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Firm and industry characteristics of exchange rate exposure and optimal hedging strategy: Evidence on China

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Firm and industry characteristics of exchange rate exposure and optimal hedging strategy: Evidence on China

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Abstract

Understanding the effect of foreign exchange rate movements on the value of firm is a critical element for the purpose of risk management. In this thesis, firm and industry specific exposures to exchange rate movements in the Chinese market before and after the exchange rate regime reform in 2005 are examined. We observe that at the one-week return horizon, among all the firms listed in the China Exchange Market before the year 2001, less than 10% of the firms exhibit significant "residual exposure" to bilateral exchange rate movements against China's major trading partners before the reform. In contrast, the proportion of firms with significant exposure increase to over 20% for some bilateral exchange rates after the reform. The "total exposure" is measured by using orthogonal market returns in place of market returns and a much higher percentage of firms exhibit significant "total exposure". We also observe that the number of firms with significant exposure increases with the return time horizon, regardless of whether it is residual exposure or total exposure. The phenomenon of asymmetric exposure is also examined; the results show that 4.5% of firms exhibit asymmetric exposure during appreciation and depreciation cycles with respect to all the major bilateral exchange rates and the percentage of firms with asymmetrical exposure also increase with the return horizon. As for the industry-specific exposure, about 90% of Chinese industries at the three-digit SIC level are significantly exposed to both bilateral and trade-weighted exchange rate movements. The predominantly positive exposure effect indicates that most industries behave like net exporters and benefit from the depreciation of RMB. Theoretical models are built to simulate how firms in export, import and import-competing industries make decisions to maximize their profits when foreign exchange rates fluctuate. We show that our models are consistent with the observed empirical relationship between the exchange rate exposure of the Chinese industries and the import elasticity against the U.S. dollar and the Japanese yen.

Key Words: Exchange rate exposure, Asymmetric exposure, Industry structure, Reform of Chinese exchange rate regime

Contents

1 Introduction

1.1 Exchange rate exposure

The Bretton Woods system was established as the rules of monetary management among the world's major industrial countries at the aftermath of the World War II. Under this system, each country adopted a monetary policy that maintained the exchange rate value of its currency at a fixed value within a minor fluctuation margin in terms of gold. The strength of the U.S. economy and the commitment of the U.S. government to the conversion of the U.S. dollars into gold at a fixed price motivated the industrial countries and international institutions to use the U.S. dollar as a reserve currency. The Bretton Woods system provided a system of fixed exchange rates and sought to encourage an open system by committing members about the convertibility of their own currencies into other currencies, which is meaningful for free trade. It played an important role in the postwar economic reconstruction of the western countries by providing an efficient mechanism for government intervention and a stable exchange rate system. However, due to the intrinsic limitation of the system and the U.S. balance of payment crisis in 1971, the United States unilaterally terminated the convertibility of the dollar to gold, which resulted in the collapse of the Bretton Woods system in 1973. By March 1976, almost all major currencies were floating. In other words, exchange rates were no longer an efficient method that can be used for the administration of monetary policy by the government. Since then, the international trading firms and institutions were exposed to the volatility of exchange rates and the estimation, determinant and management of exchange rate exposure became the key concerns for managers, investors and financial analysts.

Exchange rate exposure, which is defined as the effect of volatile exchange rate on the firm value, is an important source of macroeconomic uncertainty (Muller, 2006). For exporters and import competitors, exchange rate movements change the terms of competition with foreign firms by changing the relative price of products. A depreciation of the domestic currency decreases the foreign price of exports while increasing the domestic price of imports, to the advantage of these firms. In contrast, for manufacturing industries which produce goods by processing imported raw materials and for firms which import products for resale, an appreciation of the domestic currency benefits them by reducing their input costs. For multinational firms, exchange rate movements change the domestic value of as-

sets and liabilities denominated in foreign currencies.

Stulz (2000) decomposes the overall impact of the exchange rate movement on firm value into transaction exposure, translation exposure and economic exposure. Transaction exposure arises from the commercial transactions that have already booked and due to the time difference between the agreement of transaction and the settlement of transaction. Translation exposure arises from the translation of assets and liabilities from foreign branches or subsidiaries into the home currency according to the accounting standard. Both transaction and translation exposure are short-term exposures and can be effectively hedged by well-structured derivatives, such as futures, forward contracts, options and swaps. Economic exposure arises from indirect effect of exchange rate movements on the competitiveness of a firm. It is a long-term exposure that cannot be easily hedged away.

1.2 Reform of Chinese exchange rate regime

The evolution of the Chinese exchange rate regime can be divided into four phases since the foundation of the People's Republic of China in 1949.

The first phase (also called overvaluation phase) lasted from 1949 until the late 1970s. During this period, the China's exchange rate was fixed at a highly overvalued level. The policy, as a product of highly planned economic system, aimed to reduce China's dependence on imported manufacturing products. The foreign changes were tightly controlled by the Bank of China which was the sole institution authorized to deal with foreign exchange. As a result, there was excess demand for foreign exchange and the terms of trade for China's exports deteriorated.

The second phase (also called dual system phase) started from the late 1970s to the mid-1990s. During this period, the dual exchange rate system was adopted, in which the official exchange rate was applied to non-trade transaction while the internal settlement rate was applied to all trade transactions. The authorities continued to devalue the currency from the rate of 1.5 RMB/dollar in 1981 to 8.7 RMB/dollar in 1994. The official exchange rate during the mid-1990s was believed to be a reasonable approximation of an equilibrium rate, although it was slightly undervalued. The international trading increased rapidly owing to the Reform and Open policies and the undervalued exchange rate further improves China's export and the expansion of surplus on the current account and international reserves.

The third phase (also called pegged rate phase) started from 1997 to July 21, 2005. In order to prevent the expansion of the Asian financial crisis which broke out in 1997, the

Chinese government made a commitment not to devaluing the RMB. The exchange rate was kept at the 8.28 RMB/dollar level, which made a significant contribution to the economic and financial stability of the Asian countries and the world. Until the new round reform, the exchange rate of RMB against the U.S. dollar was strictly pegged and RMB followed the trend of the U.S. dollar. During this period, the exchange rate of RMB, either on a bilateral or multilateral basis, was on a downward spiral, which further helped the export but accumulated the pressure to appreciation as well. With a fixed exchange rate of RMB against the U.S. dollar, the Chinese government virtually bore the exchange rate exposure for the firms which have traded with the U.S., the most important trade partner of China.

The fourth phase (also called managed floating exchange rate phase) started on July 21, 2005, when the People's Bank of China announced a revaluation of the currency and a reform of the exchange rate regime. The authorities not only immediately revalued the official bilateral rate from 8.28 RMB/dollar to 8.11RMB/dollar, but also announced that the RMB would be managed "with reference to a basket of currencies" rather than pegged to the U.S. dollar henceforth. The objective of the reform is to enable the market to fully play its role in resource allocation as well as to further strengthen the managed floating exchange rate regime based on the market supply and demand. China's currency strengthened significantly owing to the reform and two relative policies. One was to reduce the value-added tax (VAT) rebate rate for a large number of export products, and the other one was to impose restrictions on the export processing regime. This structural change implies that the Chinese firms in general have become increasingly exposed to foreign exchange risk. However, due to the unavailability of data and the fixed exchange rate regime, the study on the foreign exchange rate exposure of Chinese firms is very scarce. Only Wong and Leung (2009) investigated the exchange rate exposure of Chinese banks against the U.S. dollar after the reform. Therefore, a comprehensive empirical study on the exchange rate exposure of Chinese firms and industries is meaningful because it could provide insights for Chinese firms and industries in their management of exchange rate exposure.

2 Brief Literature Review

Since the breakdown of the Bretton Woods system in early 1970s, the volatility of exchange rate and related risks have increasingly become a key concern for the international trading firms. Over the last 30 years, a lot of researches have been conducted with regard to the determinant, measurement and management of exchange rate exposure.

2.1 Determinant of exchange rate exposure

A series of theoretical models from the perspective of international trade, industrial organization and international financial management have been built to examine the factors that determine the extent to which firms and industries are exposed to the exchange rate movement. The original definition of exchange rate exposure is derived from the accounting practice which took a "balance sheet" approach to define a firm's exposure to exchange rate changes. According to this definition, only the financial items on the balance sheet described as foreign currency, such as receivables from foreign clients, debts to foreign banks, would be affected by the volatility of exchange rate. Shapiro (1975) pointed out that the traditional definition of exchange rate exposure based on the historical information is inappropriate and might provide useless or even distorted information to the investors and managers. He defined exchange rate exposure as the effect of exchange rate movement on the value of a firm from the view point of economic theory. A two-country model was built to examine the behavioral characteristics of an oligopolistic firm which tried to maximize its binational profits under the environment of inflation and devaluation of home currency. It concluded that the exchange rate exposure of a multinational firm was affected by the distribution of its sales between domestic and export market, the amount of import competition it faced domestically, the degree of substitutability between local and imported factors of production and the increasing or decreasing of marginal cost curve.

Dumas (1978) further argued that the book value of foreign currency based items in the balance sheet and income statement and the intrinsic exposure related to a firm's trade and production structure should be simultaneously considered when making decisions to hedge against exchange rate risks. A model was built to examine the factors that influence the relation between the value of a firm and the unexpected future exchange rate change. Optimal hedging decisions in the presence of bankruptcy costs and market segmentation were obtained under the exposure defined in the model.

Flood (1986) defined the effect of exchange rate change on a firm's operating cash flows as operating exposure, in contrast with contracted exposure based on a company's financial statements, and further separated the operating exposure into two components, competitive effect and conversion effect. It analyzed conceptually how a firm's marketing, purchasing and production strategy would be influenced by the exchange rate changes and concluded that the competitive structure of the industry in which the firm operates, the price elasticity of demand, the range of complements and substitutes and the structure of costs might all play some roles in the determinant of a firm's operating exposure. The concept of operating exposure was referred to as "economic exposure" by many following researches (Levi, 1994; Marston, 2001).

Following the work of Shapiro (1975), Von Ungern-Sternberg (1990), Levi (1994), Allayannis (1996), Marston (2001) focused on the effect of competitive environment in which firms operated on the exchange rate exposure of a firm. Von Ungern-Sternberg (1990) built models for the firms operated in a Cournot competitive, conjectural variation, pricing-taking or monopolistically competitive environment to examine how firms made hedging decisions in response to exchange rate changes to maximize profits. For simplicity, these models assumed linear demand and supply curve and constant marginal cost. Levi (1994) examined the relation between the exchange rate exposure and financial characteristics of a company by developing a multi-currency model for firms exporting or importing one product and taking both the tax rate and the firm's net asset position in each currency into account. He showed that a firm's exchange rate exposure to currency j was positively influenced by the demand elasticity of the product in country j and negatively influenced by the tax rate and opportunity cost of capital. Allayannis (1996) built similar models and further concluded that the exchange rate exposure of exporting firms that depends on the demand elasticity of foreign countries is asymmetric to that of importing firms that depends on the demand elasticity of the home country. Marston (2001) showed that the key determinant of economic exposure is the competitive structure of the industry in which a firm operated. He concluded that in many forms of competition, including the most commonly studied case of monopoly, the economic exposure of firms was simply proportional to the firm's net revenues based in foreign currency. In the competition of duopoly, the price elasticity of the product demand and the marginal cost were related to the exchange rate exposure. These researches integrated the theory of finance and industrial organization and provided valuable insights into the determinant of exchange rate exposure. However, none of these studies have attempted to provide empirical evidence for their models.

