The Impact of the Mean Change and Volatility of Exchange Rate on the Investment in the Open Economy with Dominating FDI: Its implication to the Asian Financial Crisis

Cao Yong

Nanyang Business School, Nanyang Technological University, Singapore
Tel. (65)7904643, Fax. (65)7930523
<aycao@ntu.edu.sg>

Abstract

This paper aims to assess the impact of volatility of exchange rate on the investment of manufacturing industries in Singapore before and after Asian financial crisis. As more than 75% of investment in the manufacturing industries has been FDI in Singapore for the past two decades, such empirical study could help to explain how the change of real or long-term foreign investment in the manufacturing industries has been responded to the volatility in the Asian financial market over the crisis period. The study is based on the panel data covering 30 manufacturing industries in Singapore and the period from 1977 to 1999. To achieve the objective of the paper, the traditional investment function is revised to include the shift of means and volatility of real effective exchange rate as explanatory variables in the econometric model. The industries are also divided into different groups in terms of their capital intensities in order to verify whether the degree of impact would differ across different industries with substantial difference in capital intensity. More importantly, the coverage of financial period would enable the study to assess the impact of the crisis on the behavior of real investment expenditures.

1. Introduction

Exchange rate movements are generally believed to have substantial effects on real economic activities like trade and investment. These effects have become more pronounced after the breakdown of Bretton Woods system, with increasing number of economies switching to flexible exchange rate regimes. One of the key features of the Asian financial crisis is the dramatic depreciation of currencies in the newly industrialized countries. Such wide-spreading depreciation generated great uncertainties that affected capital markets and real economic growths in most of the Asian countries. *Jorion (1990)* pointed out that flexible exchange rate is a major source of uncertainty for trans-national companies that need to conduct businesses in foreign currencies; it is typically four times as volatile as interest rates and ten times as volatile as inflation rate[1]. Indeed, in the Asian financial crisis, most of the Asian countries had experienced excessive short-term fluctuations in exchange rate movements and, with increasingly limited foreign reserve, has had to let the exchange rate to fluctuate beyond the normal limit set by the various monetary authorities before the crisis. Based on the experience of Singapore manufacturing industries over the Asian financial period, this study aims to assess the effect of exchange rate movements on industrial investment activities.

As noted by *Campa and Goldberg (1995),* exchange rate changes can cause large shifts in relative unit labour costs and influence the prices of goods sold in domestic and foreign markets. If producers are not perfectly hedged against exchange rate movements, their short and long run profitability, overall levels of investment and even location of production facilities can be affected by the level of exchange rates. As it is, there is a global trend that firms (both large and small) are increasingly exposed to international trade. Not only are they selling more to overseas markets, they are also purchasing more intermediate inputs from abroad. Such transactions inevitably involve conversions of one currency to another. Thus, the role of exchange rate in firms' decision-making process has become more prominent than ever.

[1] Over the period 1971-87, the annualised volatility of the dollar/mark exchange rate was 12%, against a volatility of 3% for the U.S. Treasury bill rate and 1.3% for the U.S. inflation.

To date, much of the analysis on exchange rate effects consider how they affect the performance of domestic exports, i.e. international competitiveness. As conventional wisdom goes, when domestic exchange rate appreciates, locally produced goods become dearer relative to foreign competitors', hence competitiveness of local producers deteriorates. Subsequently, their profitability and investments are adversely affected. Nonetheless, a review of past empirical studies (involving both developed and developing nations) by *Kolstad and Goldberg (1994)* on this issue reveals that they can come to vastly ambiguous conclusions. *Goldberg's (1993)* empirical results indicate that U.S. dollar depreciation in the 1980s was actually followed by investment contractions in U.S. manufacturing industries. This was unexpected, given that the depreciation should lead to better competitiveness of firms, hence investment expansions. Two plausible explanations were offered. Firstly, even though dollar depreciation resulted in an increase in export competitiveness, the advantages could be offset by a simultaneous rise in imported input costs. If the latter effect were greater, this could have a negative impact on overall profitability. The second possibility, albeit weaker, is the so-called '*portfolio and wealth effects*'[2]. Its main argument is that exchange rate changes redistribute the wealth of international investors, which in turn affects their investing power. Thus, the dollar's decline weakened the investing power of Americans (who were the largest investors in U.S. during that period) relative to foreigners, which led to overall investment contraction.

Numerous studies have attempted to provide an insight into this issue, but the results are somewhat contrasting, i.e. increased exchange rate volatility can have either positive or negative effects on investment. Notable negative effects of exchange rate volatility include that of risk aversion nature of investors (Zeira, 1990), and irreversible characteristics of investment (Pindyck, 1988). Goldberg (1993) discovered that increased exchange rate volatility is associated with contracted investment in U.S. industries, especially in the durable goods sectors. On the other hand, positive implications of increased exchange rate volatility could be due to profit convexity in prices (Abel, 1983).

Having about 75 percent of investment from FDI and most of input to be imported and the majority of products to be exported, the Singapore manufacturing industries are the perfect case for assessing the possible effect of exchange rate volatility on the industrial

[2] See Froot and Stein (1991) for a similar argument, but which relies instead on imperfect capital markets

investment. The impact of dramatic depreciation of Singapore dollars during the Asian financial crisis and hence the induced volatility of exchange rate on the industrial investment can also be assessed to some degrees in this study.

The paper is organised in the following manner. Section 2 is a brief literature review of past studies on the linkage between exchange rate patterns and investment activity. Section 3 provides an insight into the industrial structure of Singapore manufacturing industries with regards to characteristics like external exposure and investment pattern, followed by a discussion on the domestic exchange rate. Section 4 establishes the theoretical model for the exchange rate-investment framework. Data and empirical estimations are then presented in section 5. The conclusion draws some implications of the study.

2. The linkage between echange rate and investment

(1) Interaction Forces Between Exchange Rate and Sectoral Investments

Exchange rate depreciation results in a fall in relative product price, causing domestic exports to be more competitive internationally. At the same time, local demand for home made import-competing goods will also strengthen since imported final goods become dearer relative to local ones when domestic currency depreciates. This implies an increase in expected profitability of domestic producers, which translates into increase in investment and expansion of production capacities. On the contrary, exchange rate appreciation results in loss of international competitiveness and profitability. This is a typical argument often raised in U.S. Congress by advocators who attempt to stimulate national output through currency depreciation (especially auto and tobacco producers whose domestic markets face stiff competition from foreigners like the Japanese). Ceglowski (1989) finds that depreciation of the dollar significantly affected imports and exports in some U.S. industries. Similarly, Goldberg (1990) discovers significant correlation between exchange rate movements and domestic investment for many U.S. industries.

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approach. In addition, Klein and Rosengren (1992) provide further reinforcements for the argument.

Notwithstanding this, while exchange rate depreciation can potentially increase both foreign and domestic demand, it may, however, trigger off real income-reducing effects. When the domestic currency depreciates, locals may perceive their real incomes to have fallen. As a result, they may decide to spend less altogether, including domestically produced output. This inevitably leads to a contraction in domestic demand. There again, the net impact depends crucially on the producer's dependence on the domestic market.

