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Exchange Rate Exposure and Its Determinants in China*

By* HE QING, LIU JUNYI and ZHANG CE

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Abstract

This paper investigates the foreign exchange rate exposure and its determinants using the data of all firms listed on the Chinese stock market from 2005 to 2018. We find significantly linear and nonlinear exposures to bilateral as well as multilateral foreign exchange rates. Our temporal study also shows that considerably more Chinese firms were exposed to exchange rate fluctuations after the major exchange rate reform in 2015. We find a negligible role played by international operations of firms in explaining exposures. The level of exchange rate exposure is primarily explained by variables that are proxies for a firm's hedging costs. Larger firms, or firms with less leverage ratio, tend to have smaller exposures. Exposure is found to increase with a firm's growth opportunity. Last but not least, we find that leverage ratios and growth opportunities impact more significantly on exposures for firms with separation of control and cash flow rights.

JEL Classification: O24; G30; G15

Keywords: Foreign exchange exposures; China's exchange rate reform; Hedging costs; Separation of control and cash flow rights

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1. Introduction

It is well recognized that changes in the rate of exchange can affect a firm's value. Nevertheless, the relationship between exchange rate changes and firm's stock return remains a contentious issue, as a significant correlation between these variables has only been found in a small proportion of enterprises in developed countries (Jorion, 1990; He and Ng, 1998; Williamson, 2001; Bartram, 2004). An increasing number of studies aim to explain the so-called "foreign exchange exposure puzzle" (Bartram et al., 2010; Snaith et al., 2017).

In this paper, we add to this literature by presenting a comprehensive study of a large sample of Chinese public firms. The case of China is of academic interest for several reasons. First, while multiple studies have examined the foreign exposure of firms in developed countries, little is known about their counterparts in emerging market economies; and China is a large and important emerging economy where the foreign exchange exposure has yet to be thoroughly investigated. Second, exploration of foreign exchange exposure in an emerging economy such as China will offer some distinct perspectives. For instance, corporate hedging activities have long been regarded as crucial for managing exchange rate risks in developed countries.[1] Within China's underdeveloped financial system, however, hedging instruments are still limited. Whether and how hedging needs influence exchange rate exposure is therefore an intriguing issue to explore. Third, the corporate ownership structure in China differs from that of many developed countries[2], as corporate ownership in China is highly concentrated in a small group; more distinctly, controlling rights of the largest shareholder are greater than the cash flow rights (He and Rui, 2016; Tan and Tang, 2016; Zheng et al., 2018). This feature we explained below will add insights on the determinants of exchange rate exposure.

Using the data from July 21, 2005 to December 31, 2018, we empirically estimate and find statistically significant linear and nonlinear foreign exchange rate exposures of all Chinese public firms. Specifically, 5.6 percent more Chinese public firms show greater sensitivity to nonlinear exposures compared with linear exposures. In addition, considerably more firms were exposed to exchange rate fluctuations after the August 2015 reform: 26.2 percent of firms respond to nonlinear risks of the US dollar after the milestone exchange reform in 2015, whereas merely 1.4 percent respond to those risks before the reform.

We also examine whether a firm's exchange rate exposure is determined by its international operations and hedging needs. We find an insignificant role played by international operations in explaining a firm's exposure, as its proxy, the variable of foreign sale ratio, is marginally correlated with exposures. Firms that have high costs of hedging, however, are found to be more vulnerable facing the volatility of foreign exchange rates. The empirical results show that small firms, or firms with high leverage, or firms with a low book-to-market ratio, are more exposed to exchange rate fluctuations, though these effects are less pronounced prior to the exchange rate reform in 2015.

To address possible endogeneity issues, we conduct three additional tests. First, we implement a dynamic panel GMM using lagged values as the instruments. Second, we employ a two-stage least squares (2SLS) model using the previous three years' industry average of explanatory variables as instrument variables. Third, we employ event studies to examine whether the

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[1] Please see Flood and Lessard (1986), Logue (1995), Geczy et al. (1997), Bodnar et al.(1998), Chowdhry and Howe (1999), Allayannis and Ofek (2001), Allayannis et al. (2001).

[2] In most developed economies, corporate ownership and control are often separated and as such, strong legal mechanisms are needed to protect the owner's interests since the primary concerns are the conflicts of interests between the owners (principals) and managers (agents) (Jensen and Meckling, 1976).

reactions of stock price to exchange rate shocks vary with potential determinants of exchange rate exposures. Stock market reactions to exchange rate shocks are unlikely to influence a firm's foreign sales and other characteristics, and may consequently alleviate the endogeneity issue (Bartov et al., 1996). Our main results survive those tests.

Finally, we examine whether the separation of control and cash flow rights plays a role in determining foreign exchange rate exposures. One distinct feature of Chinese corporations is that in most firms that have controlling shareholders, the controlling rights of the largest shareholder are much larger than her cash flow rights (He and Rui, 2016; Fang et al., 2017, Zheng et al., 2018; He et al., 2019). The separation of control and cash flow rights enables controlling shareholders to engage in a variety of self-serving transactions, extracting private benefits of control from the firms that they run (Shleifer and Vishny, 1989; La Porta et al., 1999; Djankov et al., 2008; He et al., 2019). The more likely controlling shareholders extract the private benefits of control, the less likely she or he pursues the maximization of firm value (Bebchuk and Roe, 1999; La Porta et al., 2002; Claessens et al., 2002). Because entrenchment effects lower firm's sensitivity to cash flow, we expect that highly entrenched firms would be less likely to take risk management strategies to hedge against exchange-rate volatility. As a result, firms with the separation of control and cash flow rights are more exposed to exchange rate movements when there are greater costs of implementing hedging, i.e. high leverage ratio or low book-to-market ratio. The empirical results strongly support this hypothesis.

Our study contributes to the foreign exchange exposure literature in the following ways. First, to the best of our knowledge, this is the first academic attempt to comprehensively investigate foreign exchange rate exposure in China. Second, our evidence specifically suggests that in emerging market economies, China included, high costs of hedging may prevent firms from effectively managing foreign exchange exposures. Perhaps, a comprehensive reform of financial markets in emerging countries is therefore necessary to cope with growing exchange rate fluctuations. Last but not least, we find that a particular agency cost, entrenchment of controlling shareholders, reduces a firm's incentive to hedge against exchange rate volatility. Our study hence enriches the literature by identifying a linkage between controlling shareholders' risk attitude and exchange rate exposure in countries where corporate ownership is highly concentrated.

The remainder of the paper is organized as follows: Section 2 reviews the institutional background of our investigation and the literature relevant to it; Section 3 describes the data and our methods of research; Section 4 presents our empirical results; Section 5 discusses some robustness checks, and Section 6 concludes the paper.

2. Institutional background and literature review

2.1 Institutional background

The RMB exchange rate began fluctuating in 2005, when China undertook its first major exchange rate reform. Before then, the government had intentionally pegged the rate of the RMB to the value of the USD. From 1994 to 2005, 1 USD was equivalent to 8.28 RMB. With the value of their currency held constant, Chinese firms of this period were minimally exposed to the risks associated with rate changes.

But on July 21, 2005, the People's Bank of China (PBOC), the central bank of China, announced an end to the RMB/USD peg and adopted a managed floating exchange rate regime

that made use of a "reference basket" of currencies.[3] The RMB was allowed to fluctuate against the US dollar with a bandwidth of + or - 0.3 percent around the central parity.[4] In May 2007, the PBOC widened the bandwidth of the RMB against the USD from 0.3 percent to 0.5 percent, so as to hasten the marketization of the RMB exchange rate. However, the market oriented reform was interrupted by the 2008-2009 global financial crisis. During the crisis period, the RMB was de facto pegged to the USD at the rate of 6.83 RMB per USD. This reform was resumed on June 19, 2010, when PBOC made yet another announcement, declaring that its policy would be "to proceed further with the reform of the RMB exchange rate regime and to enhance the RMB's exchange rate flexibility," and re-emphasized that the RMB exchange rate was meant to "reflect market supply and demand with reference to a basket of currencies." The trading bandwidth was further widened to + or – 1 percent in 2012, and + or -2 percent in 2014.

Whether or not the PBOC has made use of a managed floating exchange rate for the RMB, the central bank has historically maintained a critical role in determining the RMB exchange rate. The central parity rate barely moves from day to day as a result, even though the spot exchange rates always approach the edge of the bandwidth. One of the goals of the PBOC's intervention in the foreign exchange market is to moderate the volatility of the RMB, particularly to lean against the appreciation of the RMB. China's foreign exchange reserves consequently increased from USD 733 billion in 2005 to around USD 4 trillion in 2014. Thanks to the PBOC's effort, the RMB/USD exchange rate was significantly less volatile than other foreign currencies under managed floating exchange rate regimes despite the persistence of market forces in continuing push up the value of the RMB against the USD. As shown in Figure 1, from July 2005 to July 2015, RMB/USD exchange rate had appreciated by 26 percent, an increase so gradual and steady that it might be called monotonous. During the financial crisis of 2008-09, however, the RMB/USD exchange rate hardly changed while those of the RMB/EURO, RMB/yen, and RMB/pound fluctuated a lot.

To speed up the marketization of the RMB exchange rate, on August 11, 2015 (hereafter the date of the 811 Reform), the PBOC announced its intent of "[i]mproving quotation of the central parity of the RMB against the USD[5]" targeted at the central parity quotation system. Under the new reform, the daily central parity rate set by the China Foreign Exchange Trading System (CFETS) before the market opens would be based on the closing rate of the inter-bank foreign exchange rate market the previous day, supply and demand in the market, and price movement of major currencies. The CFETS quickly launched its own foreign exchange rate index (CFETS Exchange Rate Index) in December 2015 and hence officially established an updated version of a managed floating exchange rate framework that allows for two-way fluctuations of the RMB based on the central parity, and that better responds to the supply-and-demand conditions of the foreign exchange market.

Occurring in 2015, the 811 Reform coincided with a turning point for the RMB/USD exchange rate, as well a period of profound volatility in the global financial market. In the following years, the foreign exchange market of China witnessed a significant increase in volatility of the exchange rate of the RMB against major currencies. Figure 1 presents the trends of the bilateral exchange rates between each one of the five foreign currencies and the RMB

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[3] In a speech in 2005, the then-governor of the PBOC, Zhou Xiaochuan, said "…the basket should be composed of currencies of the countries to which China has a prominent exposure in terms of foreign trade, external debt, and foreign direct investment."