In subsequent research, Allayannis (2001) cast light on the effect of markup of an industry, an important indication of market structure, on the exchange rate exposure suffered by the industry. He developed a partial equilibrium model to analyze the effect of exchange rate movement on the rate of return of a firm or industry. A Taylor series expansion of a firm's value and further application of the envelope theorem captured a firm's exchange rate exposure through three channels: the competitive structure of the market where it sells its products, the interaction of the competitive structure of the export market and the export share, and the interaction of the competitive structure of the imported input market and the imported input share. Allayannis (2001) examined the effect of exchange rate movement on stock returns which should adjust more instantaneously to an unexpected exchange rate shock instead of on investment. In addition, using the sample of the U.S. manufacturing industries from 1979 to 1995, he empirically examined the effect of exchange rate movement on industry returns and the importance of the three channels. The evidence from his empirical research is consistent with the prediction of the model: as an industry's markup falls (rises), its exchange rate exposure increases (decreases).

Bodnar (2003) stated that the pass-through and exposure of firms to exchange rate changes were related to one another due to the impact of pricing strategy on profitability. He developed duopoly models of export firms under imperfect competition to examine the relation and concluded that with a fixed market share, the pass-through decreased while the exposure increased as the substitution between the home-made and foreign-made goods increased and both pass-through and exposure were negatively related to the market share, with a fixed substitutability. He further tested the model empirically by using the export data of Japanese industries, and the model were partly supported by the empirical results.

All in all, these previous research indicated that a lot of parameters might have important influence on the sensitivity of firm value to exchange rate movements. It is impossible to set up an integrated model with all these complex factors taken into account. The robustness of the conclusions drawn from these models are yet to be tested empirically.

2.2 Measurement of exchange rate exposure

Over the past 20 years, a lot of efforts have been made to quantify the impact of exchange rate movement on the cash flow and value of firms. Martin (2005) classified the existing methods into two approaches. The first one is the capital market approach, which measures the exchange rate exposure as the sensitivity of stock returns to exchange rate movements.

The second one is the cash flow approach, which considers the effect of exchange rate movement on the cash flow of the firms.

2.2.1 Capital market approach

Adler (1984) first suggested that the exposure of an asset could be estimated by regressing its home-currency price change on the contemporaneous foreign exchange rate changes. As for the measurement of firm-specific exchange rate exposure, he suggested using the regression coefficient of firm stock return on exchange rate change as in equation 2.1.

$$R_{i,t} = \alpha_i + \varphi_i \theta_t + \varepsilon_{i,t} \tag{2.1}$$

Where $R_{i,t}$ denotes the stock return of firm i in period t, θ_t is the exchange rate change in period t, φ_i measure the exchange rate exposure to currency θ of firm i.

Some criticism against Alder's approach stated that some other macroeconomic variables may simultaneously affect the exchange rate movements and stock returns, which may imply the problem of omitted variables and multicollinearity. The improvement to the approach was made by Jorion (1990) as in equation 2.2, which is widely used in the subsequent empirical research.

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \gamma_i \theta_t + \varepsilon_{i,t} \tag{2.2}$$

Where $R_{m,t}$ is the overall stock market return in period t. γ_i measures the the difference between the firm's total exposure and the market's exposure adjusted by the firm's market β. This is referred to as the "residual exchange rate exposure" of firm i.

A lot of empirical evidence has been provided on the exchange rate exposure of firms and industries in different countries by adopting the capital market approach. However, limited success has been achieved in identifying significant exchange rate exposure. Jorion (1990) found that only 5% of U.S. multinational corporations exhibited significant exposure. Bodnar (1993) also found that only a small proportion of industries in Canada, Japan and the U.S. had significant exposures. Choi (1995) concluded that 15% of 409 U.S. multinational firms were significantly exposed to trade-weighted currency movement during the 1978-89 period. Chow (1998) found that less than 30% of Japanese firms had significant exposure at the one-month horizon and the proportion increased with the return horizon. Dominguez (2006) examined the exchange rate exposure of publicly listed firms in eight industrialized and emerging markets and found that the percentage of significant exposure to trade-weighted exchange rate varied from 5% to 25%. Muller (2007) found that about

25% of Asian firms experienced economically significant exposure to the U.S. dollar and 22.5% to the Japanese yen for the period from 1993 to 2003.

Several improvements have been made by continuous development of models to estimate exchange rate exposure. More significant exposures were found when bilateral exchange rates are used instead of trade-weighted exchange rates (Williamson, 2001; Koutmos, 2003a). Using overlapping long horizon returns was also shown to increase the frequency of detecting significant exposures (Chow, 1998; Bodnar, 1993; Dominguez, 2006).

2.2.2 Cash flow approach

Cash flow approach was first developed by Garner and Shapiro in 1984, who suggested the foreign exchange exposure can be measured as the sensitivity of the cash flow generated by the firm to exchange rates change. Martin (2003) improved the method by introducing contemporaneous and lagged effects of exchange rate effect to allow exposure to be decomposed into short- and long-term components. Foreign exchange rate exposure is measured from estimating equation 2.3.

$$UI_t = c + \sum_{q=0}^{L} w(q) X_{t-q} + u_t \tag{2.3}$$

Where, UI_t is the standardized unanticipated operating income, which is estimated as the residual from a regression of current operating income on prior periods (Walsh, 1994; Martin, 2003). X_{t-q} is the percent exchange rate change for time $t-q$, $w(q)$ is the foreign exchange rate exposure for lag q; L is the lag length determined by the Akaike (1973) criterion, u_t is the error term for time t.

Unlike the capital market approach, the cash flow approach does not incorporate people's expectation about the prospective of the firm and requires more detailed information about the operation of the firm, which is more likely to be affected by the standard used in the accounting reports. That is why the latter approach is less widely used. Martin (2003) adopted cash flow approach to examine the exchange rate exposure of U.S. banks and found significant exposure for both domestic-oriented and international-oriented banks.

2.3 The framework of thesis

Considering the lack of empirical evidence about exchange rate exposures for Asian markets and the reform of exchange rate regimes in China as a milestone event, the Chinese market is chosen as the subject of research in this thesis. Since historic research only

found weak evidence of significant exposure due to the intrinsic problem of the measurement model, some improvements will be considered in this thesis. First, trade-weighted exchange rate index used in the previous research is more difficult to detect significant exchange rate exposure if firms or industries have offsetting exposure to different currencies included in the index. Specific bilateral exchange rates of the major trade partners of China as well as a trade-weighted exchange rate index calculated on the basis of trade flows will be used. Second, previous studies have found that the extent of estimated exposure increases with the return horizon; thus, the exchange rate exposure at different return horizons (weekly, monthly and quarterly) will be investigated. Third, the potential correlation between market return and exchange rate change may imply a multicollinearity problem. The market return contains a currency exposure component, which may underestimate the exchange rate exposure. In order to address this problem, we use orthogonalized stock market return, which is the error term in the regression of market portfolio return on exchange rate change, instead of the market return. Using an orthogonal exchange rate factor is common in exposure studies (Martin, 2003). Fourth, exchange rate exposure may be asymmetric during appreciation-depreciation cycles due to asymmetric pricing behaviors, hysteresis or asymmetric hedging (Koutmos, 2003a). Asymmetric sensitivity of returns to exchange rate risk is allowed by incorporating a dummy variable to capture the potential asymmetries. Fifth, in order to investigate the effect of the Chinese exchange rate regime reform in 2005, we divide our data into two sub-periods: before and after the reform.

Exchange rate exposure will also be investigated at the industry level because an industry in one country often competes with the same industry in another country. An unexpected change in the exchange rate should have a similar impact on competitiveness and hence firm value within the industry. Compared to the firm level, the research on the industry level exposure is relatively scant. In this paper, industry-specific exposure is investigated as well. The industry level exchange rate exposure is usually linked in the literature to the activities of the industry, such as the trade ratios, the use of internationally-priced inputs and foreign investments (Bodnar, 1993), but the effect of industrial structure on exposure has not been empirically analyzed. This thesis will build models for firms operating in different industries, such as export, import and import-competing industries to investigate the factors that have a bearing on the exchange rate exposure. Furthermore, the effect of industry demand elasticity as an important indication of market structure on industry-specific exchange rate exposure will be empirically examined to test the conclusion from the theoretical models.

The remainder of the thesis is organized as follows. Chapter 3 carries out an empirical

study of the exchange rate exposure of Chinese firms before and after the reform of exchange rate regime in 2005. The exposure in different time horizons, different sub-periods and asymmetric exposure will also be examined. Chapter 4 theoretically analyzes how the direction and magnitude of exposure are influenced by the industry characteristics. We also carry out an empirical study of the exposure at the industry level. Chapter 5 discusses further research directions and Chapter 6 concludes the thesis.

3 Firm-specific Exchange Rate Exposure

3.1 Model

3.1.1 Residual exchange rate exposure

Following the definition of Adler (1984), exchange rate exposure is measured as the coefficient of a time series regression where the dependent variable is a firm's asset price and the dependent variable is unexpected exchange rate change. In this Adler (1984) model, both the firm's value, which is represented by the stock price, and exchange rate are endogenous variables and determined simultaneously. This definition does not imply that the fluctuation of a firm's asset value is caused by exchange rate movement. As the size of a single firm is negligible compared with the whole market, the partial equilibrium assumption that the exchange rate fluctuation is exogenous to the firm's value is justifiable for the estimation of exchange rate exposure at the firm level. Furthermore, in line with previous empirical research after the definition of Adler (1984), there are some researches such as Jorion (1990), Bodnar (1993), Bartov (1994), Chow (1997a), which use the actual exchange rate changes as proxy for unexpected changes in exchange rates and include the return of market portfolio in the model to control for the influence of macroeconomic factors on firm's value. The firm-specific exchange rate exposure is estimated by the following two-factor regression:

$$R_{i,t} = \beta_{0,i} + \beta_{m,i} R_{m,t} + \beta_{X,i} X_t + \varepsilon_{i,t} \tag{3.1}$$

Where $R_{i,t}$ is the stock return of firm i from period $t-1$ to t, $R_{m,t}$is the stock market portfolio return for time t, X_t is the percent change of exchange rate for time t. $\beta_{0,i}$ is a constant, $\beta_{m,i}$ is market $beta$ value of firm i, $\beta_{X,i}$ reflected the exchange rate exposure against foreign currency X of firm i, and $\varepsilon_{i,t}$ denotes the white noise error term. As the exchange rate is measured as the RMB value of one unit of foreign currency in this thesis, if $\beta_{X,i} > 0$, it indicates that a depreciation of the home currency (RMB) results in an increase in the value of firm i, if $\beta_{X,i} < 0$, firm i gains from the appreciation of RMB.

3.1.2 Total exchange rate exposure

The traditional two-factor regression is similar to the capital asset pricing model (CAPM), which associates stocks' return to the market risk. However, CAPM is built under

the efficient market hypothesis, under which the market return prices all the public and inside information into stock returns, and therefore $\beta_{X,i}$ should be zero. Furthermore, as the market return has already reflected the sensitivity of market return to exchange rate change, $\beta_{X,i}$ can be interpreted as the residual exchange rate exposure of firm i, which only measures the difference between the firm's total exposure and the market's exposure adjusted by the firm's market beta. If firm i has zero $\beta_{X,i}$, it does not mean that firm i is free from the exchange rate risk and it only implies that firm i bears the same exchange rate exposure as the market portfolio. Therefore, exchange rate exposure might be underestimated in the traditional estimation, which measures residual exposure rather than total exposure. This may account for the finding of limited significant exchange rate exposure in previous empirical studies. In addition, a multi-collinearity problem can result from the potential correlation between the market return and exchange rate change. In order to address these problems, the stock market return is orthogonalized by estimating the following regression:

$$R_{m,t} = \alpha_0 + \alpha_x X_t + V_{m,t} \tag{3.2}$$

Where the error term $V_{m,t}$ is defined as the orthogonalized market return, that is the part of market portfolio return uncorrelated with exchange rate changes. Using the orthogonalized market return in place of the market portfolio return, allows the exchange rate exposure coefficient $\beta_{X,i}$ to be interpreted as the total exchange rate exposure.