In the light of Singapore's robust export performance despite the continued appreciation of the Sing dollar[3], Tongzon and Menon (1995) examined whether a link exists between exchange rate changes and prices of Singapore's exports. Conventional *elasticity* approach has not been able to offer much insight into this phenomenon; the price elasticity estimates in most existing empirical literature are generally above unity for Singapore exports. For instance, *Lim et. al. (1988)* estimated Singapore's short and long-run price elasticities of exports at 1.67 and 2.65 respectively. A reason for the inability of the elasticities approach to account for the sluggishness of export flows to exchange rate changes may lie with incomplete pass-through. This prompted trade analysts to turn to other theories to account for the resilience of Singapore's exports. One of them is the '*pricing-to-market behaviour*', which is the practice of limiting exchange rate pass-through by adjusting firms' profit margins to remain internationally competitive. The conclusion from Tongzon and Menon (1995) is that for Singapore exporters to remain competitive, they usually adjust their markups in response to exchange rate changes.

The second aspect concerns the translation of exchange rate movements into imported intermediate input costs. Exchange rate depreciation means that more of the local currency has to be used in purchasing the same quantity of foreign intermediate inputs, thereby raising marginal costs of production. This point is especially relevant if the domestic producer has a high import content in its production process. In the absence of close substitutes for these inputs, the effect will be manifested. This is considered a form of negative supply shock that adversely affects profitability and investment of producers.

At this juncture, one sees that the net effect of a single exchange rate depreciation (or appreciation) on investment remains somewhat ambiguous. It hinges on the extent the

[3] Particularly between the period 1988 and 1993.

producer imports its inputs from abroad as opposed to its reliance on the export market. If the latter more than offsets the former, then depreciation should probably enhance profitability and investment.

In the context of Singapore manufacturing industries, since they are heavily dependent on overseas markets for both exports and imported inputs, it is believed this ambiguity is even more pronounced.

(2) Exchange Rate-Profitability Relationship

Bodnar and Gentry (1993) examined industry-level exchange rate exposures[4] for Canada, Japan and the U.S. between 1979 and 1998. They particularly stressed on industry-level analysis as they believed the effect of exchange rate movements vary across industries since each industry's relation with the world economy differed. Using augmented market model, regression results for all three countries are quite close: between 20 to 35 per cent of all industries had statistically significant exchange rate exposures. An interesting point to note is that their study suggested the impact of exchange rate movements on industry returns was larger for both Japan and Canada than for the U.S.. This coincides with international economic theory that exchange rate changes have greater impact on smaller and more internationally-oriented economies than on large continental economies like the U.S.. In another study, using a set of U.S. multinationals, Jorion (1990) found a positive relationship between these firms' exposure to exchange rate depreciation and the ratio of their foreign sales to total sales.

(3) General Equilibrium Argument

Under *general equilibrium argument*, given the existence of investment substitutability between traded and non-traded goods sectors, then with exchange rate depreciation, the resulting increase in demand for traded goods will cause scarce capital to be relocated to this sector away from the non-tradable sector (Dornbusch, 1974 and Gavin, 1988). The extent of reallocation of resources between sectors depends on the costs of relocation and the 'information content of the exchange rate signals'. The greater the uncertainty

[4] Exchange rate exposure is a measure of the correlation between real asset values and real exchange rates.

surrounding the exchange rate movement, and the costlier the reallocation process (i.e. costs arising from retraining workers and shifting plant and equipment), the greater the impediment to resource transfer. Thus, uncertainty reduces the responsiveness of investment to exchange rate changes.

(4) Location Effects

Traditionally, exchange rate movements are thought to have effects beyond adjustments in capacities of existing plants. In fact, in the longer time frame, they can even influence decisions of producers in locating their production sites across countries. Foreign direct investment (FDI) is mainly motivated by multinationals' attempt to increase flexibility of production: the producer will reallocate employment and production toward the more cost-efficient production site. With depreciation of home currency, the relative cost of producing (e.g. labour costs) in the domestic country is lowered, making it more attractive for both local and foreign firms to produce at home. Of course, the significance of this effect depends on factors like barriers to entry (e.g. initial start-up costs), non-recoverable costs of an existing industry, the type of firm level exposure to risk (e.g. through price or quantity uncertainties), and also the degree of risk-aversion of producers.

The more recent studies have deviated from the traditional argument. Aizenman (1992) analysed the implications of exchange rate flexibility for the patterns of domestic and foreign direct investments. He considered a two countries-two periods model in which there are two classes of goods. The supply side is characterised by a short-run Philips curve. In the first period, producers face investment decisions. A lag exists between the implementation of investment in productive capital and the availability of productive capacity. Producers have the flexibility to reallocate their plants to the realisation of shocks (i.e. productivity and monetary), but at the cost of extra productive capacity. A major finding of this paper is that a fixed exchange rate regime is more conducive to FDI than a flexible one. For both types of shocks, the resultant FDI was always higher under the fixed exchange rate regime. Under a flexible exchange rate regime, the concavity of the production function meant that any nominal monetary shock would reduce expected profits, hence investments fall.

(5) Portfolio and Wealth Effects

Under the *portfolio and wealth effects argument*, exchange rate movement is capable of altering the relative wealth positions of international investors. As a consequence, the investment demands for domestic versus foreign assets will change in alignment with investor-specific characteristics like degree of risk aversion and preference for home assets relative to foreign ones[5]. Take for instance yen appreciates against the U.S. dollar. In a way, the Japanese investor gains wealth relative to his American counterpart (i.e. in terms of investing power), and a corresponding shift in aggregate portfolio and direct investment demands occur. Suppose Japanese investors favour home assets to foreign ones (say due to strong nationalist feeling), then this wealth redistribution channel will diminish overall Japanese investments to the U.S.. On the other hand, if their preference is inclined towards U.S. assets (e.g. they feel that American assets are more worthwhile), then the converse will occur. Thus one follows from here that the preference of the group that enjoys an exchange rate gain ultimately has a stronger influence on investment pattern.

However, some international economists counter-argue this theory and disregard the existence of a direct relationship between foreign investments and exchange rate movements. They argue that in a world of mobile capital, risk-adjusted expected returns on all international assets will be equalised. From the *industrial organisation* view of FDI[6], the latter occurs not because of cost-of-capital differences, but because certain domestic assets are worth more under foreign control.[7] There are no real benefits to be reaped by foreigners when the U.S. dollar depreciates: the U.S. becomes a cheaper place for any firm to produce. Froot and Stein (1991) noted that between the period 1973 to 1988, whenever there was depreciation of the US dollar, it was followed by a dramatic increase in FDI into the U.S. While Froot and Stein (1991) emphasize on relative wealth effects, Klein and Rosengren (1994) instead attempt to look at the effect of currency movements on relative labour costs. Under their framework, FDI represents capital seeking relatively cheap labour. This is particularly true in industrialised countries (e.g.

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[5] Froot and Stein (1991) offer an alternative set of arguments based on imperfect capital markets.
[6] As mentioned in Froot and Stein (1991), Kindleberger (1969) and Vernon (1966) were the pioneers of this theory. Unfortunately the latter two articles are not available. For further reference, 1): Kindleberger, Charles, American Business Abroad: Six Lectures on Direct Investment, Yale University Press, 1969 ; 2): Vernon, Raymond," International Investment and International Trade in the Product Cycle", Quarterly Journal of Economics, May 1966.
[7] For instance, a Japanese auto maker may manage an existing plant more efficiently than his counterpart, and thus willing to pay a premium over the domestic bidder.