[4] There is a daily central RMB/US parity announced by China Foreign Exchange Trading System (CFETS), an affiliate of the PBOC.

[5] Available at http://www.pbc.gov.cn/english/130721/2941603/index.html.

during the sample period. Overall, the RMB had appreciated against the USD until the reform, then depreciated for around two years; in 2017 it finally began to appreciate again. Given the pegged bilateral exchange rate between the USD and the Hong Kong dollar (HKD), it would be reasonable to expect the same pattern of historical fluctuation from the RMB and the HKD. It is, however, surprising to observe the two distinguishable patterns of RMB/Euro and RMB/Pound.

In particular, after 811 Reform, the RMB had appreciated relative to the euro while depreciating relative to the pound. Additionally, the 2008-09 financial crisis shook the RMB/euro exchange rate to a greater degree than it shook the RMB against the pound. The RMB/yen rate showed a similar pattern to that of RMB/euro during the 2008-09 financial crisis before subsequently diverging from that pattern. Before the "811 Reform", the foreign exchange rate index had trended steadily upward. After it came into effect, the index took a precipitous dive and eventually stabilized. Among the five foreign currencies, the RMB/USD and the RMB/HKD demonstrated the least volatility.

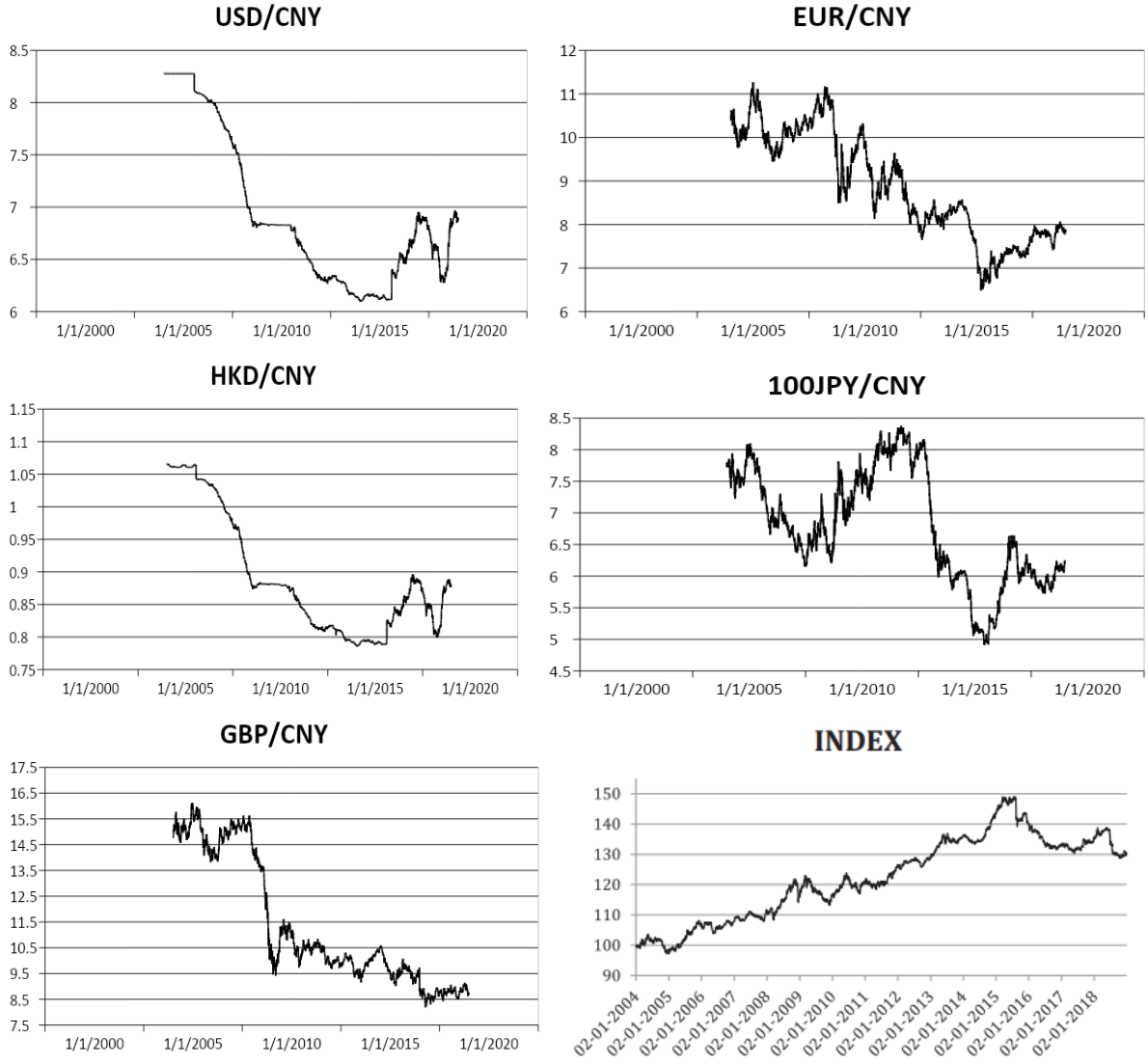

Figure 1: The bilateral foreign exchange rates (five foreign currencies) and the foreign exchange rate index

Many Chinese public firms have suffered losses caused by the unexpectedly volatile RMB exchange rate. Reuters reports that on October 10, 2017, nearly 1,400 listed Chinese manufacturers recorded currency-induced losses during the first six months after the 811 Reform. More firms turned to financial derivatives to hedge the increased exchange rate fluctuations, and only to find out that, unfortunately, China's underdeveloped financial market failed to fully arm domestic firms against the volatilities.

2.2 Literature review

Foreign exchange rate exposures have increasingly been explained as the rising volatility of the exchange rate market stemming from the ever-greater degree of economic linkage among countries. The expansion of multinational corporations in combination with the increasingly specialized subdivision of industry chains places further pressure on the exchange rate market, mainly due to the unprecedented volume of foreign currency denominated transactions. Even a firm that does no business abroad may need to adjust its activity to indirectly tackle possible foreign exchange rate risks faced by the whole industry (Hodder, 1982).

Jorion (1990), among the first to study these risks, empirically estimates foreign exchange rate exposure by analyzing the influence of exchange rate risks on a sample of the US firms. The line of the literature was further extended by the studies on a single nation (He and Ng, 1998), and studies that traced the influence of those risks across countries (Bartram and Karolyi, 2006; Doidge et al., 2006). Most empirical results, however, have found scant support for the existence of a significant effect both economically and statistically of exchange rate risks on firm value. Jorion (1990), for instance, claims that only 5.2 percent of US firms were exposed to foreign exchange rate risks in a study of 287 US multinational corporations. He and Ng (1998) also report that no more than 26.3 percent of Japanese multinational corporations whose foreign income is greater than 10 percent of their total income were significantly exposed to foreign exchange rate risks.

While most aforementioned studies are focused on a linear relationship between exchange rate risk and firm value, several researchers suggest that the relationship could be nonlinear (Bartram and Bodnar, 2012; Chaieb and Mazzotta, 2013). The nonlinearity may result from the asymmetric transitivity of exchange rates, the time lag of asset price change, or some financing arbitrage. For instance, Christophe (1997) argues that the nonlinear competitive effects result from firms' tendency toward delayed response to market changes[6]. Bartram and Bodnar (2007) show that financial hedging plays a key role in alleviating foreign exchange rate exposures. Most hedging activities are one-sided. Accordingly, the difference in how firms expect the foreign exchange rate to change will cause their respective hedging costs to vary. This may introduce nonlinearities in the relationship between firm value and the exchange rates.

Although nonlinear functions relax the assumption of the linear exposure, it is still challenging to justify a specific functional forms of linearity (Bartram and Bodnar, 2012). Chaieb and Mazzotta (2013) find that higher exposures of firms were captured when assuming the time variation relationship between firm value and exchange rates. Bodnar et al. (1998) report that 22 percent of firms use foreign exchange rate options to manage exchange rate risks;

[6] New competitors will usually enter the market as the domestic currency depreciates, and the incumbents may be reluctant to leave the market due to the heavy sunk costs they have already incurred. They thus endure the fluctuation of foreign exchange rate to compete with newcomers. The sunk costs fluctuate with the foreign exchange rate—sometimes to such an extreme extent that incumbents may have to exit the market.

consequently, suggest that the nonlinearity relationship depends on the financial strategy of option use. Assuming different generic types of nonlinear functions, Bartram (2004) finds that nonlinear exposure are substantially more significant than linear exposure in a large sample of German nonfinancial corporation. Koutmos and Martin (2003) and Priestley and Ødegaard (2007) find that the exposures of public firms are boosted by the inclusion of the nonlinearity factor that originates from the asymmetric impacts of appreciation and depreciation, respectively.

In addition to measuring firms' exposure to the risks of foreign exchange rates, some studies have investigated what factors determine those exposures. Along with others, Jorion (1990) reports that larger foreign sales are correlated with higher exchange rate exposure since foreign income raises the sensitivity of firm value to the volatility of the foreign exchange rate (Choi and Prasad, 1995; Doidge et al., 2006; Hutson and Laing, 2014). Financially distressed firms may have limited ability to manage exchange rate exposure, which may make their fundamental value sensitive to the cash flow that is subject to the volatility of exchange rate (Wei and Starks, 2013). Firms' future prospects are another important factor in exchange rate exposure. A fluctuating exchange rate disturbs firms' future cash flow and discount factor, so growing firms that rely heavily on cash flow may be more vulnerable to exchange rate risks. Chaieb and Mazzotta (2013) show that both macroeconomic variables such as GDP, inflation and monetary policy stance, and sectoral idiosyncrasy influence exchange rate exposure.

As the financial derivatives market has been booming internationally, the attitude toward and extent of using hedging tools has profoundly affected exchange rate exposure. He and Ng (1998), for example, find that while firms that are large in terms of asset size enjoy lower unit hedging cost, small ones are better incentivized to hedge against exchange rate risks. By contrast, Pantzalis et al. (2001) show that larger multinational corporations that are supposed to be exposed to greater exchange risks end up having smaller ones, which is attributable to their effective hedging activities. Wei and Starks (2013) conclude that financially distressed firms are exposed to exchange risks because they have limited access to hedging channels.

