exchange rate changes and investment does not seem to be clear in both models.

Lastly, the model of the role of firm size yields similar results using the two samples. That is, the smaller the firm size, the more sensitive a firm’s investment is to the movements of exchange rates. In the large sample, all the coefficients associated with the export channel and imported input channel are significant. In the small sample, only the results from the ‘system’ GMM are significant. Using the ‘difference’ GMM for the small sample does not yield significant results.

Table 6-17. Comparison of Key Coefficients : External Exposure

$$\text{Model}: \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}$$
$$+ \beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1} + yr_t + c_i + \upsilon_{it}$$

variables	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3	-1.896***	-1.618***	-1.364	-1.305*
β_4	2.018**	1.709**	4.272	4.306**

Table 6-18. Comparison of Key Coefficients : Including Markup Dummy

$$Model: \Delta(I/K)_{it}=\beta_1 \Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1} \\ + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^{mkup} \\ + \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}* D^{mkup} + D^{mkup} + yr_t + c_i + \upsilon_{it}$$

	Large sample		Small sample	
	'Difference' GMM	'System' GMM	'Difference' GMM	'System' GMM
β_3: low markup	-2.601***	-2.211***	-1.277	-1.522
(β_5)	(1.678**)	(1.464***)	(0.547)	(1.116)
β_3+ β_5 : high markup	-0.923	-0.747	-0.73	-0.406
β_4: low markup	2.752**	2.345**	3.953	4.451*
(β_6)	(-1.841)	(-1.650*)	(-0.614)	(-1.530)
β_4+ β_6: high markup	0.911	0.695	3.339	2.921

Table 6-19. Comparison of Key Coefficients : Including the Lag of Markup Rate

$$Model: \Delta(I/K)_{it}=\beta_1\Delta(I/K)_{it-1} +\beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-mkup_{it-1}) \\ +\beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-mkup_{it-1}) + yr_t + c_i + \upsilon_{it}$$

	Large sample		Small sample	
	'Difference' GMM	'System' GMM	'Difference' GMM	'System' GMM
β_3	-2.059***	-1.729***	-1.864	-1.586*
β_4	1.316	1.094	0.946	1.403

Table 6-20. Comparison of Key Coefficients : Including Cash Flow Dummy

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}{*}D^{cfk} \\ & + \beta_6 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1}{*}\, D^{cfk} + D^{cfk} + MKUP_{it-1} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3 : low CF/K	-2.795***	-2.455***	-1.892	-0.911
(β_5)	(1.860**)	(1.943***)	(0.145)	(-0.788)
β_3+ β_5 : high CF/K	-0.935	-0.512	-1.747	-1.699
β_4 : low CF/K	2.181**	2.059***	6.032*	2.755
(β_6)	(-1.282)	(-1.885)	(-1.680)	(-0.361)
β_4+ β_6 : high CF/K	0.899	0.174	4.352	2.394

Table 6-21. Comparison of Key Coefficients : Including the Lag of Cash Flow

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}{*}(1-CFK_{it-1}) \\ & + \beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1}{*}(1-CFK_{it-1}) + MKUP_{it-1} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3	-1.017***	-0.929***	-0.132	0.081
β_4	1.940	1.834*	-2.060	-1.751

Table 6-22. Comparison of Key Coefficients : Including Leverage Dummy

Model : $\Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^{lev} + \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}* D^{lev} + D^{lev} + yr_t + c_i + \upsilon_{it}$

	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3 : low leverage	-2.055***	-1.623***	-1.781	-1.289*
(β_5)	(0.701)	(0.307)	(0.634)	(-0.479)
β_3+ β_5 : high leverage	-1.354	-1.316	-1.147	-1.768
β_4 : low leverage	1.513	1.062	5.167	3.949*
(β_6)	(0.435)	(0.682)	(-0.833)	(0.796)
β_4+ β_6 : high leverage	1.948	1.744	4.334	4.745

Table 6-23. Comparison of Key Coefficients : Including the Lag of Leverage

Model : $\Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-LT/AT_{it-1}) +\beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-LT/AT_{it-1}) + yr_t + c_i + \upsilon_{it}$

	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3	-2.157**	-1.796***	-0.941	-1.168
β_4	1.552	0.862	5.544	3.767

Table 6-24. Comparison of Key Coefficients : Including Firm Size Dummy

$$Model : \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}$$
$$+ \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^s$$
$$+ \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\, D^s + D^s + yr_t + c_i + \upsilon_{it}$$

	Large sample		Small sample	
	‘Difference’ GMM	‘System’ GMM	‘Difference’ GMM	‘System’ GMM
β_3 : small size	-2.885***	-2.573***	-1.156	-1.511*
(β_5)	(2.054**)	(1.994***)	(-0.772)	(0.598)
β_3+ β_5 : large size	-0.831	-0.579	-1.928	-0.913
β_4 : small size	3.734*	3.644**	4.934	5.899**
(β_6)	(-2.561)	(-2.852*)	(-0.778)	(-3.859*)
β_4+ β_6 : large size	1.173	0.792	4.156	2.04

Chapter 7.