EMU), where relative labour costs are primarily determined by exchange rates. This assertion is supported by Cushman (1987) whose data show that a rise in the host-country wage or a fall in the source-country wage discourages FDI. Nevertheless, Klein and Rosengren (1994) final results only support the relative wealth hypothesis, but not the relative wage hypothesis. There was strong evidence to suggest relative wealth significantly affected U.S. inward foreign direct investment (FDI). Between 1982 and 1994, FDI to U.S. tended to decrease with a strong dollar and increase with a weak dollar. Alas, as it is inherently hard to establish a general preference (of home versus foreign assets) for the investors, the portfolio and wealth effects of an exchange rate change on investment is often ambiguous.

(6) **Exchange Rate Volatility and Investments**

When a firm decides whether to invest, the element of uncertainty plays an important role. Uncertainty can come from many areas; it may be from the demand for the product, cost of factors of production, and most certainly exchange rate risks which have direct impact on profitability. The 1997 Asian crisis clearly demonstrates how rapidly plunging currencies can cripple once healthy firms, especially if they are not well-hedged against exchange rate risks. Pindyck (1988) noticed that most investment expenditures are at least partly irreversible because such capital is industry- or firm-specific and cannot be used for other firms or industrial purposes should the owner later decide to withdraw. Irreversible investment, together with uncertain future demand or cost conditions, mean that if a firm chooses to invest today, it 'kills an option' to invest at a later date. Pindyck (1982) and Abel (1983) argued that given the current price of output, greater uncertainty leads to a higher rate of investment, regardless of the curvature of the marginal adjustment cost function[8]. However, Campa (1993), using a sample of 61 SIC U.S. wholesale industries (1980s data), found that the magnitude of FDI in these industries is negatively correlated with exchange rate volatility and the negative effects are especially pronounced in those industries involving high sunk costs. Arize (1995), Kulatilaka and Kogut (1996) and Varangis and Qian (1994) also pointed out that, since the fluctuation of exchange rates is a form of uncertainty, it would discourage trade and deter firms from investing in production capacity. This is even more so for the more risk-averse firms.

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[8] The assumption here is that the firm is perfect-competitive and risk-neutral.

In summary, the above arguments do not suggest a unique connection between exchange rate movement and investment. However, the following observations can be made to in regarding to the empirical research in this study:

(1) There is an increasing consensus that the positive effect of currency depreciation on economic growth through the improvement of export competitiveness may be substantially tradeoff by the negative effect resulted from uncertainty and wealth effect.

(2) There is also an increasing consensus that the volatility of exchange rate would affect international investment in general and foreign direct investment in particular. Hence, the open economies would be mostly affected from exchange rate volatility.

3. Model specification

Given that the primary objective of an internationally oriented producer is to maximise profits, it purchases inputs from lowest-cost sources, be it domestic or foreign, sells output in both domestic and foreign markets. Assume a constant-returns-to-scale Cobb-Douglas production technology for the firm's production occurring domestically, we have the production function for this representative producer *i* as:-

$$(1) \qquad y_i = (k^*)^{\alpha_i} (k)^{1-\alpha_i}$$

where y_i is output; k and k^* are domestic and foreign factors of production respectively; and α is the share of imported inputs in total production. All units of labour input are assumed to be supplied domestically, which implies that they can be directly subsumed into $(1-\alpha_i)$. The cost function faced by this same producer *i* takes the form:

$$(2) \qquad c_i = \{(1-\alpha_i)^{\alpha_i} \alpha_i^{-\alpha_i}\}\{w^{1-\alpha_i}(ew^*)^{\alpha_i} y_i\}$$

where e is the mean exchange rate (defined in terms of a basket of foreign currencies against a unit of local currency), w and ew^* are the home currency valued input prices of *k* and *k** respectively. To determine the effects of exchange rate changes on expected profits, a general profit function π_i is given as follows:

where p_i and p_i^* are local and foreign prices of good *i* respectively. Further specifying

$$(3) \quad \pi_i = f(e, p_i, p_i^*, w, w^*)$$

$$(4) \quad \pi_i = p_i(\hat{q}_i) \cdot \hat{q}_i + e p_i^*(\hat{q}_i^*) \cdot \hat{q}_i^* - c_i(\mathrm{e}, \mathrm{w}, \mathrm{w}^*, \mathrm{y}_\mathrm{i})$$

where $\hat{q}_i, \hat{q}_i^* \geq 0$

equation (3) leads to:

q_i and q_i^* are the output sold to domestic and foreign markets respectively, *and* $q_i + q_i^* = y_i$. Incidentally, the first term in (4) is domestic sales and the second is export sales in domestic valuation. The third term is the total cost of producing aggregated output y_i. Following from this equation, exchange rate affects profits through export sales and production cost. This is the crucial linkage between exchange rate and investment (i.e. through expected profits).

The exchange rate is assumed to follow a general log-normal distribution of the form:

e is the mean and σ^2 the variance of exchange rate respectively. A log-normal

$$(5) \quad f(x) = \frac{1}{\sqrt{2\pi}\sigma_x} \exp\left[-\frac{1}{2}(\ln x - e/\sigma)^2\right]$$

where $x \geq 0$

$$E[x] = \exp\left(e + \frac{\sigma^2}{2}\right)$$

and

$$Var[x] = \exp(2e + \sigma^2)[\exp(\sigma^2) - 1]$$

variable x has:

Under this model, the main source of uncertainty comes from exchange rate fluctuations. Using cost equation (2), and incorporating the uncertainty element of exchange rate, (4) is rewritten as:

$$(6)\quad E(\pi_i) = p_i(q_i)\cdot q_i + \exp\left(e + \frac{1}{2}\sigma^2\right)p_i^*(q_i^*)\cdot q_i^* - \exp\left(\alpha_i e + \frac{1}{2}\alpha_i^2\sigma^2\right)\cdot w^{1-\alpha_i} w^{*\alpha_i}(q_i + q_i^*)$$

Furthermore, by normalising foreign input costs w[*] to equal one, (6) is reduced to:

$$(7)\qquad E(\pi_i) = p_i(q_i)q_i + E(e)p_i^*(q_i^*)q_i^* - E(e^{\alpha_i})\cdot w^{1-\alpha_i}(q_i + q_i^*)$$

Based on (7) above, exchange rate variability affect expected profit namely through foreign sales and cost of production. Hence, changes in expected profit due to changes in the mean of exchange rate, normalised by total revenue, can be written as:

$$(8)\qquad \left.\frac{\partial E(\pi_i)}{\partial \mu}\right/ TR_i = x_i - \varphi_i \alpha_i$$

$$\text{where}\quad x_i = \frac{p_i^*(q_i^*)\cdot q_i^* \exp\left(e + \frac{1}{2}\sigma^2\right)}{p_i(q_i)\cdot q_i + p_t^*(q_i^*)\cdot q_i^* \exp\left(e + \frac{1}{2}\sigma^2\right)}$$

$$\textit{and}\quad \varphi_i = \frac{w^{*\alpha_i} w^{1-\alpha_i}(q_i + q_i^*)\exp\left(\alpha_i e + \frac{1}{2}\sigma^2\alpha_i^2\right)}{p_i(q_i)\cdot q_i + p_i^*(q_i^*)\cdot q_i^* \exp\left(e + \frac{1}{2}\sigma^2\right)}$$

According to (8), the response of expected profits to changes in the mean of the exchange rate depends on three variables. The first, χ_i, is the export share of total sales in the industry; φ_i is the ratio of expected costs to expected revenues; and α_i is the share of imported inputs in total production. The sign of χ_i is purportedly positive: Given all other things the same, exchange rate depreciation improves the export competitiveness of an industry with higher export share relatively more than another with a lower export share.