3.1.3 Asymmetric exchange rate exposure

The existence of asymmetric exchange rate exposure has been considered by several theoretical models (Marston, 1990; Knetter, 1994). A simple intuitive analysis is given below. Firstly, export firms aiming at market share will take advantage of home currency depreciation to expand their market by lowering their prices denoted by foreign currency and reducing the profit margin effectively. During the period of appreciation of home currency, export firms aiming to expand market share will not increase the foreign currency price in order to keep or even increase their market share. Therefore, for export firms the absolute value of percentage change in cash flow is less when home currency depreciates than when it appreciates. Secondly, new firms will enter into the exporting industry when the home currency depreciates. However, due to the cost of reducing capital stock or the high fixed cost, firms would not exit the market when the condition becomes unfavorable. Thirdly, export firms, especially firms with large size, would take hedging actions when a stronger home currency is expected. Similar analysis can be made to import firms and domestic firms. All

Table 3.1 Indication of exchange rate exposure coefficient

	$\beta_{X,i} > 0$	$\beta_{X,i} = 0$	$\beta_{X,i} < 0$
$\beta_{DX,i} > 0$	net exporter influenced more by depreciation		net importer influenced more by depreciation
$\beta_{DX,i} = 0$	net exporter with symmetric exposure	no exposure	net importer with symmetric exposure
$\beta_{DX,i} < 0$	net exporter influence more by appreciation		net importer influenced more by apprecation

these asymmetric behaviors can cause asymmetric exchange rate exposure. The asymmetric sensitivity of returns to exchange rate is assessed through the following regression:

$$R_{i,t} = \beta_{0,i} + \beta_{m,i}V_{m,t} + (\beta_{X,i} + \beta_{DX,i}D_{Xt})X_t + \varepsilon_{i,t} \tag{3.3}$$

Where D_{Xt} is a dummy variable which indicate the depreciation of home currency. When $X_t > 0$, then $D_{Xt} = 1$. $\beta_{DX,i}$ is the asymmetric exposure coefficient. If $\beta_{DX,i} > 0$, it means the firm is influenced less by home currency appreciation than depreciation. Table 3.1 provides a summary of the implications of different combinations of $\beta_{X,i}$ and $\beta_{DX,i}$.

3.2 Data and summary statistics

3.2.1 Stock return

One objective of this paper is to examine the effect of the Chinese new exchange rate regime on the exchange rate exposure of Chinese firms. The period from July, 2001 to December, 2009 is examined and divided into two subperiods. One is from July, 2001 to June, 2005 which covers the period after the Asian financial crisis and before the reform of the exchange rate regime; the other spans from August, 2005 to December, 2009, following the reform of the exchange rate regime in July, 2005. All of the Chinese firms listed in the Shanghai and Shenzhen Exchange before July 1st, 2001 are selected. We use A-share stocks that are denominated in RMB. After eliminating firms whose data are unavailable, the final sample comprises 1000 firms. Weekly stock price data of the selected firms are available from Datastream.

3.2.2 Market portfolio return

The stock market return $R_{m,t}$ is approximated by the value-weighted return of the Shanghai Stock Exchange A-share Index and the Shenzhen Exchange A-share index, where the weights are calculated using their respective total market values. Weekly A-share index of Shanghai and Shenzhen Exchange are collected from Datastream. Figure 3.1 shows the

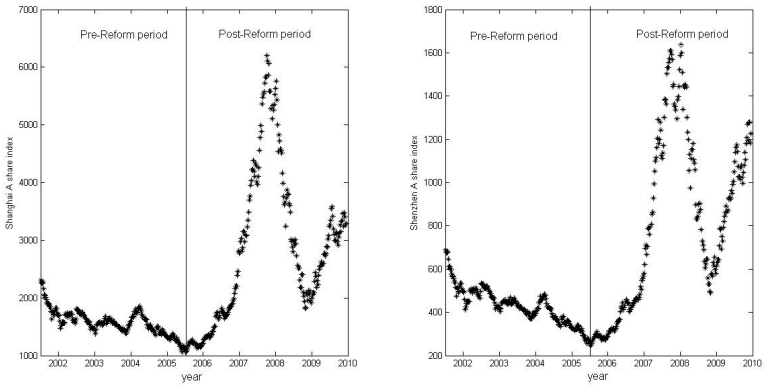

Figure 3.1 Stock market movements in China. (A-share index of Shanghai and Shenzhen Exchange from July, 2001 to Dec, 2009).

A-share index movement during the examined period. We can see that the stock market is more volatile after the reform of exchange rate regime. It does not mean that the reform causes the volatility, in fact, many other macroeconomic factors are the stimulus underlying the stock market and have significant influences on the stock price of a single firm. Therefore, it is necessary to include the market return as a regressor. As can be seen from the figure, the financial crisis which broke out in mid 2008 caused both A-share indices to drop significantly.

3.2.2.1 Foreign currency

Most previous studies examined the exposure to trade-weighted currency indices and not much evidence of significant exposure has been found. The rationale for using trade-weighted currency indices is that firms tend to be exposed to different foreign currencies with the same sign and size. However, this is hardly the case in reality. For example, if a firm exports in one currency and imports in another currency, it is likely that the firm will not be exposed to the weighted currency index composed of these two currencies. This can explain why only a very small proportion of firms have been found to have significant exposure. Given the shortcoming of using the trade-weighted currency basket, the most effective way to mitigate this is to create the firm-specific exchange rates. As the detailed information about the operation of every firm in the sample is unavailable, a compromising way is to use the bilateral exchange rates of China. Based on the export and import data from International Monetary Fund's Direction of Trade statistics, Table 3.2 shows the trade share of China's major trade partners. We can see that China mainly exports products to the U.S.,

Table 3.2 Export and import share of China

Export			Import		
Area	Millions of U.S. dollars	Percent	Area	Millions of U.S. dollars	Percent
United States	151975.39	20%	Japan	95428.65	15%
European Union	143661.96	19%	European Union	75563.91	12%
Hong Kong	116661.05	15%	Korea, Republic of	68715.56	11%
Japan	78128.73	10%	United States	48903.10	8%
Korea, Republic of	35872.79	5%	Middle East	32075.26	5%
United Kingdom	19224.13	3%	Australia	15737.24	2%
other Asia	90667.02	12%	Hong Kong	17308.19	3%
other non-Asia	120889.36	16%	other Asia	140621.5425	22%
			other non-Asia	147684.725	23%
World	755558.50	100%	World	642107.50	100%

Note: Percentages are based on the average export to and import from the country or area from 2001 to 2008. The total export and import refer to that with respect to the mainland China.

European Union, Japan, Korea and the United Kingdom, and imports material and resources from Japan, European Union, Korea, the U.S., the Middle East, Australia, and other Asian countries. The amount of export outweighs import by a great extent. It is obvious that firms are more likely to be exposed to exchange rates at which their international trades are settled; therefore, we choose the exchange rates of the countries or areas contributing a significant weight to the composition of China's international trade, including the U.S.dollar, Japanese yen, the euro, the South Korean won, the U.K.pound sterling and the Hong Kong dollar. As an important transfer harbor for the export and import of China, Hong Kong plays an important role in the international trade of China. That is why it is necessary to examine Chinese firms' sensitivity to the Hong Kong dollar movement. Figure 3.2 shows the movement of the targeted foreign currencies from year 2001 to 2009. Except the Japanese yen and the euro, all the other currencies depreciated against the Chinese yuan in the past 10 years. Before the reform of exchange rate regime in mid 2005, the exchange rate of the U.S. dollar was stable and drastically depreciated after the reform. Except the U.S. dollar, the exchange rate exposure to all the other five currencies will be examined in both the pre-reform and post-reform periods. The exchange rate exposure to the U.S. dollar will be examined only for the post-reform period. As a comparison with previous research, a trade-weighted currency based on the trade proportion will also be constructed and exposure of Chinese firms to this basket of currencies will be compared with those to bilateral exchange rates.

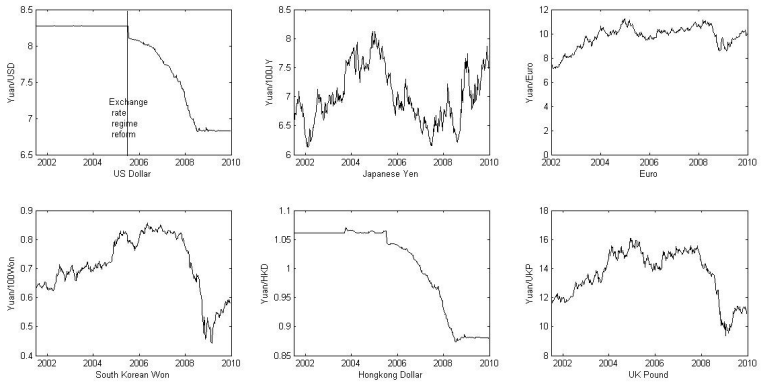

Figure 3.2 Foreign currency exchange rate movement (RMB as the basement currency). The euro was first issued in 2002, so the exchange rate against the euro starts only from 2002.

3.3 Empirical results-residual exchange rate exposure

3.3.1 Residual exchange rate exposure before and after exchange rate regime reform

Using the approach specified in equation 3.1 and robust standard errors, we examine how sensitive weekly returns of all the Chinese firms in the sample is sensitive to the selected bilateral exchange rate changes and trade-weighted exchange rate changes before and after the announcement of the reform by the People's Bank of China in July, 2005. Figure 3.3 shows the percentage of firms in the sample with significant exposure at 5% level to the U.S. dollar, the Japanese yen, the euro, the Korean won, the U.K. pound sterling,the Hong Kong dollar and the trade-weighted exchange rate during both the pre-reform and post-reform periods. We find that except for the Hong Kong dollar and the trade-weighted exchange rate, the percentage of firms with significant exposure is higher in the post-reform period. Less than 10% of firms exhibit significant exposure before the reform when the RMB was pegged to the U.S. dollar. However, a larger number of firms exhibit significant exposure after the exchange rate against the U.S. dollar is allowed to fluctuate. For example, 20% to 30% of firms are significantly exposed to the Japanese yen and the Korean won after the reform. It indicates that the reform of China's exchange rate regime does have great influence on the exchange rate risk faced by Chinese firms. Consistent with previous research, we also find that a smaller percentage of firms are significantly exposed to the trade-weighted exchange rates exposure than to a single bilateral exchange rate. It verifies that using trade-weighted

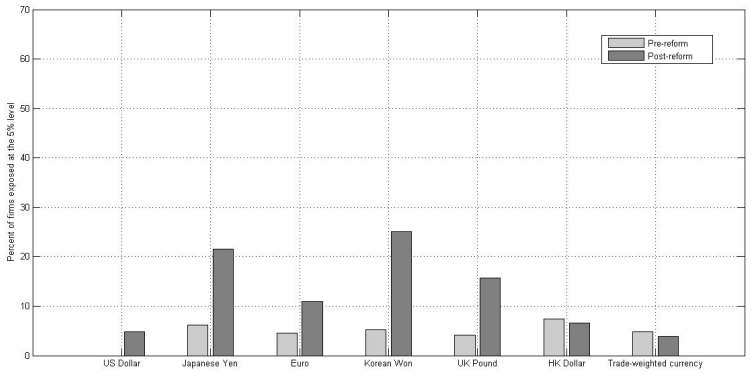

Figure 3.3 Residual exchange rate exposure of Chinese firms before and after the reform

exchange rates rather than specific exchange rates will underestimate the exposure of firms. The result that 22% of firms are exposed to the Japanese yen after the reform is consistent with the finding of Muller (2007) that 22.5% of Asian firms experienced significant exposure to the Japanese yen, and while only 5% of Chinese firms were exposed to the U.S. dollar, 25% of Asian firms were,according to Muller (2007). This may be because a regulated floating exchange rate regime rather than a freely floating rate is set up by the reform. Under the new regime, the Chinese government still intervenes in the exchange market, especially the exchange rate of RMB against the U.S. dollar. Therefore, it is not surprising that Chinese firms experience less exposure to the U.S. dollar than firms in other Asian countries even after the reform of exchange rate regimes.