CONCLUSION

The purpose of the paper is to investigate the effects of exchange rate changes on business investment through export and imported input channels. For this study, I use U.S. manufacturing firm level panel data for 1998 ~ 2007 from the 'COMPUSTAT North America' database.

The three most important variables in my study are the 'export to sales ratio', the 'imported input ratio', and the real effective exchange rate.

I create two samples in accordance with the data sources used for export ratio, which are called 'small sample' and 'large sample'. The 'small sample' uses the 'export to sales ratio' that is available from financial statement data in the 'COMPUSTAT North America' database, while the large sample uses industry level 'export to shipment ratio' as a proxy for the firm level 'export to sales ratio'.

The ratio of imported inputs to total variable cost is not directly available from a firm's financial statement. Accordingly, I estimate industry level ratios of imported inputs to total intermediate inputs using U.S. input-output tables, and then, I multiply this industry specific ratio by the firm level ratio of intermediate input to total variable costs which is available from a firm's financial statement. Thus I estimate the ratio of firm level imported input to total variable cost.

For the exchange rate variable, I use the industry specific real effective exchange rates in terms of exports and the aggregate real effective exchange rate in terms of imports, both of which are calculated by Goldberg (2004).

For the empirical analysis, I regress the change in the investment to capital ratio on: the lagged dependent variable, the change in the sales to capital ratio, exports exposure, imported input exposure and year dummies. To deal with a dynamic panel bias problem, I use GMM for dynamic panel data, where I present both the ‘difference’ GMM estimator developed by Arrelano-Bond (1991) and the ‘system’ GMM estimator proposed by Blundell and Bond (1998).

The findings of my study are as follows: first of all, in all the models, the results for the large sample are much more significant than those for the small sample. This may stem from the limitations of the small sample stated earlier in the paper, small sample size problem and possible sample selection bias problem.

Appreciation (depreciation) of domestic currency reduces (increases) firm investment through the exports channel. Also appreciation (depreciation) of the domestic currency increases (reduces) firm investment through the imported input channel.

With regard to the role of market power, firms with low markup rates are more sensitive in their investment responses to the movement in exchange rate changes both in terms of the exports channel and imported inputs channel. It is known that a firm with low market power tends to pass-through the exchange rate changes to export prices more than a firm with high market power does. These changes in the prices, with the interaction of price elasticity of demand, make sales and profits of the firm more sensitive to exchange rate changes, and thus eventually investment responses become more sensitive to the changes in exchange rates. These results are consistent with the derivation of the theoretical model and the findings of previous literatures.

With regard to the role of cash flow, my findings indicate that a low cash flow firm is more sensitive in terms of investment response to the exchange rate changes than a high cash flow firm.

With regard to the role of leverage in the relationship between exchange rate changes and investment, overall estimation results do not yield significant results using either models, though the model using the lag of leverage yields some significant results with respect to export channel. This suggests that leverage does affect the relationship between the exchange rate changes and firm investment.

Regarding the role of firm size, the results suggest that smaller firms are more responsive in their investments to exchange rate changes. This is also consistent with the derivation in the theoretical model and the findings of Nucci and Pozzolo (2001).

The findings of the paper with regard to the role of cash flow and firm size also imply that U.S. firms are exposed to widespread financial constraints. However, the results concerning the role of cash flow may partly reflect future investment opportunities to the extent that the variable on the change in the sales to capital ratio included in my empirical model cannot control for future investment opportunities perfectly.

In most of the results, the coefficients associated with the export channel are more significant than those of the imported input channel. This implies that firms' responses to the movement of exchange rates are more sensitive through the export channel than through the imported input channel.