3. Data and research design

Our sample covers all Chinese public firms from July 21, 2005 to December 31, 2018.[7] Given the decisive influence of the 811 Reform, we divide the main sample into two subsamples. Further considering that the market oriented reform was interrupted by the 2008-09 financial crisis and resumed in July 2010 (PBOC, 2010), we generate two sub-periods: the first spans from July 21, 2005 to June 18, 2010; the second spans from June 19, 2010 to August 11, 2015[8]. Analyzing sub-periods help us to understand structural changes in the impacts of exchange rate fluctuations on the firm's value.

While most existing research tends to favor the trade-weighted foreign exchange rate index, we also choose the US dollar as a foreign currency variable as it has a dominating impact on the performance of Chinese economy. This approach allowed us to explore foreign exchange rate exposures in a more comprehensive way.[9] We pick the US dollar (USD), the euro (Euro), the

[7] Chinese public firms here are referred to as A-shares (a.k.a. domestic shares) companies that are mainland China-based companies listed on the Shanghai Stock Exchange and the Shenzhen Stock Exchange.

[8] To further justify the split of the sample, we also test for structure break points for both August 11, 2015 and June 19, 2010 in the regressions. We don't report these results for brevity.

[9] On January 4, 2006, the PBOC had authorized a foreign exchange trade system & national interbank funding center to release the central parity rates of the Chinese RMB against the US dollar, the euro, the Japanese yen, and the Hong Kong dollar, and

Japanese yen (Yen), the Hong Kong dollar (HKD), the British pound (Pound), and the foreign exchange rate index weighted by monthly bilateral-trade volume in the five foreign currencies.[10] The risk-free rate in the sample is the 3-month benchmark deposit rate released by the PBOC, the market index is the CSI300 (China's main stock market index), and all exchange rate data are referenced to the exchange rate released by the PBOC. All data are daily and their sources are RESSET and the PBOC.[11]

3.1 Measures of foreign exchange rate exposures

Empirical literature has investigated almost linear exchange rate exposure. Although it appears reasonable to assume the nonlinear relationship between exchange rates and firm, we are agnostic about the true nature of the nonlinearities. Motived by these potential shortcomings in the empirical studies, we utilize both linear and nonlinear exchange rate exposures estimations.

3.1.1. Linear exchange rate exposures

Foreign exchange rate exposure is largely defined as how responsive a firm's value is to the fluctuation of the foreign exchange rate; quantitatively, it is reflected in the change of stock return of a firm in response to the change of foreign exchange rate, provided that average market return is controlled for (He and Ng, 1998; Bartram, 2004; Bartram and Bodnar, 2007; Hutson and Laing, 2014). Following the literature, we empirically assessed foreign exchange rate exposure employing the reduced-form regression model as below:[12]

$$R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i R_{st} + \varepsilon_{it} \quad (1)$$

where R_{it} is the logarithm of stock return in excess of the risk-free rate, R_{mt} is the return of the stock market index in excess of the risk-free rate, and R_{st} is the logarithm of the change of the exchange rate index (R_{st} is positive when the exchange rate variable rises). The exchange rate variable is presented in the form of foreign currency per RMB, meaning that the RMB appreciates as R_{st} rises. The degree of foreign exchange rate exposure is hence reflected in the coefficient, γ_i, associated with R_{st}; positive γ_i indicates higher stock return resulting from appreciation of the RMB, and negative γ_i suggests that appreciation of the RMB leads to lower stock return of firms. One way our approach distinguishes itself from the regression method in Bartram et al. (2010), however, is through its use of the GARCH (1,1) model, which better captures the characteristics of concentrated volatility of the stock market and exchange rate market (Koutmos and Martin, 2003; Berndt et al., 1974).

3.1.2. Nonlinear measures of foreign exchange rate exposure

Since it is difficult to justify a priori functional form of the nonlinear relationship, we adopt some exemplary and generic functional forms suggested by Bartram (2004). More specifically,

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requested the rates be the spot exchange rates and over-the-counter exchange rates of any interbank transactions; the British pound joined the club around four months later on August 1, 2006. We excluded other foreign currencies in the sample owing to the dominant volume of those five main ones in the foreign exchange rate market of China.

[10] The foreign exchange rate index used in the sample was constructed in the same way that the Chinese foreign exchange trade system & national interbank funding center do for the foreign exchange rate index, which is trade-weighted using monthly bilateral trade data.

[11] The information of RESSET is available at: http://www.resset.com/enindex

[12] We also follow Choi and Jiang (2009) using the Fama-French three factors to estimate foreign exchange rate exposure. Similar results are obtained (see Table 9).

we consider the functional forms with the inclusion of nonlinear exposures originating from (i) the asymmetric effects of appreciation and depreciation and (ii) the nonlinearity of volatility of foreign exchange rates.

First, it may be realistic to expect that firms react different in response to the currency appreciation and depreciation. To capture this the asymmetric effects, we conducted the sign bias test in regression (2)

$$\frac{\varepsilon_{it}}{\sigma_{\varepsilon_{it}}} = \mu_{it} + \tau_i Sign_t + \varphi_i Sign_t R_{st} + \omega_i (1 - Sign_t) R_{st} + \theta_i \quad (2)$$

where ε_{it} is the residual from equation (1), and $\sigma_{\varepsilon_{it}}$ is the standard error of ε_{it} ; $Sign_t$ is a dummy variable that is 1 if R_{st} is negative (RMB depreciates); and $Sign_t$ equals 0 otherwise. This model is a diagnostic residual test that examines the potential misspecification of the linear regression model (equation 1). Including the variable, $Sign_t$, can test the impact of positive and negative exchange rate movements on firm value that are not captured by the linear model.

Second, residual, ε_{it} of equation (1) has excluded the effects caused by the linear variations in exchange rate. Alternatively, we can estimate the residual, θ_{it} , from a regression using the market index as the only regressor. Specifically, we ran regression (3) to screen out the effects caused by variations of the market index (Bartram, 2004):

$$R_{it} = \alpha_i' + \beta_i' R_{mt} + \varepsilon_{it}' \quad (3)$$

Then, we use θ_{it} to replace ε_{it} in equation (2) to examine the distinctions between positive and negative shocks on firm values. Note that there is no exchange rate variables in equation (3), θ_{it} should be more sensitive than ε_{it} to the exchange rate movements.

Finally, following Bartram (2004), we adopt the cubical function to capture the nonlinear property of exchange change rate movement. The cubical function forms can estimate a convex exchange rate exposure, consistent with the idea that large exchange rate movements have a very strong effect on firm value, while small exchange rate movement exert few impacts on firm values. The regression model is as followed:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \gamma_i R_{st}^3 + \varepsilon_{it} \quad (4)$$

where R_{st}^3 is the cubical function of the foreign exchange rate.

3.2 Determinants of exchange rate exposure

To illustrate the potential determinants of the exchange rate exposure, we employ a sample model following Choi and Prasad (1995) and Bodnar et al. (2002). By definition, exchange rate exposure ($exposure_i$) can be expressed as:

$$exposure_i = \frac{dlnFV_{it}}{dlne_t} = \frac{dln\pi_{it}}{dle_t}$$

Thus, exchange rate exposure is equal to the firm value (FV_{it}) return divided by the percentage change of exchange rate movement (e_t). Assuming tax, discount and growth rates to be constant, the equation becomes the derivative of the profit (π_{it}) versus exchange rate return. A firm's profit is the sum of its domestic profit and its foreign profit, and each part equals sales revenue

(Rev_{it}^{d}, Rev_{it}^{f}) minus costs ($Cost_{it}^{d}, Cost_{it}^{f}$) including both fixed cost and variable cost. The exposure can be expressed in terms of revenue and cost:

$$exposure_i = \frac{dln(Rev_{it}^{d} + Rev_{it}^{f} - Cost_{it}^{d} - Cost_{it}^{f})}{dlne_t}$$

Additionally, Hodder (1982) consider exchange rate expose as the function of firm's net wealth, which is the assets minus liabilities. In this definition, we can re-express the exposure as:

$$exposure_i = \frac{dlnFV_{it}}{dlne_t} = \frac{dlnNW_{it}}{dlne_t} = \frac{dln(Asset_{it}^{d} + Asset_{it}^{f} - Lib_{it}^{d} - Lib_{it}^{f})}{dlne_t}$$

Where $Asset_{it}^{d}$ and Lib_{it}^{d} are dominated in local currency, and $Asset_{it}^{f}$ and Lib_{it}^{f} are in foreign currency. Combining both equations, exposure can be expressed as a function of domestic and foreign profits, revenue, cost, and assets and liabilities in both local and foreign currency.

This functional form presumes that exchange rate risks faced by a firm is not fully hedged, and demonstrated that a firm's exposure arises from its international operations, i.e. foreign revenue, costs and assets. If there is no hedging, we can expect that a firm's exposure is inevitably associated with foreign revenue, foreign debt and assets (Jorion, 1990; He and Ng, 1998; Hutson and Laing, 2014).

Proxies of international operations are likely to be the important determinants of exchange rate exposure in Chinese listed firms. China has experienced an explosive growth in international trade since the accession to the World Trade Organization (WTO) in 2001. By the end of 2018. China has been the world's largest exporter and second largest importer. Many Chinese firms have foreign subsidiaries via either green or brown foreign direct investment. Moreover, in the aftermath of 2008-09 financial crisis, many Chinese firms raised funds from international financial market. The high portion of foreign debts had subsequently exposed the firms to an unexpectedly foreign exchange risk. To quantify the level of international operations of Chinese firms, we use the following variables suggested by the literature: foreign sales to total sales, foreign loans (loans denominated by non-RMBs) to total loans, foreign subsidiary (a dummy variable, which takes the value of one if the firm has at least one oversea subsidiary, and zero otherwise). As detailed trade information is unavailable at firm level, the effects of foreign sales on exposure may be unclear[13]. Following Wei and Starks (2013), we set $FSales_i^{+}$ ($FSales_i^{-}$) as the positive (negative) difference between a firm's foreign sales ratio and the average ratio in the industry during the year. It is expected that exposures increase with $FSales_i^{+}$ (net exporters) and decreases in $FSales_i^{-}$ (net importers).