On the other hand, the sign of $\varphi_i\alpha_i$ is negative: Exchange rate depreciation hurts relatively more an industry with a higher content of imported inputs, since its overall production cost is more substantially raised. Besides imported input share α_i, the industry profit margin is expected to have an effect on this relationship as well. Following the methodology used in Domowitz, Hubbard and Peterson (1986), industry profit margin can be approximated by price-over-cost markup (MKUP), given as

$$\text{MKUP} = \frac{\text{Value of Sales} + \Delta\text{Inventories - Payroll - Cost of Materials}}{\text{Value of Sales} + \Delta\text{Inventories}}$$

which is identical to

$$\text{MKUP} = \frac{\text{Value Added - Payroll}}{\text{Value Added} + \text{Cost of Materials}}$$

Taking the *price-over-cost markup ratio* for industry i as MKUP_i, then $\varphi_i = \dfrac{1}{1 + MKUP_i}$.

Industries with a low profit margin (equivalent to a high φ_i) are less able to absorb losses due to adverse exchange rate effects, and this explains the negative sign attached to φ_i. Based on what we have seen so far, the net effect of a change in mean of exchange rates on expected profits is ambiguous. It really depends on the relative strengths of export and

$$(9) \qquad \frac{\partial E(\pi_i)}{\partial \sigma^2} \Big/ TR_i = \frac{1}{2}\left(x_i - \varphi_i \alpha_i^2\right)$$

imported input exposures. Besides the mean of exchange rate, changes in the variance of the exchange rate process also has an effect on expected profit. Referring to (7), this response, normalised by total revenue, is given as:

The Cash Flow Model[9] of investment is used to relate investment to exchange rate movement. According to the cash flow model, the internally generated cash flow, as opposed to external equity financing, has a significant impact on investment behaviour.

[9] The Cash Flow model has been initiated by John R. Meyer & Edwin E. Kuh (1957) and James Duesenberry (1958).

Hence, investment spending is believed to be a variable portion of internal cash flow. But the internal cash flow is directed determined by profit. Hence, the optimal capital stock in time period t, K_t, is a linear function of firms' expected profits π_t, we have:

$$(10) \qquad K_t^* = \phi(\pi_t)$$

Substitute this into a typical investment function

$$(11) \quad I_t = \lambda_t (K_t^* - K_{t-1}) + \delta K_{t-1} = \lambda_t K_t^* + (\delta - \lambda_t) K_{t-1}$$

We get:

$$(12) \qquad I_t = \lambda_t \phi(\pi_t) + (\delta - \lambda) K_{t-1}$$

Or, considering that $I_t = K_t - K_{t-1}$, the above equation can be re-written as:

$$(13) \qquad K_t = \lambda_t \phi(\pi_t) + (\delta - \lambda + 1) K_{t-1}$$

If we define expected profit as

$$(14) \qquad \pi_t = E(\pi_t(e_t, p_i, p_i^*, w_t, w_t^*), r_t)$$

Where E_t is the mean exchange rate at time t,

p_t, p_t^* Are the prices of good in domestic and foreign markets in time period t, respectively

w_t, w_t^* Are the domestic and foreign wage costs in time period t, respectively

R_t is the rate of interest at time t

Equation (13) can be written as :

$$(15) \qquad K_t = \lambda_t \phi(E(\pi(e, p_i, p_i^*, w, w_i^*), r)) + (\delta - \lambda + 1) K_{t-1}$$

Taking total differentiation to (15), we have

(16) $$dK_t = \lambda d(\phi(E(\pi(...),r)) + (\delta - \lambda + 1)dK_{t-1}$$

or

(17) $$I_t = \lambda d(\phi(E(\pi(...),r)) + (\delta - \lambda + 1)I_{t-1}$$

Taking into account the discussion on the determinants of expected profit from (7), (17) indicates that investment may be explained by the following:

- change in sales, y
- change in the mean of exchange rate, e; according to (8), this will be associated with export share, imported input share and markup ratio,
- change in the variance of exchange rate, σ^2; where export share, imported input share and markup will interact with it through (9),
- change in interest rate r, and lastly,
- lagged investment

Based on (17), an econometric model may be specified as follows:

(18) $$I_t^i = \beta_0 + \beta_1 \frac{y_t^i}{y_{t-1}^i} + (\beta_2 \gamma_t^i) \frac{e_t}{e_{t-1}} + (\beta_3 \gamma_t^i) \frac{\sigma_t^e}{\sigma_{t-1}^e} + \beta_4 r_{t-1} + \beta_5 I_{t-1}^i + \varepsilon_t^i$$

where all variables are in logarithm form

I_t^i	*Investment in industry i in period t (note: investment is defined as expenditure on all fixed assets)*
Y^i_t	*Sales by industry i in period t*
e_t^i	*Mean of real effective exchange rate (REER), which can either be weighted by export-trade or import-trade in period t*

(a rise in e indicates appreciation of local currency)

$\sigma^{2\,i}_{t}$ *Volatility of REER, weighted by either export-trade or import-trade, in period t*

γ_t^i *It may represent one of the following: export share (EXP), import share (IMP), price-over-cost markup (MKP), index of effective exposure (IEE), or simply takes on a value '1'.*

r_t^i *Interest rate (proxied by SIBOR)*

Equation (18) indicates that current investment of industry i depends on:

- Change in sales of industry i from the previous period (coefficient β_1). The estimated coefficient is expected to be positive as increase in sale would normally encourage more investment.
- Change in e, the mean of exchange rate (coefficient β_2); this can be an independent effect, meaning that it simply measures how a change in mean exchange rate affects investment. Alternatively, it can also be an 'interacted effect'. That is to say, the export share, import share, price-over-cost markup, or net exposure (i.e. IEE) of the industry is simultaneously taken into consideration when measuring exchange rate effects on investment. Since we defined the Singdollar effective exchange rate as one Singdollar against the foreign currencies, the rise of the effective exchange rate would mean the worsening terms of trade for exporters. According to the conventional wisdom, depreciation would help export as well as investment and hence the sign of β_2 would be negative. But many other theories discussed in section 2 nevertheless suggest that the sign might be positive instead.
- Change in the variance of exchange rate (coefficient β_3); once again, the effect can be independent, or interacted with export share, import share, price-over-cost markup or IEE. The sign of β_3 is expected to be negative as the volatility would cause investors' uncertainty and hence reduce investment.
- Change in interest rate (coefficient β_4). The coefficient is expected to be negative.
- Lagged investment of industry i (coefficient β_5).