There are some limitations in my study, the first of which concerns the samples used for the empirical analysis. The small sample may have an unknown sample selection bias, though this sample has the advantage of using firm level export sales ratio, while the large sample, created to address the limitations in the small sample, may dilute the advantages of panel data in that it uses industry level 'exports to shipment ratio' as a proxy for firm level 'exports to sales ratio'. However, these limitations on the samples are inevitable, considering that U.S. firms usually do not report their export sales in their financial statements. Another limitation concerns the exchange rate data. I could have produced more persuasive results by estimating and then using permanent component of exchange rates as well as actual exchange rates data, and then comparing the two results, since it is more reasonable to assume that firms use expected exchange rates rather than actual exchange rates in making investment decisions.

Future research could address the following issues. Cross country studies using firm level panel data of several countries would be useful in identifying possible differences in the effects of exchange rate changes and firm investment between countries. Also, studies comparing several groups of industries according to their characteristics, such as durable goods and non-durable goods, would be interesting. Until now, studies of the relationship between exchange rate changes and investment have been focused on manufacturing sectors. Analyzing service industries regarding the effects of exchanges rate changes on their investments would not only be relevant but also possible considering that U.S. government produces statistics on service trades. Another possible topic is to investigate whether the effects of exchange rate changes on investment is symmetric between periods of appreciation and depreciation.

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Appendix 1. Results with the Large Sample
: Pooled OLS, Fixed Effect, 2SLS

A1-1 : Estimation Results over the Large Sample : External Exposure

$$\text{Model : } \Delta(I/K)_{it}=\beta_1\Delta\,(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect[2]	2SLS[3]
$\Delta(I/K)_{it-1}$	-0.175***	-0.227***	-0.097***
	(0.014)[1]	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.035***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-1.247***	-1.319***	-1.619***
	(0.352)	(0.366)	(0.508)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	1.048	1.361**	2.019**
	(0.676)	(0.677)	(0.872)
Intercept	0.007	-0.045***	0.005
	(0.019)	(0.006)	(0.003)
Year dummies	F(8, 16355) =10.11	F(8, 13723) = 10.90	F(7, 13388) = 4.20
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 16355)=2.59	.	.
(F test)	(p-value : 0.000)		
R-square	0.219	0.215	0.294
# of observation	16,388	16,388	13,400

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) Random effect is rejected according to Hausman test (χ^2 (11): 327.88, p-value : 0.000).

3) 2SLS after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A1-2 : Estimation Results over the Large Sample : Including Markup Dummy

$$\begin{aligned} \textit{Model}: \Delta(I/K)_{it} = {} & \beta_1 \Delta(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * D^{mkup} \\ & + \beta_6 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * D^{mkup} + D^{mkup} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect[2]	2SLS[3]
$\Delta(I/K)_{it-1}$	-0.176***	-0.228***	-0.097***
	(0.014)[1]	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.035***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-1.788***	-1.942***	-2.418***
	(0.486)	(0.510)	(0.711)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	1.672*	2.138**	3.409***
	(0.931)	(0.928)	(1.217)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	1.348***	1.503***	1.802**
$*D^{mkup}$ [4]	(0.542)	(0.583)	(0.765)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	-1.652*	-1.925**	-3.203**
$*D^{mkup}$ [4]	(0.934)	(0.952)	(1.255)
D^{mkup} [4]	0.019***	.	
	(0.004)		
Intercept	-0.003	-0.045***	0.005
	(0.019)	(0.006)	(0.003)
Year dummies	F(8, 16352) =10.1	F(8, 13721) =10.93	F(7, 13386) =4.20
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 16352)=2.25	.	.
(F test)	(p-value : 0.001)		
R-square	0.220	0.215	0.294
# of observation	16,388	16,388	13,400

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) Random effect is rejected according to Hausman test (χ^2 (13): 2441.23, p-value : 0.000).

3) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

4) D^{mkup} =0(1), when firm average markup rate is below (above) median value.

A1-3 : Estimation Results over the Large Sample : Including the Lag of Markup Rate

$$\text{Model : } \Delta(I/K)_{it}=\beta_1\,\Delta\,(I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta\log(XER)_{jt-1}*(1-mkup_{it-1})$$
$$+\beta_4 MIRATIO_{it-1}*\Delta\log(AMER)_{t-1}*(1-mkup_{it-1}) + yr_t + \quad c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS2)
$\Delta(I/K)_{it-1}$	-0.176***	-0.229***	-0.096***
	(0.014)1)	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.035***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	-1.455***	-1.647***	-1.972***
$*(1-mkup_{it-1})$	(0.374)	(0.388)	(0.571)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	0.670	1.082	2.101**
$*(1-mkup_{it-1})$	(0.754)	(0.745)	(1.038)
Intercept	-0.000	-0.043***	0.005
	(0.019)	(0.006)	(0.004)
Year dummies	F(8, 15974) =9.28	F(8, 13382) =10.43	F(7, 13043)=4.01
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 15974)=2.43	.	.
(F test)	(p-value : 0.000)		
R-square	0.220	0.217	0.295
# of observation	16,007	16,007	13,055