With the increasing globalization of product and sales market, more recent studies show that many firms involve a range of hedging strategies in alleviating exchange rate risks (Mello et al., 1995;Huston and Laing, 2014). It is well established that extensive use of hedging can diminish a firm's exposure to exchange rate variations. As a result, a firm's incentive to hedge against currency risks is also important determinant on its exposure (He and Ng, 1998; Bartram, 2004; Hutson and Laing, 2014).

To examine whether Chinese firms' exchange rate exposures are significantly related to their hedging incentives, we consider a variety of variables that existing studies find to be important in explaining a firm's hedging needs. The size of firms is considered in nearly all studies of foreign exchange rate exposures (He and Ng, 1998; Bartram, 2004; Dominguez and Tesar, 2006; Hutson

[13] The exchange rate exposure of exporters is different from that of importers. Firms have above (below) average foreign sales are more likely to be net exporter (importer) (Wei and Starks, 2013)

and Laing, 2014). Nance et al. (1993) show that larger firms are more motivated to hedge against risks including foreign exchange rate related ones, and the working of economies of scale may also reduce hedging costs. We therefore adopt the logarithm of a firm's total assets as a proxy for its size, and predict a negative relation between the size of a firm and its foreign exchange rate exposure.

Financial distress of firms generates ambiguous impacts on its exchange rate exposures. On the one hand, financially troubled firms are more vulnerable to the volatility of foreign exchange rates[14]. He and Ng (1998) also find that financially distressed firms are more motivated to hedge against and hence be exposed less to the foreign exchange risk. On the other, financial distress may prevent firms from effectively hedging against exchange rate risks for lack of the needed resources. Wei and Starks (2013) show that financial distressed firms have limited ability, or inability to smooth out the unfavorable movements of exchange rates because of high hedging costs[15]. These firms would therefore face increased cash flow volatility and end up being exposed to pervasive foreign exchange rate risks (Hutson and Laing, 2014). The latter view will be more relevant to the case of China, as there are limited hedging tools available in China (He et al., 2016). We use two variables to measure a firm's probability of financial distress: the leverage ratio and long-term debt ratio, and expect their positive correlations with exchange rate exposure.

Firm's liquidity serves as a buffer against the volatility of foreign exchange rate for its function of lowering the expected cost of financial shocks. For example, Nance et al. (1993) demonstrate that firms with more liquid assets in the short run are less likely to stumble into financial trouble. Froot et al. (1993), suggest that firms with high short-term liquidity may lack incentives to conduct any hedging activity, and may face even more serious foreign exchange rate risks as a result. Consistent with this view, several empirical studies have found that firms with high levels of liquidity are more exposed to exchange rate movements (He and Ng, 1998; Bartram, 2004). We use the ratio of current asset to current liability (quick ratio) as the proxy of short-term liquidity, and its correlation with foreign exchange rate exposures is expected to be positive.

The potential underinvestment is more of a problem in firms with greater prospects of growth (Froot et al., 1993). A firm with good growth opportunity will have a greater incentive to employ financial derivatives to hedge against the underinvestment costs (Froot et al., 1993; He and Ng, 1998). High costs of external capital, however, may diminish a growth firm's ability to effectively hedge exchange rate movements (Wei and Starks, 2013). Provided the underdevelopment of the financial derivative market in China, exchange rate movements may cause large cash flow volatility for growth firms due to their inability of hedging underinvestment costs. We follow Geczy et al. (1997) by using book-to-market value of equity (BM) to proxy a firm's prospects. A lower BM ratio indicates a greater potential for growth and is expected to negatively correlate with foreign exchange rate exposures.

Finally, foreign exchange rate exposures may also depend on idiosyncratic characteristics of sectors where firms price the products, build the volatility of foreign exchange rates into the output price, and hedge the foreign exchange rate risks that they may run (Allayannis and Ihrig, 2001; Bartram et al., 2010). Bartram (2004) also empirically reports significant impact of sector-

[14] Smith and Stulz (1985) find that hedging activity reduces the probability of a firm's bankruptcy, and that firms hungry for credit have strong incentives to conduct hedging.

[15] Financial distressed firms have difficulties in accessing the external capital market (Opler and Titman, 1994; Molina and Preve, 2012). In addition, hedging costs relate positively with a firm's creditworthiness. Financial distressed firms have significantly difficulty finding financial institutions willing to sign financial derivative contracts. (Allayannis and Ofek, 2001)

specific variables on foreign exchange rate exposure. In equation (5), we thus classify firms into sectors based on the "guidelines for the industry classification of listed companies (2012)" issued by the China Securities Regulatory Commission (CSRC).

We employ the following regression model to test above hypotheses:

$$|\gamma_i| = a_1 + a_2 size_i + a_3 FSales_i^+ + a_4 FSales_i^- + a_5 Subsidiary_i + a_6 FLoan_i + a_7 Leverage_i + a_8 QR_i + a_9 DE_i + a_{10} BM_i + IndDummy + \varepsilon_i \quad (5)$$

Where γ_i is estimated exchange rate exposure. Considering exchange rate exposure exhibits either positive or negative signs, we transform this variable by taking absolute value. All variables are *Winsorized* at 1 percent of the forward and backward to overcome the danger of extreme values biasing our results. We also ruled out the financial sector for its anomalous features of its balance sheets. The data source of all explanatory variables of equation (5) is CSMAR, and the data are yearly averages. Please note that the data of foreign sales and foreign loans are unavailable before 2007—a major revision of financial accounting principles took place in 2007. The limited availability of the data dictated the form of regression (5). Detailed definitions of the variables are presented in the Appendix.

Table 1 reports the descriptive statistics of the main variables of equation (5).

Table 1 The descriptive statistics of the main variables

Variables	Mean	Median	Standard Deviation	25% percentile	75% percentile
August 12, 2015 to December 31, 2018					
size	3.682	3.458	1.476	2.724	4.403
$FSales^+$	0.050	0	0.125	0	0.007
$FSales^-$	-0.050	-0.016	0.061	-0.086	0
Subsidiary	0.306	0	0.405	0	0.667
FLoan	0.050	0	0.125	0	0.020
Leverage	0.519	0.514	0.305	0.368	0.656
QR	1.976	1.413	2.442	0.985	2.073
DE	0.188	0.138	0.167	0.054	0.280
BM	0.413	0.364	0.238	0.253	0.527
June 19, 2010 to August 11, 2015					
size	3.904	3.673	1.461	2.940	4.585
$FSales^+$	0.060	0	0.171	0	0.021
$FSales^-$	-0.060	-0.032	0.069	-0.105	0
Subsidiary	0.475	0.5	0.454	0	1
FLoan	0.082	0	0.175	0	0.063
Leverage	0.436	0.425	0.201	0.276	0.585
QR	2.407	1.744	2.419	1.221	2.741
DE	0.183	0.138	0.160	0.060	0.263
BM	0.356	0.302	0.244	0.204	0.443

Note: this table shows firm characteristics descriptive statistics in three sub-periods. In particular, these characteristics include firm size (size), foreign sales ($FSales^+$, $FSales^-$), subsidiary (Subsidiary), foreign loans (FLoans), leverage (Leverage), quick ratio (QR), long-term debt ratio

(DE) and book to market ratio (BM). The columns show (from left to right) mean, median, standard deviation, 25% percentile, 75% percentile. All variables are averaged across the period (2014-2017, 2009-2014).

4. Empirical results

4.1 Estimations of linear exchange rate exposures

We first estimate the linear exchange rate exposure using regression equation (1) and present the main results in Table 2. Standard errors are corrected for via auto-correlation and heteroscedasticity by Newey-West method. We categorize the percentage of firms whose γ_i is at the significance level of 5 percent or better as having a statistically significant γ_i. Belonging to this category indicates that these firms are exposed to risks associated with changes in exchange rates. To illustrate, positive γ_i means appreciation of the RMB raises the stock return of firms; negative γ_i says otherwise. Table 2 shows that 20.6 percent of Chinese public firms were exposed to the USD risk after 811 Reform, which represents a significant change in comparison with 11.8 percent rate of exposure that preceded the reform. While the foreign exchange rate exposures to the yen and the Hong Kong dollar show a pattern that mirrors that of the US dollar, those of the euro and the pound plummeted from 29 percent and 32.4 percent to 17.6 percent and 13.3 percent, respectively. By contrast, the exposure associated with the foreign exchange rate index went up mildly, going from 16.4 percent to 20.7 percent.

The finding that the exchange rate exposure to the USD has been more stable than that of the other currencies in the sample may be attributable to the attention constantly paid to the USD by the monetary authority of China before 811 Reform. The PBOC has been working diligently to ensure the stability of the USD exchange rate for decades. In particular, the PBOC sees USD exposure as an integral part of systemic financial risk borne by China's market. In keeping with this view, the bank monitors the USD exchange rate closely. Being closely watched, the USD exchange rate exerts influences on firm value through a restricted channel, and hence produces lower exposure than other foreign currencies do after 811 Reform. On the flip side, with foreign exchange rate monitoring policy leaning heavily toward the USD market, the Chinese government intervened more sparingly in the markets of the euro and the pound, thus permitting these two foreign exchange rate exposures to fluctuate. The results shown in Table 2 confirm that a disproportionate amount of exposures associated with the euro and the pound were positive prior to the 811 Reform. Only after the reform did the exposures become natural[16].

Table 2 The percentage of the Chinese public firms that show linear exposures

	August 12, 2015 to December 31, 2018			July 21, 2005 to August 11, 2015			June 19, 2010 to August 11, 2015		
	-	+	-&+	-	+	-&+	-	+	-&+
USD	15.7	4.9	20.6	9.1	2.7	11.8	17.1	1.9	18.9
EUR	6.1	11.5	17.6	3.2	25.8	29	5	7	12
HKD	16.1	4.7	20.8	7.8	2.3	10	14.6	2	16.5
JPY	8.1	7.5	15.6	8.5	4	12.5	2.3	8.9	11.3
GBP	5.5	7.8	13.3	2.6	29.8	32.4	2.6	13.8	16.4

[16] We also conduct the Chow-test to see whether there is a structural change in the sensitivity of exchange rate (bilateral and index) on firm's value. Both August 11, 2015 and June 19, 2010 are significant at 1% level.