As for the sign of exchange rate exposure, table 3.3 shows that more firms are negatively exposed to the Japanese yen, the euro, the U.K. pound sterling and positively exposed to the Korean won and the Hong Kong dollar during the pre-reform period. It indicates that more firms gain from the appreciation of RMB against the Japanese yen, the euro, the U.K. pound sterling and from the depreciation of RMB against the Hong Kong dollar and the Korean won. The situation seems different during the post-reform period when more firms are negatively exposed to all the selected bilateral exchange rates except the Japanese yen. It suggests that depreciation of RMB generally leads to a decrease of the value of firms. Theoretic analysis suggests that appreciation of home currency is favorable for net importers. Based on this view, can we conclude that most Chinese firms are net importers rather than exporters? The answer is no. Because the traditional approach adopted here measures only residual exposure rather than total exposure. Negative exposure here merely indicates that

Table 3.3 Statistics of residual exchange rate exposure of Chinese firms

Currency	Exposure Beta				Positive Exposure		Negative Exposure	
	Mean	Median	Max.	Min.	5%	10%	5%	10%
Panel A: Pre-Reform								
JY	-0.14	-0.35	0.60	-0.90	21	54	41	75
EU	-0.24	-0.39	0.95	-0.96	10	21	35	79
KW	0.05	0.40	0.85	-1.18	29	53	24	48
UK	-0.17	-0.37	0.79	-0.71	12	20	30	63
HK	4.58	6.66	25.05	-15.40	58	112	16	30
TW	-0.24	-0.83	2.37	-1.63	17	35	31	72
Panel B: Post-Reform								
US	-5.63	-5.82	5.97	-12.51	1	8	28	69
JY	0.55	0.55	1.08	-1.01	211	309	5	6
EU	-0.49	-0.55	0.88	-1.00	7	16	103	176
KW	-0.49	-0.47	0.68	-1.17	7	9	244	343
UK	-0.47	-0.48	0.60	-1.04	6	8	151	221
HK	-5.13	-5.34	6.87	-11.73	4	8	62	118
TW	-0.06	-0.87	2.04	-1.68	17	42	22	54

Note: US = U.S. dollar, JY = Japanese yen, EU = euro, KW = Korean won, UK = U.K. pound sterling, HK = Hong Kong dollar, TW = Trade-weighted currency

firms react to the depreciation of RMB by a smaller extent than the market portfolio. Therefore, negatively exposed firms are still likely to be net exporters if they have positive total exchange rate exposures. On the other hand, since weekly return data are used, it is possible that individual firm and market do not respond to the signal of exchange rate change in such a short period. It may take investors of firms some time to digest the new information and then respond; thus, using returns at longer horizon will address the lagged effect to some extent. We examine this in the next section.

3.3.2 Residual exchange rate exposure at long horizons

As mentioned before, the economic exposure is long-term exposure, which tends to be measured more accurately by using returns at long horizons. A number of previous studies have already found that the sensitivity of stock returns to exchange rate movements is stronger with increasing horizons of returns (Chow, 1998; Bartov, 1994; Bodnar, 2003). Actually, monthly returns were used by most of these studies, which suggests that our previous results based on weekly returns may underestimate the true economic exposure. In order to verify the effect of time span on the exposure, the sensitivity of 4, 12, 24 weeks' returns to exchange rate movements at the corresponding horizon are examined. The return at longer horizons is the rolling sum of weekly returns, which may lead to the problem of serial correlation. The robust Newy-West variances are used to correct the serial correlation. Figure 3.4 shows the percentage of Chinese firms with significant exposure to the bilateral

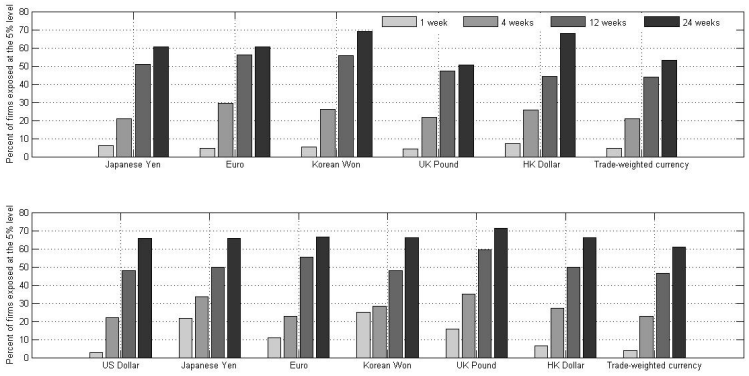

Figure 3.4 (a) Pre-reform residual exchange rate exposure at different return horizons (b) Post-reform residual exchange rate exposure at different return horizons

and trade-weighted exchange rates before and after the reform. Consistent with the previous analysis, we find that the percentage of exposed firms increase with the time horizon for all the exchange rates during both pre-reform and post-reform periods. Before the reform, only about 5.5% of firms on average were exposed to the weekly exchange rates. The percentage increased to 24% for 4 weeks' returns, to 50% for 12 weeks and 60% for 24 weeks. After the reform, about 12.4% of firms were exposed to the weekly exchange rates, while the percentage increased to 27.4% for 4 weeks' return, to 51% for 12 weeks and 66% for 24 weeks. We also find that more firms are significantly exposed after the reform than before the reform at the same time horizon, which reflects the effect of the reform on the exchange rate exposure.

Table 3.4 provides summary statistics about the signs of the exposure coefficients. We can see that the fraction of negatively exposed firms to positively exposed ones are relatively stable across different horizons for most currencies except the Hong Kong dollar and the euro. The fraction for the trade-weighted currency after the reform change with increasing horizons. The reason for the change in signs is that the effect of changes in terms of trade, competition environment, export and import ratio might only be reflected through a longer-term return. It is worth pointing out that although Chinese firms are dominatingly negatively exposed to most of the exchange rates, the gap between the proportion of negatively exposed and positively exposed firms narrows down with increasing return horizons. It means that a smaller proportion of the firms are classified as net importers based on the residual exchange rate exposure in longer return horizons.

In summary, very few firms are found to have a statistically significant exposure coef-

Table 3.4 Statistics of residual exchange rate exposure of Chinese firms at different return horizons

Currency	1 week			4 weeks			12 weeks			24weeks		
	no of firms exposed	positive	negative	no of firms exposed	positive	negative	no of firms exposed	positive	negative	no of firms exposed	positive	negative
Panel A: Pre-Reform												
JY	62	21(34%)	41(66%)	211	74(35%)	137(65%)	508	209(41%)	299(59%)	607	190(31%)	417(69%)
EU	45	10(22%)	35(78%)	295	59(20%)	236(80%)	560	150(27%)	410(73%)	604	272(45%)	332(55%)
KW	53	29(55%)	24(45%)	260	166(64%)	94(36%)	558	368(66%)	190(34%)	690	409(59%)	281(41%)
UK	42	12(29%)	30(71%)	215	44(20%)	171(80%)	473	119(25%)	354(75%)	506	182(36%)	324(64%)
HK	74	58(78%)	16(22%)	256	190(74%)	66(26%)	442	172(39%)	270(61%)	678	207(31%)	471(69%)
TW	48	17(35%)	31(65%)	209	56(27%)	153(73%)	439	182(41%)	257(59%)	533	250(47%)	283(53%)
Panel B: Post-Reform												
US	29	1(3%)	28(97%)	221	26(12%)	195(88%)	479	126(26%)	353(74%)	658	236(36%)	422(64%)
JY	216	211(98%)	5(2%)	335	280(84%)	55(16%)	500	358(72%)	142(28%)	657	515(78%)	142(22%)
EU	110	7(6%)	103(94%)	227	107(47%)	120(53%)	553	345(62%)	208(38%)	664	399(60%)	265(40%)
KW	251	7(3%)	244(97%)	282	51(18%)	231(82%)	479	202(42%)	277(58%)	662	150(23%)	512(77%)
UK	157	6(4%)	151(96%)	351	35(10%)	316(90%)	593	101(17%)	492(83%)	713	173(24%)	540(76%)
HK	66	4(6%)	62(94%)	271	21(8%)	250(92%)	498	108(22%)	390(78%)	662	230(35%)	432(65%)
TW	39	17(44%)	22(56%)	228	130(57%)	98(43%)	464	325(70%)	139(30%)	608	395(65%)	213(35%)

Note: US = U.S. dollar, JY = Japanese yen, EU = euro, KW = Korean won, UK = U.K. pound sterling, HK = Hong Kong dollar, TW = Trade-weighted currency

ficient in the weekly return horizon. Larger number of firms are significantly exposed in the monthly and quarterly return horizons. The transaction exposure that is easily mitigated by well-structured hedging strategies is reflected over short horizons, while the more robust economic exposure tends to be measured over longer horizons. We conclude that more firms bear significant economic exposures than transaction exposures.

3.4 Empirical results-total exchange rate exposure

3.4.1 Total exchange rate exposure before and after the reform

Although the traditional method of measurement of exchange rate exposure can provide an overall profile of Chinese firms' exposure, the drawback of the above regression is that only residual exposure are examined, which may underestimate the total exposure, and the sign of residual exposure may result in confusion about whether firms behave like net importers or exporters. Orthogonalized market return is constructed here to allow the beta coefficient to measure the total exchange rate exposure. Figure 3.5 presents results for the subset of firms with significant total exchange rate exposure at the 5% level before and after the reform. In the same weekly return horizon, the percentage of significantly exposed firms increases from 5.5% for residual exposure to 26% for total exposure during the pre-reform period, and from 12.4% for residual exposure to 39% for total exposure during the post-reform period. This provides convincing evidence that limited success in finding significant exposure in the previous empirical studies is because they estimate residual exposure rather than total exposure. Heterogeneity can also be observed across different exchange rates. The percentage of firms with significant exposure is the highest with respect to the exchange rate against the Japanese yen, and the lowest against the U.S. dollar, which can be explained by the regulated floating exchange rate regime as discussed above. Unlike the weak evidence of residual exchange rate exposure against the trade-weighted exchange rate index, stronger evidence of significant exposure against the trade-weighted index is found for total exposure.