Finally, to take the Asian financial crisis into the consideration, a dummy variable that approximates the impact of the crisis on investment will be added into the regression. We would expect the estimated coefficient of the dummy variable to be generally negative.

4. Data and Statistic Features of Singapore Manufacturing Industries

The main sources of data used in this study are '*Report on the Census of Industrial Production, Singapore*', '*Singapore Input-Output Table*', '*DataStream*'[10]and '*World Trade Data*'. The *Census of Industrial Production, Singapore* (henceforth referred to as *Census*) comprises comprehensive data on the local manufacturing sector for all establishments with 10 or more workers. The activities covered under the *Census* include manufacturing and industrial servicing. All activities are classified according to the latest version (1999) of two-digit level Singapore Standard Industrial Classification (SSIC) codes. Definitions and concepts used in the *Census* are generally in accordance with United Nation's recommendations for basic industrial statistics, but with certain modifications to suit local requirements and conditions. Annual Census data of the following variables for 18 industries from the period of 1977 to 1999 are used:

- *Gross Output* refers to the total value of all commodities produced (including by-products) and industrial services rendered during a given year. The valuation of commodities produced is at ex-factory price. This excludes excise duties and outward transport charges. The value of output is computed from the value of goods manufactured and changes in stocks during the year.
- *Material Inputs* comprise of actual consumption of raw or basic materials, chemicals and packing materials used in production during the year. In cases where information on materials consumed are not directly available, it is computed from total purchases of materials and changes in stocks. All valuations are at cost, which include delivery charges, commissions and duties.
- *Sales and Direct Exports* include domestically manufactured goods that are sold locally or directly exported to other countries. Excluded are resale goods not manufactured by the establishments.

[10] This is an on-line database.

- *Investment* covers all expenditure on capital assets, which are broadly classified into two major groups, namely land/building/structure and transport equipment/machinery/office equipment.
- *Net Operating Surplus* is obtained by deducting remuneration, depreciation of fixed assets and indirect taxes from net value added.

Data on exchange rates and interest rate are primarily extracted from *Datastream*. The real effective exchange rate (REER) index is constructed based on a trade-weighted basket of bilateral exchange rates (against the Sing dollar) of twelve major trading partners. There are two versions of exchange rates used in the empirical study. One is export-weighted, meant to examine the response of export-competitiveness[11] to exchange rate changes. The other is import-weighted, intended to measure the response of imported input cost to changes in exchange rate. The interest rate variable is proxied by the average monthly Singapore inter-bank overnight rates (SIBOR).

Before going to econometric estimation, it may worthwhile to review some basic feature of the used variables. The Singapore manufacturing industries have undergone drastic changes in terms of industrial content since Singapore became independent republic in 1965. In the initial phase (1965-1970) when there was abundant labour supply and wages were low, it was dominated by labour-intensive industries such as textile and footwear industries. However as the economy grew quickly and the demand for labour outstripped supply, wages rose significantly. The manufacturing industries switched to capital intensive development from early 1980s. The second half of 1980s saw Singapore's foray into higher-end electronics such as semi-conductor and disk drive. In more recent years, Singapore has intensified its efforts to become an R&D hub in the region for both MNCs and local companies. FDI has been the dominant force for the local manufacturing sector, providing most of the investment capital and technical know-how[12]. Table 1 shows that investments from local, U.S.A and Japanese firms appear to be of roughly the same magnitude throughout the 1990s. These three sources account for almost 80% of total investments within this period. Local investments have been relatively stable in the 30% range, with FDI contributing the remaining two-third of total investments. This has an

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[11] Changes in export-competitiveness affect an industry's profitability, which in turn influences investment. The theory pertaining to this linkage has already been raised in chapter two.

[12] For instance in 1985, FDI contributed 70% of gross output, 69% of value-added, 54% of employment and

important underlying implication: the *wealth and portfolio effects*[13] of exchange rate changes ought to be significant for domestic manufacturing sector. That is, shifts in exchange rate directly affect the wealth positions of foreign investors, which could potentially influence their decisions to invest here.

Table 1: Gross Fixed Assets Investment by Country (S$ mil)

Countries	**1982**	**1986**	**1990**	**1994**	**1996**	**1997**	**1998**	**1999**
Singapore	4,910	6,804	8,682	13,321	17,339	19,578	21,079	22,541
USA	3,118	5,137	8,037	12,124	14,848	19,335	20,144	20,764
Japan	1,614	3,369	7,596	10,798	12,833	14,747	15,512	16,627
Europe	3,794	4,595	7,161	9,354	9,616	11,593	11,632	13,119
Others	1,093	1,019	1,338	1,949	2,131	2,250	2,042	2,080
Total	**14,528**	**20,924**	**32,815**	**47,546**	**56,767**	**67,503**	**70,410**	**75,132**

Source: Report on the Census of Industrial Production, various years.

Due to small size and lack of nature resource, Singapore manufacturing industries are featured as producing export from imported input. In 1977, the top three industries with the highest export shares were electronics, precision instruments and petroleum products (with 90%, 84% and 75% respectively). Ten out of eighteen industries had export exposure of more than 50%. Twenty years later in 1996, there seems to be little change in the top ranking. However, the number of industries with more than 50% export exposure has fallen to seven. Some industries like electronics and refined petroleum have seen their export share declined[14], while their output have increased drastically over the same period.[15] This is largely due to the fact that domestic industries are increasingly selling more to local firms.[16] In other words, the domestic industrial base has become more integrated and local firms are more interdependent on one another. For instance, many local small and medium sized firms[17] supply peripheral components to MNCs like *Seagate* and *Hewlett Packard*.

80% of direct exports.
[13] This concept has been brought up earlier on in chapter two.
[14] Nevertheless, this decline in the latter industry could be due to a gradual fall in petroleum prices.
[15] For example, the gross output of electronics industry has increased from S$2.1 billion in 1977 to S$61 billion in 1996.
[16] This is evident from the Input-Output tables (1983, 1988 and 1990) , which reveal that inter-industry sales within the domestic economy have greatly expanded over time.
[17] These include establishments involved in activities like plastic mold injection and LED displays, etc.