INDEX	11.9	8.8	20.7	3.3	13.1	16.4	5.2	7	12.1

Note: This table reports the percentage of Chinese public firms that show linear foreign exchange rate exposure (significant at 5% level). The three columns in each period are negative, positive and total form left to right, respectively. USD=the US dollar, EUR=the euro, HKD=the Hong Kong dollar, JPY=the Japanese yen, GBP=the British pound, INDEX=currency index weighted by the five currencies.

To document the impact of foreign exchange rates on the stock return of Chinese public firms by level, following Bartram (2004), we multiplied the mean exposure coefficient, γ_i, by one standard deviation of the exchange rate. We found that in firms with negative exposure, the appreciation of the RMB relative to the US dollar by one standard deviation results in 0.195 percent decrease of the firms' market value. In firms with positive exposure, appreciation of the RMB relative to the US dollar by one standard deviation results in a 0.242 increase in the firms' market value.

Table 3 The linear exposures of Chinese public firms

	August 11, 2015 to December 31, 2018		July 21, 2005 to August 11, 2015		June 19, 2010 to August 11, 2015	
	-	+	-	+	-	+
USD	-0.195	0.242	-0.129	0.131	-0.226	0.177
EUR	-0.229	0.212	-0.156	0.118	-0.147	0.124
HKD	-0.195	0.232	-0.132	0.109	-0.214	0.160
JPY	-0.234	0.252	-0.111	0.105	-0.143	0.137
GBP	-0.228	0.216	-0.160	0.120	-0.171	0.154
INDEX	-0.203	0.235	-0.157	0.116	-0.144	0.129

Note: this table reports the impact of foreign exchange rates on the stock return of firms by level. We multiply the mean exposure coefficient, γ_i, in exposure samples by one standard deviation of the exchange rate. Foreign exchange rate exposures are estimated through equation (1). The two columns in each period are negative exposure samples and positive exposure samples, respectively. USD=the US Dollar, EUR=the euro, HKD=the Hong Kong dollar, JPY=the Japanese yen, GBP=the British pound, INDEX=currency index weighted by the five currencies.

Table 4 presents the foreign exchange rate exposures by sector as classified by CSRC. 15.6 percent of 1,520 manufacturing firms in China show negative exchange rate exposure indicating that their firm value fluctuated mildly facing the depreciation of the RMB against the USD. Mining sector by contrast suffers from the depreciation of the RMB due to the fact that the main part of its debt and investment are denominated in foreign currency. In specific, between the USD and the INDEX exchange rate risk, the mining sector is relatively vulnerable to the latter as more than one foreign currency play important roles in its overseas investment, debt, inventory adjustment and sales forecast. Exposures of airline companies in the transportation sector, for another instance, also correlates positively with the depreciation of the RMB as reflected in Table 4 that the percentage of firms showing positive USD exposures in the transportation, storage and package sector jumped from 0 to 13.1 after 811 Reform.

Table 4 The percentage of firms having linear exposures by industry

	August 12, 2015 to December 31,2018					July 21, 2005 to August 11, 2015				
	# of firms	USD		INDEX		# of firms	USD		INDEX	
		-(%)	+(%)	-(%)	+(%)		-(%)	+(%)	-(%)	+(%)
Farming, forestry, animal husbandry, and fishery	37	2.7	5.4	8.1	10.8	19	0	0	0	15.8
Mining	62	9.7	9.7	21	8.1	44	0	20.5	31.8	2.3
Manufacturing	1520	15.6	5.7	11.6	8.1	675	9.5	2.4	3.1	13.8
Electricity, heat, gas, and water utility	94	17	5.3	20.2	13.8	79	6.3	2.5	0	13.9
Construction	72	18.1	6.9	13.9	9.7	31	6.5	0	3.2	3.2
Whole sales and retails	128	26.6	5.5	20.3	8.6	109	8.3	0.9	1.8	21.1
Transportation, storage, and package	84	10.7	13.1	4.8	10.7	52	11.5	0	0	15.4
Hotel and restaurant	8	0	0	12.5	0	6	0	16.7	0	16.7
Telecommunication, software, and information & technology service	160	16.9	10	13.8	10	43	11.6	2.3	0	7
Financial service	60	15	3.3	8.3	0	32	18.8	3.1	0	15.6
Real estate	109	19.3	5.5	11	4.6	112	7.1	3.6	2.7	8
Rental service and business service	31	19.4	19.4	3.2	25.8	17	17.6	0	0	17.6
Scientific research and technological service	22	18.2	0	9.1	4.5	5	20	0	0	0
Water resources, environment and public facilities management	31	29	3.2	12.9	6.5	15	13.3	0	6.7	6.7
Education	2	0	0	0	0	2	50	0	0	0
Public health and social work	7	14.3	0	0	14.3	3	33.3	0	0	33.3
Culture, sports, and entertainment	31	9.7	6.5	6.5	12.9	20	5	0	0	20
Others	19	15.8	0	5.3	10.5	24	12.5	0	0	8.3

Note: this table displays the percentage of firms having linear exposures by industry, as classified by China Securities Regulatory Commission (CSRC). The first column for each period reports the number of the firms in each industry and the next four columns report the percentage of Chinese public firms that show significant foreign exchange rate exposure with regard to both US dollar (USD) and exchange rate index (INDEX).

4.2 Estimations of nonlinear exchange rate exposures

Nonlinear exchange rate exposures of Chinese public firms are presented in Table 5, which shows that more than 26 percent of Chinese public firms have been exposed to nonlinear exchange risks after the 811 Reform. Relative to linear exposures, 5.6 percent more firms show nonlinear exposures to the USD. As for the euro, 20.3 percent of firms are exposed to nonlinear exchange risks, as opposed to 17.6 percent to linear ones. Table 5 and 2 combined suggest Chinese public firms as a whole are more sensitive to nonlinear exchange rate risks than linear ones. In terms of the temporal study of the 811 Reform watershed, a mere 1.4 percent of firms responded to nonlinear risk of the USD prior, as opposed to 26.2 percent after; 8 percent and 4.7 percent responded to the euro and the HKD prior, respectively, compared to 20.3 percent and 26.5 percent after. The fact that a growing number of Chinese public firms are exposed to nonlinear exchange risks may signal the efficacy of China's efforts to marketize the RMB exchange rate. Another way of expressing the same idea is that supply and demand have begun to play a more critical role in determining the market value of the RMB. That Chinese public firms are more sensitive to nonlinear exchange risks also suggests they are vulnerable to the extreme volatility of the foreign exchange rate. To hedge against this volatility, they have resorted to using financial derivatives to hedge against nonlinear exchange rate risks.

Table 5 The percentage of firms having nonlinear exposures

	August 11, 2015 to December 31, 2018			July 21, 2005 to August 11, 2015			June 19, 2010 to August 11, 2015		
	-	+	-&+	-	+	-&+	-	+	-&+
USD	21.6	4.6	26.2	0.8	0.6	1.4	11.1	2.5	13.6
EUR	15.0	5.3	20.3	1.9	6.1	8.0	6.8	6.1	12.8
HKD	22.1	4.4	26.5	2.1	2.6	4.7	9.6	2.9	12.5
JPY	8.1	5.9	14.0	3.1	4.9	8.0	1.4	4.0	5.4
GBP	2.5	5.2	7.7	3.6	17.8	21.4	4.3	11.4	15.8
INDEX	16.5	7.6	24.1	3.1	11.3	14.4	6.5	4.3	10.8

Note: This table reports the percentage of Chinese public firms that have nonlinear foreign exchange rate exposure (significant at 5% level). The three columns in each period are negative, positive and total form left to right, respectively. USD=the U.S. dollar, EUR=the euro, HKD=the Hong Kong dollar, JPY=the Japanese yen, GBP=the British pound, INDEX=currency index weighted by the five currencies.

Table 6 presents the results of the sign bias test, based on equation (2), of exposures that capture the biased component attributable to the asymmetric influences of appreciations and depreciations. As shown in Table 6, three coefficients of USD exposure are similar in Panel A and Panel B before 811 Reform, indicating the volatility of the USD exchange rate may have been absorbed by the market return index. The USD exchange rate risk in China has become an integral part of the systemic financial market risk rather than an idiosyncrasy of it before 811 Reform. By contrast, notable changes in the exposures to the euro and to the foreign exchange market index as well as USD after 811 Reform may still merit consideration as idiosyncrasies.

Table 6 Sign bias test of exposures

	August 11, 2015 to December 31, 2018			July 21, 2005 to August 11, 2015			June 19, 2010 to August 11, 2015		
	τ_i	φ_i	ω_i	τ_i	φ_i	ω_i	τ_i	φ_i	ω_i
					Panel A				
USD	2.7	6.1	2.5	6.1	3.2	5.3	5.5	5.8	1.2
EUR	5.5	3.1	16.4	3.4	2.6	3.8	4.7	3.8	2.4
HKD	2.5	5.6	2.2	6.8	2.5	3.1	4	4.5	1.6
JPY	2.6	3.4	4.6	3.3	4.7	4.4	3.3	7.2	4.5
GBP	3.4	7.1	7.3	2.8	3.6	3	2.9	5.6	1.8
INDEX	4.9	7.6	3.4	6.5	2.6	3	3.7	3.7	2.1
					Panel B				
USD	2.8	9.1	1.8	6	3.4	5.7	5.4	5.8	2.8
EUR	5.4	6	13.1	3.4	6.4	12	4.7	3.5	5.5
HKD	2.6	8.7	2.3	6.8	3.2	5.8	4	5.6	3.6
JPY	2.5	4.1	5.6	3.3	7.1	4.5	3.3	7.6	6.8
GBP	3.4	9.5	6.9	2.8	5	10.4	2.9	4.3	5.4
INDEX	5	9.7	4	6.5	8.2	9.9	3.7	4.8	4.6

Note: This table reports the percentage of Chinese public firms that show significant sign bias foreign exchange rate exposure (at 5% level). The three coefficients, $\tau_i, \varphi_i,$ and $\omega_i,$ henceforth work together to reflect the possible biased influences of exchange rate change, upward versus downward, on a firm's stock market value. Panel A presents the estimated exposures using equation (1) and (2), while Panel B presents the estimated exposures using equation (3) and (2). USD=the U.S. Dollar, EUR=the Euro, HKD=the Hong Kong dollar, JPY=the Japanese yen, GBP=the British pound, INDEX=currency index weighted by the five currencies.