In line with the previous analysis, we also summarize the distribution of the signs of those significant total exchange rate exposures. Table 3.5 shows that the mean, median and maximum value of the exposure coefficients are all positive, compared to the prevalence of negative coefficients in residual exchange rate exposure. As argued above, the total ex-

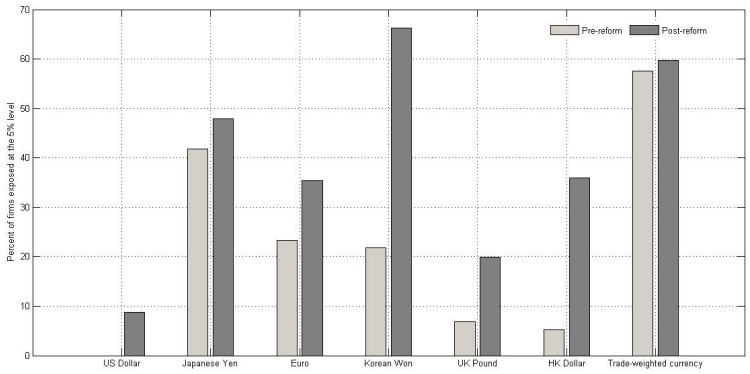

Figure 3.5 Total exchang rate exposure of Chinese firms before and after the reform

Table 3.5 Statistics of total exchange rate exposure of Chinese firms

Currency	Exposure Beta				Positive Exposure		Negative Exposure	
	Mean	Median	Max.	Min.	5%	10%	5%	10%
Panel A: Pre-Reform								
JY	0.51	0.49	1.16	0.25	418	538	0	1
EU	0.49	0.47	1.38	0.23	233	341	0	1
KW	0.73	0.70	1.49	0.28	215	297	3	9
UK	0.50	0.48	1.10	0.29	58	95	11	26
HK	8.87	8.59	27.57	-11.51	45	83	7	16
TW	1.31	1.24	3.64	0.62	576	665	0	0
Panel B: Post-Reform								
US	4.96	5.14	9.97	-9.74	84	138	3	8
JY	0.65	0.63	1.34	-0.83	477	594	2	3
EU	0.65	0.62	1.41	0.29	354	453	0	0
KW	0.49	0.46	1.24	-0.68	663	758	0	0
UK	0.35	0.44	0.88	-0.60	199	292	0	1
HK	3.53	4.59	9.65	-9.55	356	474	3	6
TW	1.43	1.37	3.53	0.63	597	690	0	0

Note: US = U.S. dollar, JY = Japanese yen, EU = euro, KW = Korean won, UK = U.K. pound sterling, HK = Hong Kong dollar, TW = Trade-weighted currency

change rate exposure is a more convincing indicator of the international trading position for firms. It is intuitive that exporters and import competitors will gain from a depreciation of home currency, which should lead to positive exposure coefficients. For the same reason, negative coefficients are expected for importers. From Table 3.6, we can see that among firms that are significantly exposed, more than 90% of them exhibit positive exposure coefficients at both the 5% and 10% significance level. The overwhelming positive exposure reflects the fact that most Chinese firms behave as net exporters rather than net importers. This is consistent with the observation that as "the manufactory of the World", China exports far than it imports, and a huge amount of trading surplus has accumulated over the last

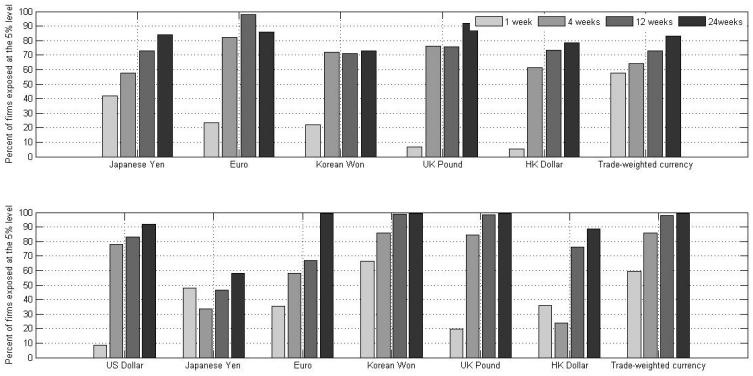

Figure 3.6 (a) Pre-reform total exchange rate exposure at different return horizons (b) Post-reform total exchange rate exposure at different return horizons

three decades.

3.4.2 Total exchange rate exposure at long horizons

Figure 3.6 presents a summary of the percentage of firms significantly exposed over different return horizons. Consistent with the results of residual exchange rate exposure, the number of exposed firms generally increases with the horizon except for some cases. For example, the number of firms exposed to the euro movement at the 12 weeks' return horizon(977 firms) is larger than that at the 24 weeks' return horizon(857 firms) during the pre-reform period; the number of firms exposed to the Japanese yen and the Hong Kong dollar movement at the 1 week' return horizon is larger than that at the 4 weeks' return horizon during the post-reform period. During the 4 years before the reform, about 68% of firms on average are found to be significantly exposed to the exchange rate movement of the selected foreign currencies at the monthly frequency, while the percentage increases to 77% at the quarterly, to 82% at the semi-yearly frequency. During the 4 years after the reform, about 64% of firms on average are found to be significantly exposed to the exchange rate movement of the selected foreign currencies at the monthly frequency, while the percent increases to 81% at the quarterly, to 91% at the semi-yearly frequency. The positive effect of the reform on the exchange rate exposure at different time horizons can also be observed from Figure 3.6.

Table 3.6 presents the statistics on the signs of significant exposure at different horizons. We can see that Chinese firms are overwhelmingly positively exposed at different

Table 3.6 Statistics of Total exchange rate exposure of Chinese firms at different return horizons

Currency	1 week			4 weeks			12 weeks			24weeks		
	no of firms exposed	positive	negative	no of firms exposed	positive	negative	no of firms exposed	positive	negative	no of firms exposed	positive	negative
Panel A: Pre-Reform												
JY	418	418(100%)	0	576	571(99%)	5	727	690(94%)	37	841	801(95%)	40
EU	233	233(100%)	0	824	822(99%)	2	977	977(100%)	0	857	831(96%)	26
KW	218	215(98%)	3	719	714(99%)	5	711	653(91%)	58	728	555(76%)	173
UK	69	58(84%)	11	761	761(100%)	0	755	732(96%)	23	921	911(98%)	10
HK	52	45(86%)	7	612	598(98%)	14	735	636(86%)	99	783	703(89%)	80
TW	576	576(100%)	0	640	638(99%)	2	728	689(94%)	39	832	811(97%)	21
Panel B: Post-Reform												
US	87	84(96%)	3	780	775(99%)	5	832	783(94%)	49	917	886(96%)	31
JY	479	477(99%)	2	334	279(83%)	55	464	302(65%)	162	581	406(69%)	175
EU	354	354(100%)	0	583	579(99%)	4	667	618(92%)	49	994	994(100%)	0
KW	663	663(100%)	0	858	857(99%)	1	990	989(99%)	1	993	993(100%)	0
UK	199	199(100%)	0	845	845(100%)	0	983	983(100%)	0	995	995(100%)	0
HK	359	356(99%)	3	240	154(64%)	86	763	733(96%)	30	888	823(92%)	65
TW	597	597(100%)	0	860	859(99%)	1	978	977(99%)	1	992	990(99%)	2

Note: US = U.S. dollar, JY = Japanese yen, EU = euro, KW = Korean won, UK = U.K. pound sterling, HK = Hong Kong dollar, TW = Trade-weighted currency

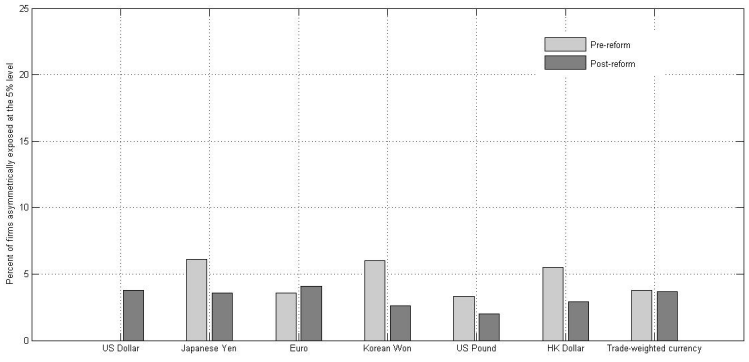

Figure 3.7 Asymmetric exchange rate exposure of Chinese firms before and after the reform

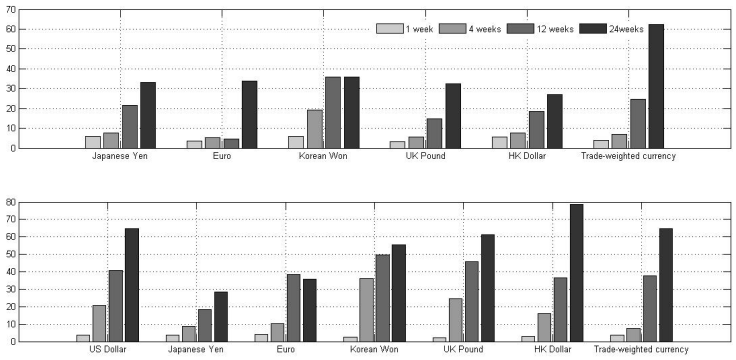

Figure 3.8 (a) Pre-reform asymmetric exchange rate exposure at different return horizons (b) Post-reform asymmetric exchange rate exposure at different return horizons

return horizons. This provides further confirmation that most of Chinese firms behave as net exporters, and therefore benefit from a depreciation of RMB. Part of the reasons for why there is only a limited number of firms having negative total exposure is the selection of the sample. Only the firms listed in exchanges are selected, but most of the Chinese imports are conducted by governmental authorities and small firms that are usually not listed in exchanges.

3.4.3 Asymmetric exchange rate exposure

In addition to the total exchange rate exposure, we also examine the extent of asymmetric exposure for Chinese firms. Figure 3.7 presents the percentage of firms with significant asymmetric exposure using weekly orthogonalized return data. We can see that only about

4.5% of firms exhibit asymmetric exposure to all the major bilateral exchange rates and the percentage of firms asymmetrically exposed is higher before the reform except for the euro. This implies that the reform leads to structural change not only in the exchange rate exposure of Chinese firms, but also in the asymmetric exposure behavior. As for the reason why only a small number of firms exhibit asymmetric exposure, we think it is due to the adoption of a short weekly return horizon. As analyzed above, asymmetric exposure arises from factors such as asymmetric pricing, asymmetric transaction cost, and asymmetric hedging. It takes some time for these factors to influence the cash flow and stock price of firms. Therefore, it is reasonable for the weekly movement of share price not to respond to depreciation and appreciation asymmetrically. It is expected that asymmetric exposure will occur at longer return horizons. Figure 3.8 shows the percentage of firms that are asymmetrically exposed to appreciation-depreciation cycles over different horizons. As predicted, the number of firms that are asymmetrically exposed is generally increasing with the return horizon.

Table 3.7 reports the number of firms with different combinations of significant $\beta_{DX,i}$ and $\beta_{X,i}$ at the 4 weeks' return horizon. We can see that most combinations fall into the diagonal of the matrix, where the asymmetric exposure coefficient and the exposure coefficient have the same sign. It indicates that net exporters (with $\beta_{X,i} > 0$) are influenced more by home currency depreciation than by appreciation (with $\beta_{DX,i} > 0$) and net importers (with $\beta_{X,i} < 0$) are influenced more by home currency appreciation than by depreciation (with $\beta_{DX,i} < 0$). Net exporters may take hedge strategies against the unfavorable condition when home currency is expected to be stronger, which may mitigate the negative effect of the appreciation. However, no hedging action will be taken when the situation is expected to become favorable. This kind of one-sided hedging behavior of risk-averse managers can partly explain the same sign of $\beta_{DX,i}$ and $\beta_{X,i}$ found in this empirical analysis. As an exception, Chinese firms seem to being influenced more by the RMB appreciation against the U.S. dollar than by depreciation. This is likely due to the fact that after the reform, the RMB tends to appreciate more often than to depreciate against the U.S. dollar.