Table 2 Export Exposure of Industries (%)

Industry	1977	1980	1985	1990	1996	1997	1998	1999
F&B and Tobacco Products	39.4	45.2	50.9	48.7	48.0	45.4	42.8	40.8
Textiles & Textile Manufactures	58.2	50.1	37.1	38.3	38.2	44.3	39.5	38.7
Wearing Apparel Except Footwear	70.6	71.0	75.8	82.9	77.3	80.8	85.8	85.8
Leather, Leather Products & Footwear	49.5	39.3	33.2	32.4	36.7	59.9	63.8	72.3
Wood & Wood Products except Furniture	60.6	54.6	46.6	51.3	30.8	23.1	25.0	29.8
Paper & Paper Products	14.9	9.1	35.7	37.5	35.0	35.7	34.2	36.9
Publishing, Printing & Reproduction of Recorded Media	20.0	18.1	15.9	20.3	24.1	24.2	25.1	24.9
Refined Petroleum Products	75.2	67.3	63.8	56.5	33.9	38.4	29.4	27.2
Chemicals & Chemical Products	45.3	58.2	64.8	68.9	74.5	68.5	71.3	75.8
Rubber & Plastic Products	29.2	27.7	21.0	23.6	20.2	25.6	29.7	33.1
Non-metallic Mineral Products	15.6	20.4	7.9	12.1	11.9	11.2	12.2	18.4
Basic Metals	26.2	41.9	35.7	33.5	24.1	25.6	20.7	20.5
Fabricated Metal Products except Machinery & Equipment	23.5	29.4	25.2	29.2	27.3	27.5	27.3	31.1
Machinery & Equipment	64.3	68.9	59.9	58.9	55.9	53.7	61.4	59.6

Electrical Machinery & Apparatus	64.3	61.4	67.2	63.3	54.3	55.3	53.0	55.0
Electronic Products & Components	90.0	87.1	89.5	85.4	77.1	76.8	78.6	77.6
Medical, Precision & Optical Instruments, Watches & Clocks	84.4	91.7	94.1	90.2	84.0	88.6	89.7	89.6
Transport Equipment	55.7	51.2	60.0	60.3	50.6	50.0	51.0	54.9

Source: Report on the Census of Industrial Production, various years.

Imported input exposure measures constructed from the Singapore input-output tables are presented in Table 3. Following Goldberg (1993) and Campa & Goldberg (1997), the imported input share for industry i α^i is derived as follows:-

Where I = Index representing the output industry

J = Index representing the production input industry

m^j_t = Share of imports in consumption of industry j in period t

$p^j_t q^i_{j,t}$ = Value of inputs from industry j used in the production of industry i in period t

M^i_t = Direct imports of industry i in period t

VP^i_t = Value of total production of industry i in period t

Based on 1990 figures, the top three industries in terms of imported input exposure are refined petroleum, electronic and textile. Generally, the majority of industries do not have drastic change in their imported input share over the period 1983 to 1990. On average, the manufacturing industries have imported input share of 53% in 1990. By comparing the imported input share in 1983 with 1990, eleven out of the eighteen industries experience an increase in imported input share. All things remaining the same, this implies that response of imported input cost to changes in exchange rate should become more significant over this period.

Table 3. Imported Input Share of SSIC Industries

Industry	**1983**	**1988**	**1990**
F&B and Tobacco Products.	0.529	0.480	0.467

Textiles & Textile Manufactures	0.585	0.622	0.604
Wearing Apparel Except Footwear	0.515	0.593	0.588
Leather, Leather Products & Footwear	0.495	0.574	0.502
Wood & Wood Products except Furniture	0.594	0.591	0.542
Paper & Paper Products	0.455	0.555	0.516
Publishing, Printing & Reproduction of Recorded Media	0.358	0.420	0.380
Refined Petroleum Products	0.923	0.891	0.885
Chemicals & Chemical Products	0.361	0.359	0.409
Rubber & Plastic Products	0.688	0.516	0.549
Non-metallic Mineral Products	0.497	0.500	0.439
Basic Metals	0.425	0.589	0.579
Fabricated Metal Products except Machinery & Equipment	0.507	0.534	0.502
Machinery & Equipment	0.474	0.530	0.507
Electrical Machinery & Apparatus	0.539	0.561	0.551
Electronic Products & Components	0.686	0.666	0.673
Medical, Precision & Optical Instruments, Watches & Clocks	0.474	0.436	0.477
Transport Equipment	0.328	0.391	0.399

Source: Derived from the Report on Census of Industrial Production (various years) and Singapore Input-Output Tables (1983, 1988 & 1990).

The net external exposure of an industry can be achieved by combining the export exposure with the imported input exposure to derive at the *Index of Effective Exposure (IEE)*[18]. This index is a ratio of the export exposure to the imported input exposure, which is:

$$IEE_t^i = \frac{\chi_t^i}{\alpha_t^i}$$

where χ_t^i = export/sales

and α_t^i = imported input share

[18] The IEE index was first used in Goldberg (1993),and also subsequently in Campa and Goldberg (1997).

If the IEE is greater than one, it means that the export exposure of an industry is greater than its imported input exposure. With exchange rate depreciation, the export competitiveness of this industry improves, but at the same time its profitability is hurt as a result of higher imported input costs. However, the former effect is relatively stronger than the latter (since export exposure is greater); thus overall, this industry should potentially benefit from exchange rate depreciation. The resulting increase in expected profitability will usher in more investments for this industry. On the contrary, an industry with IEE less than one implies that its imported input exposure is greater than its export exposure. Exchange rate depreciation could then hurt this industry on the whole. Based on table 4, the number of industries with IEE greater than one in the above period has remained relatively stable over time. There are generally more industries with imported input exposure greater than export exposure.

Table 4: Evolution of Export Exposure, Imported Input Exposure and Net External Exposure of Singapore Manufacturing Industries through Two Decades

	1983			1988			1991		
Industry	χ_i	α_I	IEE_i	χ_i	α_i	IEE_i	χ_i	α_i	IEE_i
F&B and Tobacco Products	0.462	0.529	0.874	0.478	0.480	0.996	0.470	0.467	1.005
Textiles & Textile Manufactures	0.403	0.585	0.688	0.359	0.622	0.578	0.396	0.604	0.656
Wearing Apparel Except Footwear	0.696	0.515	1.352	0.839	0.593	1.415	0.818	0.588	1.392
Leather, Leather Products & Footwear	0.261	0.495	0.528	0.264	0.574	0.460	0.366	0.502	0.729
Wood & Wood Products except Furniture	0.492	0.594	0.829	0.501	0.591	0.848	0.432	0.542	0.797
Paper & Paper Products	0.301	0.455	0.661	0.372	0.555	0.670	0.374	0.516	0.726
Publishing, Printing & Reproduction of Recorded Media	0.155	0.358	0.431	0.209	0.420	0.498	0.233	0.380	0.612

Refined Petroleum Products	0.645	0.923	0.699	0.633	0.891	0.710	0.410	0.885	0.463
Chemicals & Chemical Products	0.640	0.361	1.772	0.656	0.359	1.825	0.698	0.409	1.706
Rubber & Plastic Products	0.288	0.688	0.419	0.222	0.516	0.431	0.238	0.549	0.433
Non-metallic Mineral Products	0.159	0.497	0.319	0.137	0.500	0.274	0.107	0.439	0.244
Basic Metals	0.216	0.425	0.508	0.371	0.589	0.629	0.226	0.579	0.390
Fabricated Metal Products except Machinery & Equipment	0.263	0.507	0.520	0.290	0.534	0.542	0.273	0.502	0.544
Machinery & Equipment	0.699	0.474	1.475	0.602	0.530	1.135	0.614	0.507	1.210
Electrical Machinery & Apparatus	0.613	0.539	1.138	0.634	0.561	1.130	0.613	0.551	1.113
Electronic Products & Components	0.874	0.686	1.274	0.863	0.666	1.296	0.821	0.673	1.220
Medical, Precision & Optical Instruments, Watches & Clocks	0.937	0.474	1.977	0.939	0.436	2.153	0.914	0.477	1.915
Transport Equipment	0.533	0.328	1.625	0.697	0.391	1.783	0.603	0.399	1.512

Source: Computed from the Report on Census of Industrial Production and Singapore Input-Output tables.