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A1-4 : Estimation Results over the Large Sample : Including Cash Flow Dummy

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1\, \Delta\,(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * D^{cfk} \\ & + \beta_6 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * D^{cfk} + D^{cfk} + MKUP_{it-1} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS[2]
$\Delta(I/K)_{it-1}$	-0.182***	-0.233***	-0.097***
	(0.014)[1]	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.036***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-2.068***	-2.000***	-2.786***
	(0.486)	(0.518)	(0.704)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	1.621**	1.583**	2.551***
	(0.676)	(0.708)	(0.926)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	2.055***	1.753***	2.534***
$*D^{cfk}$ [3]	(0.614)	(0.637)	(0.841)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	-2.678**	-2.167**	-2.586*
$*D^{cfk}$ [3]	(1.157)	(1.095)	(1.457)
D^{cfk} [3]	0.006	.	
	(0.004)		
$MKUP_{it-1}$	0.054***	0.092***	0.116***
	(0.009)	(0.015)	(0.020)
Intercept	-0.008	-0.046***	0.004
	(0.019)	(0.007)	(0.004)
Year dummies	F(8, 15970) =8.95	F(8, 13379) =8.72	F(7, 13040)=3.12
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.003)
Industry dummies	F(20, 15970)=1.66	.	.
(F test)	(p-value : 0.032)		
R-square	0.228	0.223	0.301
# of observation	16,007	16,007	13,055

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

3) D^{cfk} =0 (1), when firm average cash flow rate (CF/K) is below (above) median value.

A1-5 : Estimation Results over the Large Sample : Including the Lag of Cash Flow

$$\text{Model : } \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta\log(XER)_{jt-1}{*}(1-CFK_{it-1})$$
$$+ \beta_4 MIRATIO_{it-1}{*}\Delta\log(AMER)_{t-1}{*}(1-CFK_{it-1}) + MKUP_{it-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS[2]
$\Delta(I/K)_{it-1}$	-0.181***	-0.232***	-0.096***
	(0.014)[1]	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.036***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}{*}\Delta\log(XER)_{it-1}$	-0.808***	-0.861***	-1.327***
$*(1-CF/K_{it-1})$	(0.218)	(0.242)	(0.353)
$MIRATIO_{it-1}{*}\Delta\log(AMER)_{it-1}$	1.833**	1.896**	3.118***
$*(1-CF/K_{it-1})$	(0.787)	(0.809)	(1.173)
$MKUP_{it-1}$	0.055***	0.086***	0.109***
	(0.008)	(0.015)	(0.020)
Intercept	0.003	-0.051***	0.005
	(0.018)	(0.006)	(0.003)
Year dummies	F(8, 15973)=14.69	F(8, 13381) =13.63	F(7, 13042) =4.60
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 15973)=1.60	.	.
(F test)	(p-value : 0.044)		
R-square	0.229	0.226	0.303
# of observation	16,007	16,007	13,055

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A1-6 : Estimation Results over the Large Sample : Including Leverage Dummy

$$\textbf{Model :}\ \Delta(I/K)_{it} = \beta_1\Delta\,(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^{lev} + \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\,D^{lev} + D^{lev} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS 2)
$\Delta(I/K)_{it-1}$	-0.176***	-0.227***	-0.097***
	(0.014) 1)	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.025***	0.027***	0.035***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-1.153**	-1.530**	-1.800**
	(0.564)	(0.600)	(0.805)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	0.390	1.328	2.029
	(1.598)	(1.658)	(1.989)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-0.004	0.680	0.574
$*D^{lev}$ 3)	(0.690)	(0.729)	(0.931)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	0.777	-0.149	-0.168
$*D^{lev}$ 3)	(1.532)	(1.586)	(1.940)
D^{lev} 3)	0.005	.	.
	(0.004)		
Intercept	0.004	-0.046***	0.005
	(0.019)	(0.006)	(0.003)
Year dummies	F(8, 16352) =10.17	F(8, 13721) =10.97	F(7, 13386) =4.23
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 16352)=2.15	.	.
(F test)	(p-value : 0.002)		
R-square	0.219	0.215	0.294
# of observation	16,388	16,388	13,400

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) D^{lev} =0 (1), when firm average of ‘LT/AT’ is below (above) median value.