4.3 The determinants of exchange rate exposure

We focus in this section on the determinants of exchange rate exposures to both USD and the foreign exchange rate market index. We follow Bartram et al. (2010) and Wei and Starks (2013) by taking the absolute value of the coefficient γ_i in the equation (2) to measure foreign exchange rate exposure. Referring to related research and considering the special characteristics of China's market, we include the nine determinants of foreign exchange rate exposures in equation (5), which we previously discussed in section 3.2. We also conduct a Chow test to examine whether the driving forces of exchange rate exposure have changed around the 811 reform.

The regression results of equation (5) are presented in Table 7, in which column (I) and (III) show the results of the sample period from June 19, 2010 to August 11, 2015. Column (II) and (IV) show the period from August 11, 2015 to December 31, 2018.

In terms of the USD risk exposure, the results in column (I) and (II) of Table 7 show a consistent correlation between exchange rate exposures and hedging costs. We find that size of firms presents a negative effect at the 99-percent significance level, which indicates that larger firms suffer less foreign exchange rate exposure in all subsamples. Larger firms are found by several studies to have a low cost for their economies of scale (Nance et al., 1993; Hutson and

Laing, 2014). In addition, the leverage ratio positively correlates with the exposures to the USD at 95-percent significance level in both subsample periods, indicating that highly leveraged firms are more exposed to exchange rate risks. More leveraged firms essentially bear a greater probability of financial distress, hence the consequent higher costs of hedging may have prevented these firms from effectively managing impacts of exchange rate volatilities on their firm values. Statistically insignificant notwithstanding, we find a positive relationship between exchange rate exposure and long-term debt ratio (DE), which is consistent with the hedging cost hypothesis. Finally, firms' international operations ($FSales^{+}$) are found to correlate with exchange rate exposure only marginally in both sample periods.

The regression results of foreign exchange rate index show a similar pattern, which is perhaps due to the fact that the USD exchange rate leads in weight among the main foreign currencies constituting the index. The results of the Chow tests confirm the existence of structural change around the 811 reform period. The F-statistics for all specifications statistically significantly reject the hypothesis that the coefficient vectors are the same for the two periods. Interestingly, we find that the magnitude of leverage is smaller in USD exposure than it is in index exposure. This may be due to the rapid development of hedging tools against USD after 811 reform, even though the number of tools is still small in China relative to developed nations. As a result, highly leveraged firms are less (more) exposed to USD (Index) exchange rate risks after the 811 reform. We also find the size of firms significantly negatively correlated with the index exposure only after 811 reform. Considering the increased exchange rate volatilities after 811 reform, larger firms are more incentivized to hedge against index volatility. Book-to-market ratio is also found to correlate with index exposures negatively suggesting high growth firms are more easily exposed to overall exchange rate risks, as the exchange rate market volatility may make hedging more costly for the firms with high growth opportunities.

Table 7 The determinants of linear exchange rate exposures

	(I) USD(γ_i)	(II) USD(γ_i)	(III) INDEX(γ_i)	(IV) INDEX(γ_i)
size	-0.0641***	-0.0484***	-0.0000	-0.0391***
	(-3.88)	(-5.97)	(-0.01)	(-4.07)
$FSales^{+}$	0.1721	0.0275	0.0008	0.0275
	(1.43)	(0.42)	(0.02)	(0.34)
$FSales^{-}$	-0.0442	-0.1197	0.0163	-0.1439
	(-0.16)	(-0.87)	(0.16)	(-0.91)
Subsidiary	0.0199	0.0010	-0.0133	0.0184
	(0.57)	(0.06)	(-0.87)	(0.94)
FLoan	0.0258	-0.0269	0.0061	-0.0698
	(0.25)	(-0.62)	(0.15)	(-1.49)
Leverage	0.2563**	0.1177**	0.0789*	0.1436**
	(2.49)	(2.00)	(1.91)	(2.20)
QR	0.0137	0.0039	0.0043	0.0036
	(1.14)	(0.67)	(1.08)	(0.59)
DE	0.0403	0.0577	-0.0411	0.0802
	(0.40)	(1.09)	(-1.14)	(1.39)
BM	0.0066	-0.0007	-0.0093	-0.0254*
	(0.30)	(-0.06)	(-0.68)	(-1.75)

IND Dummy	YES	YES	YES	YES
Constant	0.4248***	0.3045***	0.1970***	0.4175***
	(5.32)	(5.24)	(7.00)	(5.11)
Observations	1,541	2,417	1,541	2,417
R-squared	0.121	0.075	0.086	0.084
Chow-test	8.03***		4.05***	

Note: This table reports the regression of firm characteristics and industry dummies on linear exchange rate exposures. Coefficient and robustness t-statistics for firm characteristics are reported in the table. Column (I) and (III) show the results of the sample period from June 19, 2010 to August 11, 2015. Column (II) and (IV) show the period from August 11, 2015 to December 31, 2018. We report F-statistics for the Chow-test on the existence of structural break around the August 11, 2015. Significant level: ***1 percent; ** 5 percent; * 10 percent.

4.4 The determinants of nonlinear foreign exchange rate exposure

Table 8 reports the regression results of equation (5), which are similar to those in Table 7 except that the value of γ_i is estimated nonlinearly based on equation (4), instead of the linear equation (1). A positive correlation between exposures and the cost of hedging activity is presented, and size of firms remains negatively correlated with exposures, while leverage turns to an insignificant factor prior to the 811 reform in the nonlinear regression. Book-to-market ratio is also found to be nonlinearly negatively correlated with exposures after 811 reform. In gauging the nonlinear impact of hedging motivation on exposures, we find that firms with greater quick ratios (more liquidity) appear to have significantly larger exchange rate exposure after 811 reform. Similar to the linear findings, firms with high short-term liquidity are less incentivized to hedge, and hence more nonlinearly exposed to increased exchange rate fluctuations after 811 reform.

In terms of international operations, a firm's foreign sale is found to significantly increase nonlinear exchange rate exposures when the firm is a net-exporter, or proxied by $FSales_i^+$ in the regression (He and Ng, 1998; Wei and Starks 2013). This impact of foreign sales turned insignificant after the 811 reform, however, both in statistical significance and magnitude. The reverse may indicate the growing capability of Chinese public firms in terms of hedging against exchange rate risk due to international operations. Confirming the split of time in the sample, the Chow test shows structural change and the F-statistics for all specifications statistically significantly reject the hypothesis that the coefficient vectors are the same for the two periods divided by the 811 reform.

Table 8 The determinants of nonlinear exchange rate exposures

	(I) USD(γ_i)	(II) USD(γ_i)	(III) INDEX(γ_i)	(IV) INDEX(γ_i)
size	-0.7088***	-0.0474***	-0.0060	-0.0756***
	(-2.92)	(-4.98)	(-0.55)	(-4.33)
$FSales^+$	1.6026	0.0728	0.0968**	-0.0078
	(0.99)	(1.23)	(2.52)	(-0.06)
$FSales^-$	4.0051	0.0127	-0.0621	0.2312
	(1.11)	(0.08)	(-0.39)	(0.72)
Subsidiary	0.1598	-0.0138	-0.0032	-0.0046
	(0.31)	(-0.45)	(-0.14)	(-0.12)

FLoan	1.0706	-0.0142	-0.0957	0.0126
	(0.77)	(-0.23)	(-1.67)	(0.11)
Leverage	0.3014	0.1302**	0.0249	0.2367*
	(0.22)	(2.32)	(0.49)	(1.91)
QR	0.0443	0.0054**	0.0017	0.0120**
	(0.44)	(2.75)	(0.27)	(2.12)
DE	0.0363	0.0173	-0.0101	0.0236
	(0.27)	(0.65)	(-0.36)	(1.29)
BM	0.3080	-0.0448**	0.0031	-0.0396*
	(0.75)	(-2.61)	(0.21)	(-1.70)
IND Dummy	YES	YES	YES	YES
Constant	2.1813**	0.4738***	0.1992***	0.6640***
	(2.23)	(8.40)	(4.25)	(8.99)
Observations	1,541	2,417	1,541	2,417
R-squared	0.086	0.057	0.059	0.062
Chow-test	4.85***		3.52***	

Note: This table reports the regression of firm characteristics and industry dummy on nonlinear exchange rate exposures. Coefficient and robustness t-statistics for firm characteristics are reported in the table. Column (I) and (III) show the results of the sample period from June 19, 2010 to August 11, 2015. Column (II) and (IV) show the period from August 11, 2015 to December 31, 2018. A Chow-test is conducted to examine the existence of structural break around the August 11, 2015. F-statistics and significant level for the Chow-test are displayed in the table. Significant level: ***1 percent; ** 5 percent; * 10 percent.

4.5. Robustness Check

Two methodological issues merit attention and need to be addressed. First, Dominguez and Tesar (2006) show that $|\gamma_i|$ changes the distribution of original γ_i and hence deviates the resulting error term away from normal distribution. To resolve this problem, they transform it into $\sqrt{|\gamma_i|}$ to run the final regression. Hutson and Laing (2004) adopt this method in their study of foreign exchange rate exposure. Second, in both linear and nonlinear regressions of the determinants of exchange rate exposures, the coefficients estimated from the first stage may be influenced by measurement error and hence confound the results of the second stage. Allayannis and Ofek (2001) and Kim et al. (2006) mitigate this possibility by inversing the standard error from the first stage and using it as the weight for the second stage of the WLS regression.

We adopt all these remedies and report estimated results in Table 9. The sample time in the regression ranges from August 11, 2015 to December 31, 2018. The first two columns are the results of linear exposures of $\sqrt{|\gamma_i|}$ replacing $|\gamma_i|$; The second two columns report the results of the WLS regression; We omit the year 2015 in the third two columns; Finally, we apply Fama-French three factors model to re-estimate γ_i, and show the results in the last two columns. Reassuringly, Table 9 confirms that the firm size and leverage ratio remain the statistically significant determinants of the foreign exchange rate exposure of Chinese public firms.