At the time of Singapore's independence from Britain in 1965, Singdollar was pegged to the British pound. Then it gave way to U.S. dollar peg when the pound was devalued in 1972. However not long after that, the weakening of U.S. dollar prompted the Monetary Authority of Singapore (MAS) to peg the Singdollar to an undisclosed trade-weighted basket of currencies of her major trading partners. Since then, to a large extent, Singapore is said to operate a managed-float exchange rate system. Before the Asian financial crisis, Singdollar had been on the upward trend against the currencies of most of her trading partners. After the financial crisis, Singapore dollar has depreciated largely against currencies of most developed countries but appreciated against the Asian trade partners except Hong Kong and China. *Trade-Weighted Real Effective Exchange Rate* (henceforth known as REER) index is hence derived as a comprehensive measure of the strength of a currency versus a basket of other currencies in real terms. Trade aggregates of major trading partners are used as weights for the computation of REER. The first step in the calculation of this index is to decide which currencies are to be included in the basket. The conventional criterion is to use trade contributions by trading partners of the host country[19]. The countries with highest aggregates are selected and weights are assigned accordingly based on their respective trade contributions. In my study, the selected basket comprises of currencies from 12 countries, which account for more than 70% of Singapore's total trade[20]. The included countries are Australia, China, France, Germany, Hong Kong, Indonesia, Japan, Korea, Malaysia, Thailand, U.K. and U.S.A.. The derived REER is the geometric average of its exchange rate in the foreign currencies multiplied by the relative consumer price indices, weighted by their respective bilateral trade contributions.

$$e_t = \prod \left(R_t \cdot \frac{q_t^l}{q_t^{f,i}} \right)^w$$

Where

	Π	=	Symbol indicating product of elements
	R_t	=	Nominal exchange rates (i.e. foreign currencies per local currency) in period t
	w	=	Trade weights assigned to each trading partner's currency
	q_t^l	=	Consumer price index of local country in period t
	$q_t^{f,i}$	=	Consumer price index of foreign country i in period t

For purpose of this study, I construct two variations of REER. One index is weighted by export trade; this is to be used for analysing the export competitiveness aspect of exchange rate movement. The other index is weighted by import trade, which is meant to capture the response of imported input cost to changes in exchange rate. From Table 5, we see that generally Singdollar has appreciated against the basket of currencies between 1977 and 1997 but depreciated after 1997. However, the Asian financial crisis caused the Singdollar to depreciate dramatically and such depreciation has hence also caused dramatic volatility in the Singdollars.

Table 5: Exchange rate of Singapore Dollar, 1980 - 1999

[19] Trade contributions are derived by summing up total exports to and imports from each trading partner.
[20] From 1990 to 1996, on average these 12 countries make up more than 70% of Singapore's total trade.

Years	S$/US$	REER (Export-weighted) Foreign currencies/S$	REER(Import-weighted) Foreign currencies/S$
1980	2.50	1.18	1.55
1985	2.20	1.27	1.82
1990	1.70	1.56	2.55
1995	1.42	2.10	3.99
1996	1.40	2.19	3.51
1997	1.55	2.06	2.27
1998	1.65	1.73	2.80
1999	1.70	1.87	2.77

Source: Singapore Statistic Yearbook and Datastream

For the estimation of exchange rate volatility, I used the Generalised Autoregressive Conditional Heteroskedasticity (GARCH) modeling technique which was introduced by Engle (1982) and subsequently modified by Bollerslev (1986). In effect I employ GARCH (1,1), which specifies that the variance today of a variable depends upon three terms, namely a constant, yesterday's forecast variance (i.e. the GARCH term) , and yesterday's news about volatility, taken to be the squared residual from yesterday (the ARCH term). Figures 1 and 2 present the volatility of the export-weighted and import-weighted REER respectively. It can be seen that both volatility indices exhibit similar patterns. For the period 1981 to 1993, the exchange rate volatility for both constructs is rather low. However after 1993, there seems to be greater variance in exchange rate movements. The implication of this is that investors might have to take into account the additional risks posed by uncertain exchange rates, which could adversely affect investments.

5. Regression Output Analysis

A *panel data model* is estimated for equation (18). The fundamental advantage of a panel data set over a purely cross- sectional or time-series one is that it allows the researcher greater flexibility in modeling differences in behaviour across individual units. The SUR technique is used in the estimation as it is almost a conventional wisdom to use SUR in the panel data with different industries that may be correlated each other to some extends.

The 18 manufacturing industries chosen for the estimation are divided into two groups according to the relative importance of import input and export exposures in the industries. The industries with their export exposure larger than import input exposure are grouped into one and the industries with the opposite feature are grouped into another. The objective of segregating the net export exposure (i.e. those with IEE greater than one) industries from those with net import exposure in the regressions is to find out if investments of these two groups of industries with vastly dissimilar external orientation react differently to exchange rate changes. For the former group, I am particularly concerned with how their export-competitiveness (which then leads to profitability and hence investment responses) react to exchange rate movements. It is for this reason that I use export-weighted exchange rate in the empirical estimation. For the latter group, which relies heavily on imported inputs into production, I am keen to examine if exchange rate changes affect production costs (i.e. especially the imported portion) significantly enough to result in changes in investments (through profitability). That is why import-weighted exchange rate is used.

Table 6 and *Table* 7 reports the estimation results. Four regressions are performed due to the term γ used to interact with exchange rate and volatility of exchange rate. In regression 1, γ takes a value of 'one'. This means that we only measure the independent effect of changes in mean (and volatility) of exchange rate on investment. In regression 2, γ represents export share. Compared to regression 1, regression 2 is to test whether the interaction of industry export share with exchange rate and its volatility will affect the degree of impact of the two terms on investment. In regression 3, the industry import share is used to interact with exchange rate and its volatility. Similarly, γ represents industry mark-up in regression 4 and net exposure in regression 5.[21]

Table 6: Industries with Export Exposure > Import Exposure (using Export-weighted Exchange Rate)

Regression	γ	β_1	β_2	β_3	β_4	β_6*	DW	Adj. R^2

[21] Since the objective of this study is to investigate exchange rate effects on industrial investment, the variables of prime concern are the change in mean as well as change in variance of exchange rate (i.e. β_2 and β_3). In addition, the interest rate variable will be discussed as well. The lagged investment variable, present in the estimation as dictated by mathematical expression (18), will not be presented in the output tables or discussed in detail as its implication is not the main concern of this study.