3.5 Why is there a larger number of significant exposure after the reform?

The empirical results above show more Chinese firms exhibit significant exposure after the reform. It is easy to understand this phenomena in the case of the U.S. dollar, because the exchange rate of RMB against the U.S. dollar becomes floated after the reform. However, how do we explain the more significant exposure against the other foreign currencies after the reform, given that the RMB is floated against these currencies before and after

Table 3.7 Combination of asymmetric and symmetric exposure coefficient

	US		JY		EU		KW		UK		HK		TW	
	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$	$\beta_{X,i}>0$	$\beta_{X,i}<0$
Panel A: Pre-Reform														
$\beta_{DX,i}>0$	-	-	64	0	19	0	159	0	22	5	16	0	54	0
$\beta_{DX,i}<0$	-	-	5	8	8	27	9	25	16	32	20	19	4	10
Panel B: Post-Reform														
$\beta_{DX,i}>0$	14	0	65	1	68	0	351	1	20	0	232	0	42	0
$\beta_{DX,i}<0$	164	29	0	21	20	13	9	1	95	44	8	5	23	10

Note: US=U.S. dollar, JY=Japanese yen, EU=euro, KW=Korean won, UK=U.K. pound sterling, HK=Hong Kong dollar, TW=Trade-weighted currency

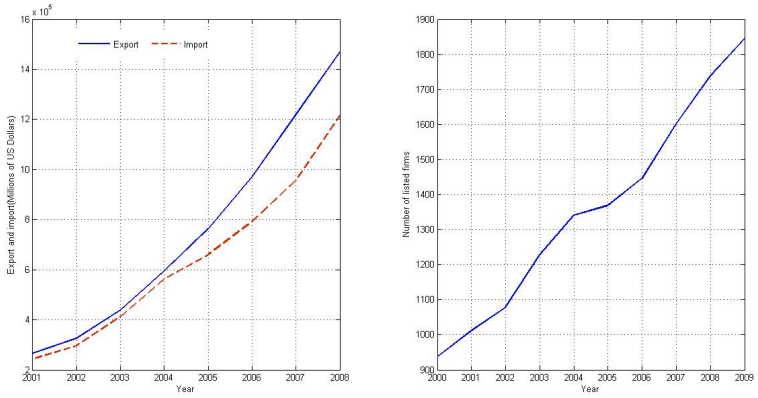

Figure 3.9 (a) Exports and imports of China during 2001-2008 (b) Number of firms listed in the Shanghai and Shenzhen Exchange during 2000-2009

Table 3.8 Statistics of exchange rate change before and after reform

	Pre-Reform				Post-Reform			
Currency	Mean	Std.Dev	Min.	Max.	Mean	Std.Dev	Min.	Max.
US Dollar					-0.0076	0.0017	-0.0083	0.0060
Japanese Yen	0.0006	0.0128	-0.0352	0.0436	-0.0001	0.0171	-0.0500	0.0780
Euro	-0.0002	0.0146	-0.0656	0.0535	-0.0016	0.0138	-0.0424	0.0432
Korean Won	0.0011	0.0099	-0.0284	0.0291	-0.0015	0.0190	-0.0815	0.1029
Uk Pound	0.0011	0.0118	-0.0307	0.0287	-0.0014	0.0173	-0.0931	0.0495
HK Dollar	0.0001	0.0006	-0.0017	0.0063	-0.0007	0.0018	-0.0094	0.0060

the reform? Can we presume that the reform changes the macroeconomic environment in which Chinese firms operate? Due to limited macroeconomic data at the weekly level, it is difficult to conduct a quantitative investigation into this possibility. Here, we propose some hypotheses for the larger number of significant exposure after the reform and verify them in a qualitative way.

First, one possible reason is that the exchange rate against the other foreign currencies become more volatile after the reform. Table 3.8 shows the key statistics of the percent exchange rate change for all the foreign currencies selected before and after the reform. The most prominent pattern we can observe is that the standard deviation during the post-reform period is significantly larger than the pre-reform period for all the foreign currencies. This confirms our hypothesis that the reform leads to more volatile exchange rate against the other foreign currencies, which results in the higher exchange rate exposure faced by Chinese firms.

Secondly, the increasingly active role of China in international trade could also be a reason for the larger number of exchange rate exposures after the reform. Figure 3.9(a) shows that the export and import value of China are steadily increasing from year 2001 to 2008; the average growth rate is 28% for export and 26% for import. The more the firms involved in the international market, the higher probability that they will be exposed to the change of exchange rates. In addition, previous works have concluded that the more competitive environment in which firms operated, the higher exchange rate exposure are firms likely to suffer from (Levi, 1994; Allayannis, 1996; Marston, 2001). From Figure 3.9(b), we can see that the number of firms listed in the Shanghai and Shenzhen Exchange has drastically increased in the past 10 years. With more firms entering the market, it is predictable that Chinese firms will a more competitive environment, which makes it difficult for firms to maintain a high markup and to pass through the negative influence of exchange rate movements thus a higher exchange rate exposure.

4 Industry-specific Exchange Rate Exposure

4.1 The effect of industry characteristics on exchange rate exposure

In the previous chapter, we examine the effect of exchange rate movements on the value of Chinese firms before and after the reform of the exchange rate regime using the capital market approach. As established in the previous studies, other factors, both macroeconomic and microeconomic ones, can influence the direction and size of the exposure. However, due to data availability, few empirical studies were conducted to test the prediction of these theoretical analysis. In this chapter, we make the first attempt to established empirically the connection between microeconomic foundations and the incidence of exchange rate exposures. We begin by building models to examine how firms operating in the export, import and import-competing industries are exposed to the exchange rate movement and what factors are likely to influence the size and direction of the exposure.

4.1.1 Exchange rate exposure of an export Cartel

The economic exposure of a firm is measured as the sensitivity of the firm value to the exchange rate change. The value of a firm can be expressed as the present value of future net cash flows(eq. 4.1).

$$V = \sum_{t=1}^{\infty} \frac{CF_t}{(1+\rho)^t} = \sum_{t=1}^{\infty} \frac{(1-\tau)\pi_t}{(1+\rho)^t} \tag{4.1}$$

where CF_t represent the net cash flow of the firm at time t which is equal to the after-tax profits pi_t, ρ is the discount rate and τ is the tax rate. Assuming that the profit is constant from year to year, the value of the firm can be written as in equation 4.2. Further assume a constant discount rate and tax rate. The exchange rate exposure can be measured as the derivative of the value of the firm with respect to the exchange rate as in equation 4.3.

$$V = \frac{CF}{\rho} = \frac{(1-\tau)\pi}{\rho} \tag{4.2}$$

$$\frac{dV}{dx} = \frac{(1-\tau)}{\rho}\frac{d\pi}{dx} \tag{4.3}$$

As an export Cartel, which we can also treat as an export firm operating in a monopolistic

environment, the firm's profit can be written as

$$\pi = TR - TC = \sum_{i=0}^{k} x_i p_i q_i - c \sum_{i=0}^{k} q_i \tag{4.4}$$

where π is the profit, TR is the total revenue, TC is the total cost, x_i is the exchange rate against the currency of country i($x_0 = 1$ represents the home currency), p_i is the price in country i, q_i is the quantity sold to country i(q_0 is the amount sold domestically), and c is the assumed constant marginal cost.

The firm choose the quantity to maximize its profit. Assuming that the firm's output does not affect the exchange rate, the first-order condition for profit maximization is given by

$$dTR/dq_i = dTC/dq_i \Rightarrow x_i p_i + x_i q_i \frac{dp_i}{dq_i} = c \Rightarrow p_i = \frac{c}{x_i(1 - 1/\sigma_i)} \tag{4.5}$$

where$\sigma_i = -\frac{p_i dq_i}{q_i dp_i} > 1$ is the elasticity of demand in country i. Assume that the firm can price discriminately in different countries; then $sigma_i$ is the import elasticity for the product in country i. Equation 4.5 is equivalent to $x_i p_i = \frac{c}{(1-1/\sigma_i)}$, which means that the home currency price is negatively related to the demand elasticity: the more elastic the demand in country i, the lower the price.

From equation 4.5, we have

$$\frac{dp_i}{dx_i} = -\frac{p_i}{x_i} \tag{4.6}$$

According to the definition of exchange rate exposure and taking into account equation 4.6, we have

$$\frac{d\pi}{dx_i} = p_i q_i + x_i p_i \frac{dq_i}{dp_i}\frac{dp_i}{dx_i} + x_i q_i \frac{dp_i}{dx_i} - c\frac{dq_i}{dp_i}\frac{dp_i}{dx_i} = p_i q_i - (1-\sigma_i) p_i q_i + c\frac{dq_i}{dp_i}\frac{p_i}{x_i} = \sigma_i q_i (p_i - \frac{c}{x_i}) \tag{4.7}$$

With $\sigma_i > 1$ and equation 4.3, we have

$$\frac{dV}{dx} = \frac{(1-\tau)}{\rho}\frac{d\pi}{dx} = \frac{(1-\tau)}{\rho}\sigma_i q_i (p_i - \frac{c}{x_i}) > 0 \tag{4.8}$$

The positive exchange rate exposure shows that the export firm benefit from a depreciation of the home currency. In addition, equation 4.8 indicates that the exchange rate exposure of an export firm depends on the import elasticity for the product in country i. The firm selling to a country with a higher demand elasticity will suffer from a higher exchange rate exposure. As argued above, a firm operating in a more competitive environment has

less power to pass through the negative influence of exchange rate movements through increasing the foreign currency price, hence bearing a higher exchange rate exposure. The exchange rate exposure also depends on the profit generated in country i which is the per unit mark-up $(p_i - \frac{c}{x_i})$ multiplied by the amount sold q_i. Besides, the tax rate τ and the discount rate ρ can also affect the exchange rate exposure through changes in the tariff policy or the interest rate.

4.1.2 Exchange rate exposure of an import Cartel

As with the exporter, we can write the profit of an import Cartel or a firm in a monopolistic import industry as in equation 4.9

$$\pi = TR - TC = p\sum_{i=0}^{k} q_i - \sum_{i=0}^{k} x_i c_i q_i \tag{4.9}$$

where p is the price of the product in the home market and in the home currency, c_i is the average purchase price from country i in the currency of country i. We assume that the product imported from different countries are homogenous and will be sold at the same price in the home country.

The importer choose the amount of import to maximize its profit and the first-order condition for profit maximization is given by

$$dTR/dq_i = dTC/dq_i \Rightarrow p + q_i\frac{dp_i}{dq_i} = x_i c_i \Rightarrow p = \frac{x_i c_i}{1 - 1/\sigma} \Rightarrow \frac{dp}{dx_i} = \frac{p}{x_i} \tag{4.10}$$

Given the definition of exchange rate exposure and equation 4.6, we have

$$\frac{d\pi}{dx_i} = p\frac{dq_i}{dp}\frac{dp}{dx_i} + q_i\frac{dp}{dx_i} - c_i q_i - x_i c_i \frac{dq_i}{dp}\frac{dp}{dx_i} = (1-\sigma)q_i(\frac{p}{x_i} - c_i) \tag{4.11}$$

where $\sigma = -\frac{p dq_i}{q_i dp} > 1$ is the demand elasticity for the imported product in the home country.