A1-7 : Estimation Results over the Large Sample : Including the Lag of Leverage

$$Model : \Delta(I/K)_{it} = \beta_1\ \Delta\ (I/K)_{it-1} + \beta_2\Delta(S/K)_{it}+\beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*(1-LT/AT_{it-1}) + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*(1-LT/AT_{it-1}) + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS[2)
$\Delta(I/K)_{it-1}$	-0.175*** (0.014)[1)	-0.227*** (0.015)	-0.096*** (0.015)
$\Delta(S/K)_{it}$	0.025*** (0.001)	0.027*** (0.001)	0.035*** (0.001)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$ $*(1-LT/AT_{it-1})$	-1.406** (0.618)	-1.610** (0.650)	-1.655* (0.904)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$ $*(1-LT/AT_{it-1})$	0.065 (1.504)	0.814 (1.533)	1.982 (2.034)
Intercept	0.004 (0.019)	-0.045*** (0.006)	0.006* (0.003)
Year dummies (F test)	F(8, 16311) =12.01 (p-value : 0.000)	F(8, 13681) =13.13 (p-value : 0.000)	F(7, 13342) =4.80 (p-value : 0.000)
Industry dummies (F test)	F(20, 16311)=2.66 (p-value : 0.000)	.	.
R-square	0.219	0.215	0.293
# of observation	16,344	16,344	13,354

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A1-8 : Estimation Results over the Large Sample : Including Firm Size Dummy

$$\begin{aligned} \text{Model : } \Delta(I/K)_{it} = {} & \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^s \\ & + \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\ D^s + D^s + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	$2SLS^{2)}$
$\Delta(I/K)_{it-1}$	-0.176***	-0.228***	-0.097***
	$(0.014)^{1)}$	(0.015)	(0.015)
$\Delta(S/K)_{it}$	0.026***	0.027***	0.035***
	(0.001)	(0.001)	(0.001)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-1.945***	-2.302***	-2.582***
	(0.636)	(0.689)	(0.932)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	2.415	3.242*	4.068*
	(1.775)	(1.886)	(2.248)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	1.526**	2.039***	1.879*
$*D^{s\ 3)}$	(0.694)	(0.760)	(0.971)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	-2.066	-2.757	-2.885
$*D^{s\ 3)}$	(1.690)	(1.802)	(2.199)
$D^{s\ 3)}$	0.019***	.	.
	(0.004)		
Intercept	-0.008	-0.046***	0.005
	(0.019)	(0.006)	(0.003)
Year dummies	F(8, 16352) =10.18	F(8, 13721) =11.13	F(7, 13386) =4.37
(F test)	(p-value : 0.000)	(p-value : 0.000)	(p-value : 0.000)
Industry dummies	F(20, 16352)=1.70	.	.
(F test)	(p-value : 0.026)		
R-square	0.220	0.215	0.294
# of observation	16,388	16,388	13,400

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

3) D^s =0 (1), when firm average sale is below (above) median value.

Appendix 2. Results with the Small Sample
: Pooled OLS, Random Effect, 2SLS

A2-1 : Estimation Results over the Small Sample : External Exposure

$$\text{Model : } \Delta(I/K)_{it}=\beta_1\Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta \log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}*\Delta \log(AMER)_{t-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect2)	2SLS3)
$\Delta(I/K)_{it-1}$	-0.163***	-0.162***	-0.063*
	(0.029)1)	(0.029)	(0.042)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	-0.858	-1.058*	0.029
	(0.575)	(0.561)	(1.081)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	3.444*	3.329*	4.347*
	(1.908)	(1.780)	(2.764)
Intercept	0.012	-0.004	0.004
	(0.080)	(0.024)	(0.010)
Year dummies	F(9, 3715) =2.97	Chi2(9) = 26.56	F(8, 2501) =1.61
(F test, Wald test)	(p-value : 0.002)	(p-value : 0.002)	(p-value : 0.117)
Industry dummies	F(20, 3715)=1.05	.	.
(F test)	(p-value : 0.396)		
R-square	0.251	0.249	0.287
# of observation	3,749	3,749	2,514

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : robust standard error

2) Random effect is not rejected according to Hausman test (χ^2 (13): 13.15, p-value : 0.437)

3) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A2-2 : Estimation Results over the Small Sample : Including Markup Dummy

$$\textit{Model} : \Delta(I/K)_{it}=\beta_1\,\Delta\,(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}$$
$$+\ \beta_4 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}{*}\Delta log(XER)_{jt-1}{*}D^{mkup}$$
$$+\ \beta_6 MIRATIO_{it-1}{*}\Delta log(AMER)_{t-1}{*}\ D^{mkup} + D^{mkup} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect[2)	2SLS[3)
$\Delta(I/K)_{it-1}$	-0.163***	-0.163***	-0.063
	(0.029)[1)	(0.029)	(0.042)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$	-1.230	-1.374*	-0.637
	(0.754)	(0.744)	(1.354)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$	4.090*	4.115**	6.094**
	(2.198)	(2.100)	(3.112)
$XRATIO_{it-1}{*}\Delta log(XER)_{it-1}$ $*D^{mkup\ 4)}$	1.260	1.230	1.646
	(1.044)	(1.043)	(2.088)
$MIRATIO_{it-1}{*}\Delta log(AMER)_{it-1}$ $*D^{mkup\ 4)}$	-2.555*	-2.551	-4.951
	(2.025)	(2.010)	(3.160)
$D^{mkup\ 4)}$	0.022**	0.024***	
	(0.010)	(0.009)	
Intercept	0.010	-0.015	0.004
	(0.080)	(0.026)	(0.010)
Year dummies	F(9, 3712) =3.00	Chi2(9) = 27.13	F(8, 2499) =1.71
(F test)	(p-value : 0.001)	(p-value : 0.001)	(p-value : 0.091)
Industry dummies	F(20, 3712)=0.91	.	.
(F test)	(p-value : 0.573)		
R-square	0.253	0.251	0.288
# of observation	3,749	3,749	2,514

***, **, * represent significance at 1%, 5% and 10%, respectively

1) ( ) : robust standard error

2) Random effect is not rejected according to Hausman test (χ^2 (15): 18.03, p-value : 0.261)

3) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

4) D^{mkup} =0(1), when firm average markup rate is below (above) median value.

A2-3 : Estimation Results over the Small Sample : Including the Lag of Markup Rate

$$\text{Model : } \Delta(I/K)_{it} = \beta_1 \Delta(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} * \Delta log(XER)_{jt-1} * (1-mkup_{it-1}) + \beta_4 MIRATIO_{it-1} * \Delta log(AMER)_{t-1} * (1-mkup_{it-1}) + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS[2]
$\Delta(I/K)_{it-1}$	-0.161***	-0.160***	-0.060
	(0.030)[1]	(0.030)	(0.043)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-1.230*	-1.374*	-0.185
$*(1-MKUP_{it-1})$	(0.722)	(0.708)	(1.179)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	0.571	0.709	1.635
$*(1-MKUP_{it-1})$	(2.029)	(1.922)	(3.113)
Intercept	0.045	-0.043	0.000
	(0.076)	(0.029)	(0.010)
Year dummies	F(9, 3616) =3.16	Chi2(9) = 25.70	F(8, 2435) =1.57
(F test)	(p-value : 0.001)	(p-value : 0.002)	(p-value : 0.128)
Industry dummies	F(20, 3616)=1.07	.	.
(F test)	(p-value : 0.373)		
R-square	0.251	0.250	0.284
# of observation	3,650	3,650	2,448

***, **, * represent significance at 1%, 5% and 10%, respectively

[1] ( ) : robust standard error

[2] 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A2-4 : Estimation Results over the Small Sample : Including Cash Flow Dummy