Table 9 Robustness Check

	(1) USD(γ_i)	(2) INDEX(γ_i)	(3) USD(γ_i)	(4) INDEX(γ_i)	(5) USD(γ_i)	(6) INDEX(γ_i)	(7) USD(γ_i)	(8) INDEX(γ_i)
size	-0.0429***	-0.0336***	-0.0465***	-0.0370***	-0.0440***	-0.0322***	-0.0492***	-0.0421***
	(-6.88)	(-4.37)	(-5.19)	(-3.37)	(-5.55)	(-3.42)	(-6.21)	(-4.51)
$FSales^+$	0.0195	0.0172	0.0386	0.0545	0.0235	0.0303	0.0799	0.0517
	(0.32)	(0.29)	(0.56)	(0.57)	(0.36)	(0.33)	(1.18)	(0.55)
$FSales^-$	-0.0819	-0.1201	-0.1551	-0.1472	-0.1104	-0.1457	-0.0867	-0.1787
	(-0.97)	(-1.01)	(-1.09)	(-0.88)	(-0.81)	(-1.09)	(-0.63)	(-1.23)
Subsidiary	-0.0017	0.0165	-0.0070	0.0101	0.0034	0.0158	-0.0053	0.0256
	(-0.10)	(1.09)	(-0.39)	(0.47)	(0.21)	(0.89)	(-0.32)	(1.10)
FLoan	-0.0214	-0.0491	-0.0523	-0.0844	-0.0325	-0.0764	-0.0100	-0.0471
	(-0.48)	(-1.27)	(-1.07)	(-1.51)	(-0.76)	(-1.52)	(-0.24)	(-1.06)
Leverage	0.0842*	0.1280**	0.1157*	0.1194*	0.1267**	0.1548*	0.1454**	0.1789**
	(1.79)	(2.54)	(1.88)	(1.72)	(2.17)	(1.97)	(2.52)	(2.51)
QR	0.0010	0.0038	0.0055	0.0035	0.0059	0.0064	0.0054	0.0054
	(0.26)	(0.85)	(0.90)	(0.58)	(1.00)	(1.01)	(0.92)	(0.99)
DE	0.0410	0.0846*	0.0629	0.0910	0.0646	0.0738	0.0339	0.0520
	(0.82)	(1.89)	(1.12)	(1.50)	(1.27)	(1.61)	(0.66)	(1.21)
BM	0.0049	-0.0172	0.0051	-0.0211	-0.0101	-0.0289*	0.0017	-0.0171
	(0.42)	(-1.41)	(0.38)	(-1.22)	(-0.93)	(-1.77)	(0.14)	(-1.08)
IND Dummy	YES	YES	YES	YES	YES	YES	YES	YES
Constant	0.5358***	0.6076***	0.2876***	0.4271***	0.2860***	0.3871***	0.3140***	0.4143***
	(18.22)	(9.39)	(4.72)	(5.20)	(4.93)	(8.52)	(5.55)	(9.75)
Observations	2,417	2,417	2,379	2,380	2,417	2,417	2,417	2,417
R-squared	0.074	0.074	0.079	0.084	0.075	0.082	0.084	0.082

Note: This table reports four robustness results during the period from August 11, 2015 to December 31, 2018. The first two columns are the results of linear exposures of $\sqrt{|\gamma_i|}$ replacing $|\gamma_i|$; The second two columns report the results of the WLS regression; We omit the year 2015 in the third two columns. Finally, we apply Fama-French three factors model to re-estimate γ_i, and show the results in the last two columns. Robust t-statistics are reported between parentheses. Significant level: ***1 percent; ** 5 percent; * 10 percent.

Admittedly, the OLS regressions in the study may be subject to endogenous problems, especially considering that foreign exchange rate exposure and the leverage, foreign trade, capital flow could be determined simultaneously. In addition, the endogeneity problem may also rise due to the omission of important variables. To address the possible endogeneity concern, we employ three additional tests.

First, we adopt Arellano and Bover (1991) dynamic panel GMM procedure to address potential endogeneity where one or more of the explanatory variables are not strictly exogenous. This technique utilizes appropriate lags of the changes in both dependent variables and regressors to address the potential endogeneity of all the regressors, and can also account for time-invariant unobservable heterogeneity (i.e. time-invariant firm-specific characteristics).

Table 10 presents the GMM regression results of equation (3)[17]. The GMM instrumental variables are validated by the Sargan and Hansen over-identification tests. The first-order and second-order serial correlations of the Arellano-Bond tests are conducted to show that the original error terms are serially uncorrelated (Arellano and Bond, 1991.) Supporting the hedging cost hypothesis, firm size and leverage ratio remain the statistically significant determinants of the foreign exchange rate exposure of Chinese public firms. In addition, firms with lower BM ratios, or higher quick ratios, are more exposed to exchange rate fluctuations after the 811 reform.

Table 10 Endogeneity—Two-step GMM

	(I) USD(γ_i)	(II) USD(γ_i)	(III) INDEX(γ_i)	(IV) INDEX(γ_i)
l. γ_i	0.0098	-0.0973	-0.0226	-0.0216
	(0.11)	(-0.83)	(-0.67)	(-1.32)
size	-0.1399***	-0.1433**	-0.2020**	-0.0472***
	(-5.23)	(-2.32)	(-1.99)	(-3.61)
$FSales^+$	-0.1278	-0.0790	-0.4298*	-0.0153
	(-0.94)	(-0.45)	(-1.76)	(-0.19)
$FSales^-$	0.6550*	-0.6413	0.0960	0.0714
	(1.88)	(-1.30)	(0.19)	(0.53)
Subsidiary	0.0333	0.5112*	0.3687	0.0852**
	(0.86)	(1.65)	(1.10)	(2.37)
FLoan	-0.0895	-0.0580	0.7029	-0.2446**
	(-0.86)	(-0.14)	(1.00)	(-2.15)
Leverage	0.0051***	0.0023**	0.0138***	0.0028***
	(2.58)	(2.49)	(2.74)	(3.20)
QR	0.0161*	-0.0054	0.1473***	0.0052
	(1.73)	(-0.76)	(2.69)	(1.08)
DE	-0.0970	-0.0776	-2.0485**	-0.1105
	(-0.88)	(-0.76)	(-1.99)	(-1.23)
BM	0.0147	0.0013	0.1343	-0.0397***
	(0.53)	(0.04)	(1.37)	(-2.74)
Controls	YES	YES	YES	YES
AR(1)	0.006	0.009	0.000	0.000
AR(2)	0.753	0.329	0.909	0.253
Sargan test	0.839	0.393	0.125	0.247
Hansen J test	0.102	0.122	0.310	0.296

Note: This table provides the results estimated by the dynamic GMM using one-year lagged values and the difference of size and leverage as instruments. Industry dummy, year dummy and constant are included but not reported. Robust t-statistics are reported between parentheses. AR(1) and AR(2) are the p-values of Arellano-Bond test for AR(1) and AR(2), respectively. Sargan test and Hansen J test report the p-value of the over-identification test. Column (I) and (III) show the results of the sample period from June 19, 2010 to August 11, 2015. Column (II)

[17] We re-estimated equation (1) for each year of 2009-2018. 2010-2014 and 2015-2018.The lag variables are one period lagged.

and (IV) show the period from August 11, 2015 to December 31, 2018. Significant level: ***1 percent; ** 5 percent; * 10 percent.

Second, we employ a two-stage least squares (2SLS) approach to examine the relationship between explanatory variables and the exchange rate exposure. A valid instrument should related with the potential explanatory variable, but have no direct impact on the exchange rate exposure. Following the literature (Liu et al., 2015; Coles et al., 2018), we use the previous three years' industry average of explanatory variables, to proxy for firm level variables accordingly. This methodology satisfies both relevant and exclusive conditions. For instance, the previous three years' industry mean of leverage ratio is likely to affect a firm' leverage ratio, satisfying the relevant criteria. However, it is unlikely that this variable affect future firm specific exchange rate exposure, except through its effects on firm's leverage ratio. We report the second-stage results of the 2SLS tests in Table 11[18].

Table 11 Endogeneity—IV-2SLS

	(I) USD(γ_i)	(II) USD(γ_i)	(III) INDEX(γ_i)	(IV) INDEX(γ_i)
size	-0.2072***	-0.0836**	0.0729	-0.0294**
	(-3.18)	(-2.15)	(0.87)	(-2.41)
Fsales	0.0361	0.0780	0.4301	0.0072
	(0.10)	(0.25)	(0.92)	(0.14)
Subsidiary	0.0068	-0.0096	-0.4769	0.0184
	(0.02)	(-0.16)	(-1.26)	(0.85)
FLoan	0.6325	0.1795	0.7773	-0.0743
	(1.03)	(0.52)	(1.11)	(-1.33)
Leverage	0.9097**	0.4013*	3.3573**	0.5441**
	(2.08)	(1.74)	(2.06)	(2.04)
QR	0.1219**	0.0183	0.1793	0.0264*
	(1.97)	(1.46)	(1.42)	(1.96)
DE	0.0535	-0.0052	0.3521	-0.0059
	(0.17)	(-0.08)	(0.97)	(-0.11)
BM	0.0844	0.0096	-0.4672**	-0.0844**
	(0.89)	(0.19)	(-2.21)	(-2.37)
Controls	YES	YES	YES	YES
Observations	1,541	2,417	1,541	2,417

Note: This table shows the results of second stage of 2SLS using the previous three year industry average as instrument variables. Independent variables reported include firm size (size), foreign sales (Fsales), subsidiary (Subsidiary), foreign loans (FLoans), leverage (Leverage), quick ratio (QR), long-term debt ratio (DE), book to market ratio (BM) and constant are included but not reported. Column (I) and (III) show the results of USD and INDEX exchange rate shock during the period from June 19, 2010 to August 11, 2015, respectively. Column (II) and (IV) show the results of USD and INDEX exchange rate shock during the period from August 11, 2015 to December 31, 2018, respectively. Robust t-statistics are reported between parentheses. Significant level: ***1 percent; ** 5 percent; * 10 percent.