Given $\sigma > 1$ and equation 4.3, we have

$$\frac{dV}{dx} = \frac{(1-\tau)}{\rho}\frac{d\pi}{dx} = \frac{(1-\tau)}{\rho}(1-\sigma)q_i(\frac{p}{x_i} - c_i) < 0 \tag{4.12}$$

The negative exposure indicates that the import firm will suffer a loss from a depreciation of the home currency. Further, the higher the elasticity, the greater the losses. Again, many other factors, such as the profitability in the home currency $q_i(\frac{p}{x_i} - c_i)$, the tax rate and the discount rate can also affect the exchange rate exposure.

4.1.3 Exchange rate exposure of import-competing firm

As for an import-competing firm who uses local raw materials and sells the products in the domestic market, although it is not directly involved in the international trading market, the strategic decisions of an import-competing firm are influenced by its competitors who import products from foreign countries for resale and are inevitably affected by the exchange rate movement. Therefore, a firm competing with an import firm indirectly suffers from foreign exchange rate exposure through the competing interaction with the import firm. It is expected that the sign of exchange rate exposure of an import-competing firm will be opposite to that of an import firm. That is, an import-competing firm benefits from a home currency depreciation. To verify this, we build a duopoly model to examine how an import-competing firm is affected by the exchange rate change. The duopoly game consists of an import firm who imports products from foreign countries for resale and a domestic firm who produces and sells the same product to the local market. The import firm (firm 1) imports q_1 units of goods at a price in a foreign currency of c_1, while the domestic firm (firm 2) produces q_2 units at a cost in the home currency of c_2. The products are assumed to be homogenous and the price is determined by the total amounts of the products in the local market, by the reverse demand function $P = P(q_1, q_2)$. For simplicity, we consider a linear demand curve with price given by $P = a - b(q_1 + q_2)$. The profit of each firm can be measured in the home currency as follows:

$$\pi_1 = q_1 P(q_1, q_2) - x c_1 q_1 \tag{4.13}$$

$$\pi_2 = q_2 P(q_1, q_2) - c_2 q_2 \tag{4.13'}$$

The exchange rate explicitly enters only the profit function of firm 1. The two firms choose the amount to import (produce) to maximize their profits. The decision of firm i will affect the decision of the other firm; thus, the first-order condition will include a "conjectural variations" term of the form $dq_i/dq_j, i \neq j$. The first-order condition of the two firms are given by equation 4.14.

$$\frac{d\pi_1}{dq_1} = P(q_1, q_2) + q_1 \frac{dP}{dq_1} + q_1 \frac{dP}{dq_2}\frac{dq_2}{dq_1} - x c_1 = 0 \tag{4.14}$$

$$\frac{d\pi_2}{dq_2} = P(q_1, q_2) + q_2 \frac{dP}{dq_2} + q_2 \frac{dP}{dq_1}\frac{dq_1}{dq_2} - c_2 = 0 \tag{4.14'}$$

The exact form of the conjectural variation term will depend on the nature of competition. In this case, we consider the Cournot competition where each firm takes the other

firm's output as given, such that $dq_i/dq_j, i \neq j$ is equal to zero. Again, with the linear demand curve, the first-order condition can be rewritten as in equation 4.15.

$$P(q_1, q_2) + q_1 \frac{dP}{dq_1} = xc_1 \Rightarrow a - b(q_1 + q_2) - bq_1 = xc_1 \tag{4.15}$$

$$P(q_1, q_2) + q_2 \frac{dP}{dq_2} = c_2 \Rightarrow a - b(q_1 + q_2) - bq_2 = c_2 \tag{4.15'}$$

Solve this simultaneous equation. We have

$$q_1^* = \frac{a + c_2 - 2xc_1}{3b} \tag{4.16}$$

$$q_2^* = \frac{a - 2c_2 + xc_1}{3b} \tag{4.16'}$$

Substitute equation 4.16 in the profit function. We have

$$\pi_1 = \frac{a + c_2 - 2xc_1}{3b} \frac{a + c_2 + xc_1}{3} - xc_1 \frac{a + c_2 - 2xc_1}{3b} \tag{4.17}$$

$$\pi_2 = \frac{a - 2c_2 + xc_1}{3b} \frac{a + c_2 + xc_1}{3} - c_2 \frac{a - 2c_2 + xc_1}{3b} \tag{4.17'}$$

We can see that both firms' profits are related to the exchange rate. The exchange rate exposure of each firm is given by equation 4.18

$$\frac{d\pi_1}{dx} = -\frac{4c_1(a + c_2 - 2xc_1}{9b} = -\frac{4c_1}{3} q_1^* < 0 \tag{4.18}$$

$$\frac{d\pi_2}{dx} = \frac{2c_1(a - 2c_2 + xc_1)}{9b} = \frac{2c_1}{3} q_2^* > 0 \tag{4.18'}$$

Equation 4.18 shows that the import firm is negatively exposed to the exchange rate movement while the import-competing firm is positively exposed. Thus, an import-competing firm will benefit from a home currency depreciation, consistent with above intuitive prediction.

4.2 Industry-specific exchange rate exposure

After theoretically analyzing how firms in different industries are exposed to exchange rate changes, we now examine empirically the industry-specific exchange rate exposure in the Chinese market. Previous empirical researches find little evidence about significant industry-specific exposures. For instance, Bodnar (1993) found that only 11 of 39 U.S. industries, 4 of 19 Canadian industries and 7 of 20 Japanese industries exhibit significant foreign exchange exposures at the 10 percent significance level during 1979 to 1988. Choi (1995) found that 2 of 20 two-digit SIC-based portfolios are significantly affected by exchange rate movements at the 10 percent level. In contrast, Allayannis (1995) found strong

evidence of significant industry exposures of U.S. manufacturing industries at the four-digit SIC level. Two factors may help explain the insignificant industry exposure finding of the previous research. The first one is the difference between "residual exposure" and "total exposure" as pointed out above. The method used by the previous research only measures the residual exposure, which is the difference between the industry's total exposure and the market's exposure adjusted by the industry's market beta. Following the firm-specific studies, the orthogonalized market return will be used to measure "total exposure". Secondly, aggregating industry groups may average out the exposure effect. To avoid this drawback, a less aggregated industry classification at the three-digit SIC level will be used in this paper.

4.2.1 Data

Industry portfolio returns are the average return of firms belonging to the industry. It is important to choose an appropriate industry classification system. In the Datastream database, four-digit SIC codes (1987 version) are assigned to both U.S. and non-U.S. companies according to the type of business in which they are engaged. A company may have up to eight SIC codes assigned to it depending on the number of business segments which make up the company's revenue. The SIC code of all the firms examined in Chapter 3 is obtained, based on which we build the industry portfolio at the three-digit SIC level. A total of 299 industry portfolios result. The reason why we do not use the most disaggregated four-digit SIC level is that a lot of four-digit SIC codes only include a single corresponding firm. It is also difficult to find industry characteristic data, such as demand elasticity, at such a disaggregated level. The exchange rate and market return data come from the same source as in Chapter 3. Weekly data are used and the 4 weeks' time horizon is chosen to examine the industry-specific exposure.

4.3 Empirical results

Due to space constraints, we do not report the exposure coefficients for all the 299 industries; instead, we present the results in an aggregated manner that shows the number of significant industries in each industry group. The 299 industries are classified into 11 groups according to the highest level SIC classification. The mean and median of significant exposure coefficients are also reported in Table 4.1 and Table 4.2.

As can be seen from Table 4.1and Table 4.2, with total exposure measured in place of residual exposure, a large percentage of industries are significantly exposed to the exchange

Table 4.1 Statistics of Industry-specific exposure before the reform

Industry Group	N	JY			EU			KW			UK			HK		
		N*	Mean	Median	N*	Mean	Median	N*	Mean	Median	N*	Mean	Median	N*	Mean	Median
AGRICULTURE, FORESTRY, AND FISHING	19	17	0.45	0.44	14	0.49	0.47	18	0.71	0.60	17	0.73	0.69	2	-1.82	-1.82
MINING	19	15	0.54	0.56	18	0.64	0.63	16	0.62	0.62	19	0.85	0.79	5	1.26	2.72
CONSTRUCTION	10	9	0.35	0.32	9	0.46	0.43	9	0.66	0.62	10	0.65	0.59	0	0.00	0.00
MANUFACTURING	112	103	0.44	0.42	105	0.52	0.52	107	0.65	0.63	108	0.69	0.68	21	4.01	4.34
TRANSPORTATION AND PUBLIC UTILITIES	30	28	0.44	0.42	28	0.47	0.48	29	0.66	0.65	29	0.65	0.64	4	-2.35	-3.54
WHOLESALE TRADE	18	18	0.42	0.42	18	0.48	0.48	18	0.67	0.68	18	0.64	0.64	1	5.67	5.67
RETAIL TRADE	30	26	0.43	0.40	26	0.48	0.40	27	0.71	0.67	28	0.68	0.61	5	6.04	5.15
FINANCE, INSURANCE, AND REAL ESTATE	15	13	0.47	0.48	15	0.53	0.56	15	0.63	0.67	15	0.66	0.65	1	-4.01	-4.01
SERVICES	42	39	0.47	0.45	33	0.52	0.49	39	0.73	0.70	42	0.67	0.60	9	6.44	7.34
PUBLIC ADMINISTRATION	3	2	0.54	0.54	1	0.32	0.32	2	0.69	0.69	1	0.51	0.51	2	3.84	3.84
NONCLASSIFIABLE ESTABLISHMENTS	1	1	0.69	0.69	1	0.87	0.87	1	0.78	0.78	1	1.26	1.26	0	0.00	0.00
Total number	299	271			268			281			288			50		

Note: N is the number of 3-digit SIC industries in each industry group. N* is the number of industries with significant exposure.
US=U.S. dollar, JY=Japanese yen, EU=euro, KW=Korean won, UK=U.K. pound sterling, HK=Hong Kong dollar, TW=Trade-weighted currency

Table 4.2 Statistics of Industry-specific exposure after the reform

Industry Group	N	US			JY			EU			KW			UK			HK		
		N*	Mean	Median	N*	Mean	Median	N*	Mean	Median	N*	Mean	Median	N*	Mean	Median	N*	Mean	Median
AGRICULTURE, FORESTRY, AND FISHING	19	16	5.26	5.06	7	0.53	0.50	17	0.86	0.89	15	0.56	0.60	18	0.85	0.83	11	3.76	3.23
MINING	19	17	6.66	7.75	9	0.15	0.33	17	1.03	1.10	19	0.76	0.79	18	1.09	1.10	16	5.28	6.27
CONSTRUCTION	10	10	6.96	6.89	9	0.38	0.40	10	0.82	0.81	10	0.56	0.58	10	0.97	0.95	10	4.97	5.06
MANUFACTURING	112	109	6.22	6.21	46	0.37	0.37	110	0.91	0.92	111	0.66	0.65	110	0.99	0.98	102	4.21	4.10
TRANSPORTATION AND PUBLIC UTILITIES	30	27	5.82	5.71	13	0.20	0.26	29	0.86	0.84	29	0.64	0.62	29	0.95	0.93	26	3.99	3.92
WHOLESALE TRADE	18	18	5.79	5.57	4	0.27	0.26	18	0.91	0.93	18	0.66	0.65	18	0.96	0.97	18	3.52	3.58
RETAIL TRADE	30	29	5.62	5.63	9	0.41	0.36	27	0.92	0.88	30	0.61	0.61	29	0.94	0.93	26	3.08	3.11
FINANCE, INSURANCE, AND REAL ESTATE	15	14	6.21	6.19	7	0.08	0.25	15	0.81	0.77	15	0.68	0.63	15	1.12	1.12	14	4.04	4.06
SERVICES	42	39	6.46	6.07	19	0.24	0.32	41	0.92	0.88	40	0.68	0.63	42	0.99	0.96	36	4.57	4.12
PUBLIC ADMINISTRATION	3	1	7.38	7.38	1	0.78	0.78	3	1.34	1.44	3	0.80	0.72	2	1.69	1.69	1	4.58	4.58
NONCLASSIFIABLE ESTABLISHMENTS	1	1	9.20	9.20	0	0.00	0.00	1	0.61	0.61	1	0.55	0.55	1	0.83	0.83	1	7.08	7.08
Total number	299	281			124			288			291			292			261		

Note: N is the number of 3-digit SIC industries in each industry group. N* is the number of industries with significant exposure.