$$\begin{aligned} \textit{Model} : \Delta(I/K)_{it} = {} & \beta_1\, \Delta\,(I/K)_{it-1} + \beta_2 \Delta(S/K)_{it} + \beta_3 XRATIO_{it-1} {*} \Delta log(XER)_{jt-1} \\ & + \beta_4 MIRATIO_{it-1} {*} \Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1} {*} \Delta log(XER)_{jt-1} {*} D^{cfk} \\ & + \beta_6 MIRATIO_{it-1} {*} \Delta log(AMER)_{t-1} {*}\, D^{cfk} + D^{cfk} + MKUP_{it-1} + yr_t + c_i + \upsilon_{it} \end{aligned}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect	2SLS2)
$\Delta(I/K)_{it-1}$	-0.176**	-0.176***	-0.063
	(0.029)1)	(0.029)	(0.042)
$\Delta(S/K)_{it}$	0.034***	0.034***	0.045***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-0.465*	-0.550	-0.495
	(0.834)	(0.815)	(1.465)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	1.933	2.265	5.953*
	(2.401)	(2.274)	(3.489)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-0.725	-0.677	0.698
$*D^{cfk}$ 4)	(1.075)	(1.064)	(2.058)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$ $*D^{cfk}$ 3)	0.342	0.201	-1.784
	(2.158)	(2.136)	(3.357)
D^{cfk} 3)	-0.008	-0.010	.
	(0.011)	(0.009)	
$MKUP_{it-1}$	0.158**	0.160***	0.168***
	(0.033)	(0.032)	(0.061)
Intercept	0.040***	-0.051*	0.005
	(0.075)	(0.030)	(0.010)
Year dummies	F(8, 3612) =2.34	Chi2(9) = 19.65	F(8, 2442) =1.48
(F test, Wald test)	(p-value : 0.017)	(p-value : 0.020)	(p-value : 0.159)
Industry dummies	F(20, 3612)=0.92	.	.
(F test)	(p-value : 0.560)		
R-square	0.268	0.267	0.292
# of observation	3,650	3,650	2,448

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

3) D^{cfk} =0 (1), when firm average cash flow ratio (CF/K) is below (above) median value.

A2-5 : Estimation Results over the Small Sample : Including the Lag of Cash Flow

$$\textit{Model} : \Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta\log(XER)_{jt-1}*(1-CFK_{it-1}) \\ + \beta_4 MIRATIO_{it-1}*\Delta\log(AMER)_{t-1}*(1-CFK_{it-1}) + MKUP_{it-1} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect	2SLS[2]
$\Delta(I/K)_{it-1}$	-0.172***	-0.171***	-0.060
	(0.029)[1]	(0.029)	(0.042)
$\Delta(S/K)_{it}$	0.034***	0.034***	0.046***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	0.358	0.330	0.416
$*(1-CFK_{it-1})$	(0.478)	(0.476)	(0.723)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	-2.740*	-2.612*	-3.584*
$*(1-CFK_{it-1})$	(1.609)	(1.588)	(2.119)
$MKUP_{it-1}$	0.147***	0.149***	0.147**
	(0.032)	(0.031)	(0.062)
Intercept	0.047	-0.052	-0.002
	(0.079)	(0.029)	(0.010)
Year dummies	F(9, 3615) = 1.92	Chi2(9) = 17.32	F(8, 2434) =1.48
(F test, Wald test)	(p-value : 0.045)	(p-value : 0.044)	(p-value : 0.158)
Industry dummies	F(20, 3615)=1.16	.	.
(F test)	(p-value : 0.284)		
R-square	0.270	0.268	0.292
# of observation	3,650	3,650	2,448

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A2-6 : Estimation Results over the Small Sample : Including Leverage Dummy

Model : $$\Delta(I/K)_{it} = \beta_1\Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^{lev} + \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}*D^{lev} + D^{lev} + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect	2SLS2)
$\Delta(I/K)_{it-1}$	-0.163**	-0.163***	-0.062
	(0.029)1)	(0.029)	(0.041)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-0.861	-0.931	-0.211
	(0.590)	(0.585)	(1.230)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$	3.907	3.663	6.368*
	(2.386)	(2.298)	(3.433)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$ $*D^{lev}$ 3)	-0.134	-0.371	0.090
	(1.342)	(1.324)	(2.393)
$MIRATIO_{it-1}*\Delta log(AMER)_{it-1}$ $*D^{lev}$ 3)	-0.644	-0.462	-2.931
	(2.344)	(2.319)	(3.563)
D^{lev} 3)	0.002	0.012	.
	(0.011)	(0.009)	
Intercept	0.011***	-0.050	0.004
	(0.081)	(0.030)	(0.010)
Year dummies	F(9, 3712) =2.99	Chi2(9) = 26.85	F(8, 2499) =1.61
(F test, Wald test)	(p-value : 0.002)	(p-value : 0.002)	(p-value : 0.116)
Industry dummies	F(20, 3712)=0.92	.	.
(F test)	(p-value : 0.564)		
R-square	0.251	0.249	0.287
# of observation	3,749	3,749	2,514

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

3) D^{lev} =0 (1), when firm average of 'LT/AT' is below (above) median value.