1	-	0.946**	0.457*	-0.061**	0.129**	-0.117**	2.91	0.90
		0.147	0.260	0.018	0.058	0.061		
2	EXP	0.962**	0.694**	-0.078**	0.131**	-0.110*	2.89	0.90
		0.148	0.394	0.028	0.057	0.060		
3	IMP	0.961**	0.867*	-0.102**	0.131**	-0.111*	2.89	0.90
		0.147	0.482	0.035	0.057	0.060		
4	IEE	0.946**	0.353*	-0.047**	0.126**	-0.118**	2.92	0.90
		0.146	0.207	0.015	0.056	0.059		
5	MKP	0.953**	0.495*	-0.070**	0.126**	-0.118**	2.91	0.90
		0.146	0.283	0.020	0.057	0.060		

*Notes: Figures in parentheses are the standard errors. ** Significant at the 5% level, * significant at 10* level, 2-tailed test.*

For regression 1, the sales coefficient is positive as one can normally expect and highly statistically significant. β_2 has a positive sign and is statistically significant at 10% level. Such an estimate is against the conventional wisdom about the negative impact of currency appreciation on investment. A few plausible explanations can be offered, which hopefully may shed some light on Singapore's export competitiveness in relation to exchange rate changes. One possibility is the existence of "pricing-to-market" behaviour as asserted by Tongzon and Menon (1995). Local producers attempt to limit exchange rate pass-through by adjusting their profit margins whenever currency appreciates. Of course, this is provided that their profit margins are sufficient to cushion the negative exchange rate impact. At the same time though, exchange rate appreciation also leads to cheaper imported inputs, which at least helps to partially offset the loss in competitiveness. Moreover, the portfolio and wealth effect of currency appreciation may have been quite strong for foreign investors in Singapore who have been eventually the dominating investors in Singapore manufacturing industries. β_3 has an expected negative sign. This confirms that increased exchange rate volatility in Singapore has been a form of uncertainty for investors. Assuming these investors are risk averse, they will inevitably reduce investments in the face of uncertainties in exchange rates. The statistically significant positive sign of interest rate coefficient (β_4) may be more or less unexpected from the classical theoretical considerations. However, if exchange rate appreciation would have led to investment increase in these concerned Singapore manufacturing industries as we argued before, a symmetric increase in interest rate following the appreciation in exchange rate should also have had a positive impact on investment. The coefficient for the Asian Financial Crisis dummy is negative as expected and is also statistically significant. Such an estimate is in accordance with the estimated effect of exchange rate volatility and once more confirms that capital market volatility together with sharp currency depreciation would surely lead to substantial negative impact on investment. The dummy variable is defined as for the period of 1997 to 1999. This means that the negative effect suggested by the estimated dummy variable coefficient has a long-lasting negative impact on investment in the Singapore export-dominated manufacturing industries.

For regression 2, the coefficient signs are exactly the same as in regression 1. I would especially like to highlight β_2 and β_3. It appears that higher export share leads to greater investments when exchange rate appreciates as suggested by the relatively larger estimated β_2. Nevertheless, the impact of exchange rate volatility would also have had enlarged negative impact associated with a larger export share on investment as suggested by the relatively larger estimated magnitude of β_3. The regression 3 uses import exposure to interact with exchange rate and produces the largest magnitudes for coefficients for β_2 and β_3, compared to all other regressions. A plausible explanation is that, as a small open economy with import of almost every kind of input, the mean change and volatility of exchange rate associated with a increasing import exposure would have affected the export-dominated industries so much more than any other effect. Regression 4 uses net export exposure (IEE) to interact with exchange rate in the estimation. It is hence quite understandable that the estimated magnitudes of the coefficients β_2 and β_3 are reduced to some extends compared those in regression 2 and 3. However, there are still considerable magnitudes for the two coefficients. It hence suggests that the export-dominated manufacturing industries have been still significantly affected by the mean change and volatility of exchange rate. In other words, these Singapore industries that have used import to produce export have still been affect by exchange rate movement. Finally, regression 5 uses markup ratio to interact with exchange rate. The estimated results are quite similar to those from regression 1. It may suggest that the cost-profit effect on investment has been closely associated with the exchange rate effect.

Table 7: Industries with Import Exposure > Export Exposure (using Import-weighted Exchange Rate)

Regression	γ	β_1	β_2	β_3	β_4	β_6*	DW	Adj. R^2
1	-	1.759**	-0.226	0.019	-0.065	-0.168**	2.45	0.88
		0.202	0.190	0.022	0.077	0.077		
2	EXP	1.729**	-0.525	0.030	-0.065	-0.171**	2.45	0.88
		0.203	0.588	0.069	0.078	0.078		
3	IMP	1.745**	-0.386	0.028	-0.061	-0.172**	2.45	0.89
		0.202	0.342	0.040	0.078	0.076		
4	IEE	1.745**	-0.354	0.024	-0.073	-0.169**	2.45	0.89
		0.203	0.311	0.037	0.078	0.078		
5	MKP	1.568**	-0.202	0.019	-0.046	-0.152**	2.43	0.89
		0.213	0.235	0.026	0.083	0.083		

*Notes: Figures in parentheses are the standard errors. ** Significant at the 5% level, * significant at 10* level, 2-tailed test.*

Table 7 comprises of regressions that make use of import-weighted exchange rates for the study of the import dominating industries. Generally speaking, for all the four regressions, only the sales and Asian financial crisis dummy are statistically significant. Compared to the export-dominated industries that are studied in Table 6, the import-dominated industries have been at relatively domestic-market oriented. The estimated result may be explained as an indication that the investment of import-dominated industries have been mainly affected by the domestic market demand but not substantially affected by the mean change and volatility of exchange rate as well as the change of interest rate.

6. Conclusion

This study aims to assess whether investment in Singapore manufacturing industries has affected by the mean change and volatility of exchange rate. Since the Singapore manufacturing industries have been dominated by foreign direct investment, such study can be used to verify, to some extends, whether foreign direct investment will sensitively respond to exchange rate change in the open economy. The cash flow theory of investment was used to derive the estimated econometric model for the relationship between investment and exchange rate movement. The panel data consisting of 18 manufacturing industries over the period of 1977 to 1999 was used in the regression.

The empirical results seem to suggest that the investment from export-dominated industries would respond positively to the appreciation of Singapore dollar but would be negatively affected by exchange rate volatility. Such finding is in accordance with the argument from the exchange theory of portfolio and wealth effect. In other words, the empirical result suggests that the exchange theory of portfolio and wealth would be more prevalent in the small open economy with substantial foreign direct investment. In such open economy, the domestic production must use substantial input from import and substantial numbers of investors are foreign entities. Hence, domestic currency appreciation would help to bring down the cost of imported input on one hand and, on the other hand, would enhance the wealth of the foreign investors. The volatility of exchange rate change, in the contrary, would have led to instability or uncertainty for the imported input cost and investors' wealth and would hence affect the investment negatively.

Based on the empirical finding, we could thus explain why foreign direct investment has been increased steadily, in general, over the past 35 years although Singapore dollar has been appreciated steadily also in the past. We could also explain why, in particular, the Asian financial crisis which has caused Singapore dollar depreciated dramatically over the past three years have a long lasting negative effect on foreign direct investment in the Singapore manufacturing industries.

The empirical finding also suggests that the import-dominated industries would not be substantially constrained from the exchange rate movement. Such finding eventually renders some supports to the finding for the export-dominated industries. These import-dominated industries are largely domestic market oriented and are dominated by local investors. These industries have been also dominated from small-size firms in Singapore. Therefore, the portfolio and wealth effect of exchange rate change may not be that prevalent in these industries.

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