US=U.S. dollar, JY=Japanese yen, EU=euro, KW=Korean won, UK=U.K. pound sterling, HK=Hong Kong dollar, TW=Trade-weighted currency

rate change of the selected foreign currencies both before and after the reform, which is contrary to the little significant exposure finding of previous studies. Consistent with the results of firm-specific exposure, all Chinese industries experience predominantly positive foreign currency exposures, which indicates that most industries behave like net exporters and benefit from a depreciation of RMB. Among all the foreign currencies, Chinese Industries show less significant exposure to the Hong Kong dollar before the reform and to the Japanese yen after the reform. industries with insignificant exposures are concentrated in the Service and Public administration industry group. Clearly, industries in these groups are either less likely to be involved in the international market or more likely to resort to hedging derivatives.

4.4 The effect of industry characteristics on exposure

4.4.1 Empirical results

Based on the results of the model built in Chapter 4.1, the direction of exposure depends on whether a firm operates in an export, import, or import-competing industry, and the magnitude of exposure is related to several factors, including demand elasticity of the products, mark-up, tax rate and discount rate. The exposure of a net exporter is positive and positively related to the demand elasticity, while the exposure of a net importer is negative and negatively related to the demand elasticity. The results in Chapter 4.2 show that most Chinese industries exhibit positive exposures; thus, a large proportion of Chinese industries have their imports outweighed by exports, and behave as net exporters. To provide evidence about how the competition situation in an industry influences the magnitude of exposure, we now examine empirically the relation between import elasticity and the exposure coefficient of industries with positive exchange rate exposure. Broda (2006) provides the import demand elasticities for several countries at the three-digit HS (Harmonized System 1992 classification) level, including the U.S. and Japan. In the previous section, we measure the industry-specific exchange rate exposure at the three-digit SIC level. We need to find the concordance between the three-digit HS level and the three-digit SIC level. Fortunately, Jon Haveman[①] provides such concordance. We regress the significant positive exposure coefficient on the corresponding import elasticity to see whether the exposure is positively related to the elasticity. As one three-digit SIC code might concord with more than one three-digit

[①] (http://www.macalester.edu/research/economics/page/haveman/Trade.Resources/tradeconcordances.html)

Table 4.3 Relation between Industry-specific exposure and demand elasticity

	Coefficient of elasticity	Standard error	P value	No of obs
US	0.411*	0.0186	0.029	124
Japan	0.006	0.006	0.32	54

Table 4.4 Relation between exposure, size and demand elasticity

	Elasticity			Size			No of obs
	Coeff.	S.E.	P value	Coeff.	S.E.	P value	
US	0.333*	0.0176	0.061	0.0005	0.0003	0.114	124
Japan	0.005	0.006	0.358	-5.04e-06	4.63e-06	0.281	54

HS code, we choose the median elasticity of all the concordant HS code as the independent variable. Table 4.3 reports the results of the relation between the Chinese industry exposure to the U.S. dollar and the Japanese yen after the reform and the import elasticity of the U.S. and Japan in the corresponding industry.

From Table 4.3, we can see that the regression coefficients of exposure on import elasticity are both positive, which indicates that the exchange rate exposures of Chinese industries are positively related to the demand elasticity. The higher the demand elasticity, the large the exposure. This is consistent with the conclusion we obtain from the model built in Chapter 4.1. Although positive, the coefficient in the case of Japan is not significant at the 10% level. It may be due to the fact that a smaller number of industries are significantly exposed to the Japanese yen movements. These empirical results provide some evidence on how the industry-specific exposure is influenced by the competition situation in an industry.

4.4.2 Robustness test

Although the empirical regression above provides some evidence about the positive relation between exchange rate exposure and demand elasticity, caveats remain. As noted above, in addition to demand elasticity, there are several factors that might influence the magnitude of exchange rate exposure; a simple regression of exposure on elasticity might suffer from the omitted variable problem. Previous works provided some evidence about the effect of the firm size on the exchange rate exposure. Chow (1998) found a positive effect of firm size on the exchange rate exposure for Japanese firms. Bodnar (2003) documented a strong relation between firm size and exposure for US firms. In contrast, Choi (2009) found that the effects of firm size on exposure are insignificant when the firms are classified into multinationals and non-multinationals.

$$\beta_{X,j} = \gamma_0 + \gamma_1 e_{X,j} + \gamma_2 MV_j + \mu_j \tag{4.19}$$

In this section, we introduce a variable representative of size into the model to test the robustness of the results in Table 4.3. The specification of the new model is as in equation 4.19, where $\beta_{X,j}$ is the exchange rate exposure against foreign currency X of industry j, $e_{X,j}$ is the import demand elasticity of industry j in country X , MV_j is the market value of industry j which represents the industry size. The market value of an industry is not directly available; thus, we use the median of market value of the firms in industry j as a proxy. The industry-specific exposure and demand elasticity are measured at the three-digit SIC level. Table 4.4 shows the regression results with the size variable introduced. We can see that the regression coefficients of exposure on import elasticity of the U.S. and Japan are still positive. The size coefficients for the U.S. and Japan are not significant at the 10% level. Thus, the positive relation between the exchange rate exposure and the demand elasticity is robust to the inclusion of firm/industry size.

5 Discussion

In this thesis, we have provided a considerable amount of empirical evidence to help understand the extent to which the Chinese firms and industries are exposed to the exchange rate movement after the reform of exchange rate regime in 2005. In this section, we discuss some potential caveats. First, the traditional capital market approach fails to consider the potential correlation between market return and exchange rate change which may result in underestimation of the exchange rate exposure. The orthogonalized market return is proposed in this thesis to estimate the total exchange rate exposure, which is successful in detecting more significant exposure than the traditional approach. However, using the orthogonalized market return might fail to account for the cases where the market return and exchange rate are related due to macroeconomic factors that are not related to exposure. Thus, there is a risk of overestimation of the exposure. Second, in previous works, two types of variables were sometimes added to the capital market model to reduce the problem of multicollinearity and to test the robustness of the results. They are factors constructed based on the index in the financial market, such as SMB(Small minus Big) and HML(Hign minus Low) factors proposed by Fama and French (1992), and macroeconomic variables, such as money supply, inflation rate and trade balance. We did not conduct such robustness checks here, as these financial factors are not available for the Chinese market and the macroeconomic variables at the weekly horizon are not available, either. Given that most of the previous works confirmed the robustness of the capital market model, we do not expect our estimation results to change much if these variables were available and controlled for. Third, the robust Newy-West variance estimators are used to account for possible serial correlations when the overlapping return at longer horizon is used. According to Valkanov (2003), the italicized-statistic in long-horizon regressions does not converge to well-defined distributions. Therefore, the exposure which is significant based on the traditional italicized-test might not be actually significant if the real distribution function is available. Fourth, the models built for the export and import industry assume a monopolistic structure; thus, the interaction of firms in the same industry is not considered. The model built for the import-competing industry assumes homogenous goods, which may not be realistic. Fifth, the simple regression of exposure on elasticity does not consider other factors that may influence the exposure. Hence it might suffer from the problem of omitted variables. In general, due to the complexity of the effect of the exchange rate movement on firm values, it is impossible to set up an integrated framework with all these complex

factors considered. Our understanding of the mechanism of exchange rate exposure is still not complete and the problems discussed above deserve further investigation in the future research.

6 Conclusions

It has been increasingly recognized that the fluctuation of exchange rates influences the cash flow and the value of firms. The reform of the exchange rate regime of China on July 21, 2005, ended the era of fixed exchange rates. The exchange rate exposure suffered by Chinese firms and industries thus became an important issue for research. In this thesis, the firm and industry-specific exchange rate exposures of the Chinese market are studied. This provides useful insights for Chinese firms and industries in their measurement and management of exchange rate exposure.

For the firm-specific exposure, the traditional capital market approach is first used to measure the "residual exchange rate exposure" against the exchange rate movement of the foreign currencies of China's major trade partners, including the U.S., Japan, European Union, South Korean, UK and Hong Kong. All the firms listed in the China Exchange Market before year 2001 are selected. At the one week's return horizon, less than 10% of firms exhibit significant exposure before the reform, while the percentage of significant exposure increases to over 20% for some currencies after the reform. The "total exchange rate exposure" is then measured by using orthogonalized market return to replace the market return. As a result, the average percentage of significantly exposed firms increase from 5.5% for residual exposure to 26% for total exposure during the pre-reform period, and from 12.4% for residual exposure to 39% for total exposure during the post-reform period. The dominant positive sign of total exposure reflects the fact that most of the Chinese firms behave as net exporters rather than net importers. In order to distinguish the short-term transaction exposure from the long-term economic exposure, which tends to be more accurately measured by using returns at long horizons, we also estimate the exposure of 4, 12, 24 weeks' return to exchange rate movements at the corresponding horizon. Consistent with previous studies, the number of firms with significant exposure increases with the time horizon, in terms of eihter residual exposure or total exposure. This indicates that firms bear more significant economic exposure, which cannot be mitigated by well-structured hedging strategies, than transaction exposure. We further examine the existence of asymmetric exchange rate exposures over the appreciation-depreciation cycles. The results indicate that about 4.5% of firms exhibit asymmetric exposure during appreciation and depreciation cycles for all the major bilateral exchange rates and the percentage of firms asymmetrically exposed is higher during the pre-reform period at the one week's return horizon. The number of firms with asymmetric exposure also increases with the return horizon. In summary, the reform of the

exchange rate regime results in a structural change of exchange rate exposure of Chinese firms.

For industry-specific exposure, we theoretically analyze how firms operating in different industries respond to the exchange rate movement. Models are built to simulate how firms in export, import and import-competing industries make decision to maximize their profits when foreign exchange rates fluctuate. We conclude that firms in export and import-competing industries benefit from a depreciation of the home currency, while firms in import industries gain from an appreciation of the home currency. Other factors, such as the demand elasticity, the mark-up, and the tax rate, also affect the magnitude of the exchange rate exposure. The total exchange rate exposure of the industry at the three-digit SIC level is also estimated by using the orthogonalized market return at the 4 weeks' return horizon. About 90% of Chinese industries are significantly exposed to both bilateral and trade-weighted exchange rate movements. The predominantly positive exposure indicates that most industries behave like net exporters and benefit from a depreciation of RMB. The relation between the exchange rate exposure of Chinese industries against the U.S. dollar and the Japanese yen and the import elasticity of the U.S. and Japan are also examined. The positive regression coefficient is consistent with the theoretical results,namely that the higher the demand elasticity, the higher the exchange rate exposure for firms operating in the export industries.

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