A2-7 : Estimation Results over the Small Sample : Including the Lag of Leverage

$$\text{Model : } \Delta(I/K)_{it} = \beta_1 \Delta(I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta\log(XER)_{jt-1}*(1-LT/AT_{it-1}) + \beta_4 MIRATIO_{it-1}*\Delta\log(AMER)_{t-1}*(1-LT/AT_{it-1}) + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Fixed Effect	2SLS[2]
$\Delta(I/K)_{it-1}$	-0.162***	-0.161***	-0.058
	(0.030)[1]	(0.030)	(0.042)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta\log(XER)_{it-1}$	-0.787	-1.020	1.136
$*(1-LT/AT_{it-1})$	(0.937)	(0.927)	(1.836)
$MIRATIO_{it-1}*\Delta\log(AMER)_{it-1}$	4.468	3.908	8.292*
$*(1-LT/AT_{it-1})$	(3.221)	(3.104)	(4.746)
Intercept	-0.049	-0.006	0.006
	(0.034)	(0.023)	(0.010)
Year dummies	F(9, 3710) =3.41	Chi2(9) = 26.79	F(8, 2496) =1.94
(F test, Wald test)	(p-value : 0.001)	(p-value : 0.002)	(p-value : 0.050)
Industry dummies	F(20, 3710)=1.19	.	.
(F test)	(p-value : 0.253)		
R-square	0.250	0.247	0.285
# of observation	3,744	3,744	2,509

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS is run after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

A2-8 : Estimation Results over the Small Sample : Including Firm Size Dummy

$$\text{Model : } \Delta(I/K)_{it} = \beta_1\Delta (I/K)_{it-1} + \beta_2\Delta(S/K)_{it} + \beta_3 XRATIO_{it-1}*\Delta log(XER)_{jt-1} + \beta_4 MIRATIO_{it-1}*\Delta log(AMER)_{t-1} + \beta_5 XRATIO_{it-1}*\Delta log(XER)_{jt-1}*D^s + \beta_6 MIRATIO_{it-1}*\Delta log(AMER)_{t-1}* D^s + D^s + yr_t + c_i + \upsilon_{it}$$

Dep. Var : $\Delta(I/K)_{it}$	Pooled OLS	Random Effect	2SLS2)
$\Delta(I/K)_{it-1}$	-0.164***	-0.163***	-0.064
	(0.029)1)	(0.029)	(0.042)
$\Delta(S/K)_{it}$	0.033***	0.033***	0.044***
	(0.002)	(0.002)	(0.004)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$	-1.116	-1.179	0.546
	(0.806)	(0.799)	(1.546)
$MIRATIO_{it-1}*\Delta log(AXER)_{it-1}$	5.300**	5.134**	4.325
	(2.662)	(2.589)	(3.616)
$XRATIO_{it-1}*\Delta log(XER)_{it-1}$ *D^s 4)	0.566	0.483	-1.864
	(0.989)	(0.985)	(1.790)
$MIRATIO_{it-1}*\Delta log(AXER)_{it-1}$ *D^s 4)	-3.693	-3.673	0.610
	(2.276)	(2.259)	(3.382)
D^s 4)	0.030***	0.035***	.
	(0.010)	(0.009)	
Intercept	-0.007	-0.060**	0.004
	(0.081)	(0.030)	(0.010)
Year dummies	F(9, 3712) =2.92	Chi2(9) = 26.11	F(8, 2499) =1.53
(F test, Wald test)	(p-value : 0.002)	(p-value : 0.002)	(p-value : 0.140)
Industry dummies	F(20, 3712)=0.83	.	.
(F test)	(p-value : 0.673)		
R-square	0.253	0.252	0.288
# of observation	3,749	3,749	2,514

***, **, * represent significance at 1%, 5% and 10%, respectively.

1) ( ) : robust standard error.

2) 2SLS after differencing all the variables; Instrumented variable, ΔI_{it-1}; Instruments : I_{it-2}

3) D^s =0 (1), when firm average sale is below (above) median value.

VITA

Seung-Won Lee was born on February 10, 1968 in South Korea. After attending public schools, he received a bachelor's degree in economics in 1991 and also a master's degree in public administration in 1995, respectively from Seoul National University in South Korea. In December 2008, he received a Ph. D. in Economics from the University of Missouri-Columbia. He is currently working for the Ministry of Strategy and Finance in South Korea. He has been married to Sun-Young Ko since 1995 and has a son, Jeong-Woo and a daughter, Soo-Hyung.