[18]We don't report these results for brevity. In unreported results, available upon request, first stage results indicate that

Finally, we employ event study analysis to examine whether reactions of stock prices to exchange rate shocks vary with firm characteristics. One advantage to this method is that market reactions to exchange rate shocks are unlikely to influence a firm's foreign sales and other characteristics, and that may consequently alleviate the endogeneity concern. Following Wei and Starks (2013), we define exchange rate shocks as daily currency movements beyond three standard deviations. We drop the event days if they are no more than 7 days apart and include only the first event day to avoid the possible bias caused by overlapping windows. Eventually we sample 11 and 6 event days for USD/CNY exchange rate movements before and after the 811 reform, while 13 and 6 for INDEX exchange rate. Then, a three-day window cumulative abnormal returns (CAR_i) is calculated for each event days; and its absolute value ($|CAR_i|$) proxies the market reaction as the independent variable. Firm characteristics in the regression are one-year lagged, reducing the possibility that exchange rate movement affects a firm's balance sheet causing reverse causation. We also include industry and time dummies. The regression model is thus as follow:

$$|CAR_i| = \varphi_1 + \varphi_2 size_i + \varphi_3 FSales_i^+ + \varphi_4 FSales_i^- + \varphi_5 Subsidiary_i + \varphi_6 FLoan_i + \varphi_7 Leverage_i + \varphi_8 QR_i + \varphi_9 DE_i + \varphi_{10} BM_i + IndDummy + Time\ Dummy + \varepsilon_i \quad (6)$$

The results are reported in Table 12. As expected, firms with higher leverage ratio, lower book-to-market ratio, or smaller size appear to have significantly larger market reactions. In addition, quick ratio is significantly positively correlated with the market reaction, indicating that short term liquidity lowers the incentive to hedge.

Table 12 Endogeneity—Event Study

	(I)	(II)	(III)	(IV)
	|CAR(-1,+1)|	|CAR(-1,+1)|	|CAR(-1,+1)|	|CAR(-1,+1)|
size	-0.0019***	-0.0032***	-0.0007***	-0.0071***
	(-8.34)	(-6.63)	(-4.37)	(-16.49)
$FSales^+$	0.0013	0.0009	0.0004	0.0020
	(0.65)	(0.99)	(0.39)	(0.83)
$FSales^-$	0.0055	0.0006	-0.0012	0.0089
	(1.52)	(0.24)	(-0.58)	(1.30)
Subsidiary	-0.0004	-0.0001	-0.0001	0.0009
	(-0.77)	(-0.25)	(-0.42)	(1.34)
FLoan	0.0002	-0.0013	-0.0007	0.0018
	(0.08)	(-1.53)	(-0.62)	(1.39)
Leverage	0.0032***	0.0059***	0.0024**	0.0100***
	(2.99)	(3.45)	(2.55)	(10.72)
QR	0.0206***	0.0117*	0.0165***	0.0048
	(2.80)	(1.91)	(5.98)	(0.44)
DE	-0.0008	0.0016	-0.0003	0.0029
	(-0.71)	(0.80)	(-0.40)	(1.14)
BM	-0.0071***	-0.0183***	-0.0064***	-0.0083***
	(-4.50)	(-16.80)	(-9.23)	(-3.70)
Controls	YES	YES	YES	YES
Observations	22,937	15,782	27,882	20,114

R-squared	0.190	0.077	0.127	0.140

Note: This table shows the results of event study. The dependent variable is the absolute value of firms' cumulative abnormal returns over the 3-days window (-1, +1). Independent variables reported include firm size (size), foreign sales ($FSales^+$, $FSales^-$), subsidiary (Subsidiary), foreign loans (FLoans), leverage (Leverage), quick ratio (QR), long-term debt ratio (DE), book to market ratio (BM), industry dummy, year dummy and constant are included but not reported. Column (I) and (III) show the results of USD and INDEX exchange rate shock during the period from June 19, 2010 to August 11, 2015, respectively. Column (II) and (IV) show the results of USD and INDEX exchange rate shock during the period from August 11, 2015 to December 31, 2018, respectively. Robust t-statistics are reported between parentheses. Significant level: ***1 percent; ** 5 percent; * 10 percent.

5. Effects of controlling shareholder entrenchment

In this section, we examine whether the difference in the governance structure of Chinese corporations has an impact on the variation of exposure to exchange rate risks. Unlike the listed firms in developed market economies, corporate ownership in most emerging market economies is highly concentrated. China is not an exception. Corporations are usually controlled through pyramid structures and cross-holdings among firms. Firms' daily operational activities and risk management practices are actually the products of controlling shareholders' decision making (He and Rui, 2016; Tan and Tang, 2016). In addition, control rights are commonly separated from cash flow rights (Claessens, et al., 2000). In companies with such governance structure, agency costs due to the separation of ownership and control are less prevalent and severe. The separation of cash flow and control rights, however, has facilitated controlling shareholders to tunnel resources away from firms for their own benefits through self-dealings at the expense of minority shareholders (Johnson et al., 2000; Claessens et al., 2002; Du et al., 2013). This entrenchment effect is particularly prevalent for China. For example, Jiang et al. (2010) show that a large proportion of firms' financial resources are siphoned off by controlling shareholders through inter-corporate loans in China.

Controlling shareholders have substantial discretion over the exchange rate risk management, and their attitude towards risk management is tied to their maximization of private benefits of control. It is, therefore, reasonable to examine whether the entrenchment effect contributes to the foreign exchange rate exposure. To test this hypothesis, we split our sample into two subgroups: firms that have a separation of control and cash flow rights (Entrenched firms) and those otherwise. We accordingly construct a dummy variable for entrenched firms, and incorporate this dummy into our benchmark regression (He and Ng, 1998). The regression model with entrenched firms is as below:

$$|\gamma_i| = b_1 D + b_2 size_i D + b_3 FSales_i^+ D + b_4 FSales_i^- D + b_5 Subsidiary_i D + b_6 FLoan_i D + b_7 Leverage_i D + b_8 QR_i D + b_9 DE_i D + b_{10} BM_i D + c_1 + c_2 size_i + c_3 FSales_i^+ + c_4 FSales_i^- + c_5 Subsidiary_i + c_6 FLoan_i + c_7 Leverage_i + c_8 QR_i + c_9 DE_i + c_{10} BM_i + IndDummy + Time\ Dummy + u_i \quad (7)$$

Where D is a dummy variable that takes the value of one if a firm has a separation of control and cash flow rights, and zero otherwise. We include the dummy variable, firm characteristics and their interaction terms to examine the entrenchment effects on exchange rate exposure. The results are reported in Table 13.

Expectedly, the effects of leverage and BM ratios on exchange rate exposure are not only statistically significant, but also significantly different between entrenched firms and the other firms. In particular, the interaction terms, Leverage*D, are significantly positive, while interaction terms, BM*D, are significantly negative. The results report in column (VI) shows that a one unit increase in leverage ratio causes the level of exchange rate exposure for an entrenched firm to increase by 0.0018, while that for the other firms to increase by 0.0009, a 50 percent difference. Similarly, a one unit increase in BM ratio leads to a drop of 0.286 for entrenched firms and 0.187 for the other firms. The results indicate that hedging costs play a more pronounced role in explaining a firm's exchange rate exposure for entrenched firms. This may be due to the fact that entrenched firms have less incentive to hedge facing high costs, hence their firms' values are more exposed to exchange rate movements[19].

Table 13 Separation

VARIABLES	(I) USD(γ_i)	(II) USD(γ_i)	(III) USD(γ_i)	(IV) INDEX(γ_i)	(V) INDEX(γ_i)	(VI) INDEX(γ_i)
D	0.0784	0.0003	0.0835	0.0195	-0.0196	0.0372
	(1.58)	(0.02)	(1.30)	(0.70)	(-0.94)	(1.01)
size*D	-0.0097		-0.0178	-0.0016		-0.0007
	(-0.83)		(-1.08)	(-0.23)		(-0.08)
$FSales^{+}$*D			-0.0920			-0.0747
			(-0.80)			(-0.97)
$FSales^{-}$*D			0.3016			0.1963
			(1.11)			(1.12)
Subsidiary*D			-0.0276			-0.0236
			(-0.79)			(-1.02)
FLoan*D			0.0862			-0.0026
			(1.13)			(-0.07)
Leverage*D		0.0010*	0.0018*		0.0008*	0.0009*
		(2.00)	(1.83)		(1.72)	(1.67)
QR*D			0.0025			0.0009
			(0.72)			(0.69)
DE*D			-0.0701			0.0354
			(-0.73)			(0.53)
BM*D			-0.0308			-0.0984***
			(-0.50)			(-2.84)
size	-0.0470***	-0.0497***	-0.0451***	-0.0196***	-0.0202***	-0.0205***
	(-5.45)	(-6.46)	(-4.92)	(-4.11)	(-4.50)	(-4.42)
$FSales^{+}$	0.0535	0.0540*	0.0827	0.0425	0.0426	0.0647*
	(0.92)	(2.01)	(1.16)	(1.50)	(1.50)	(1.74)
$FSales^{-}$	0.1174	0.1196	0.0355	-0.1001	-0.0986	-0.1565
	(0.78)	(0.79)	(0.21)	(-1.06)	(-1.05)	(-1.60)
Subsidiary	0.0168	0.0163	0.0247	-0.0027	-0.0031	0.0038
	(1.00)	(0.54)	(1.25)	(-0.24)	(-0.27)	(0.30)

[19] Please note that, the positive sign of dummy variable (D) in most specifications, although statistically insignificant, is consistent with the expectation that entrenched firms have less incentive to hedge than other firms.

FLoan	-0.0317	-0.0319	-0.0675	0.0078	0.0074	0.0074
	(-0.80)	(-1.03)	(-1.29)	(0.33)	(0.31)	(0.27)
Leverage	0.0015***	0.0012**	0.0010*	0.0011***	0.0009**	0.0009**
	(2.70)	(2.26)	(1.73)	(3.47)	(2.62)	(2.50)
QR	0.0073*	0.0074*	0.0064	-0.0007	-0.0005	-0.0009
	(1.75)	(1.79)	(1.47)	(-0.39)	(-0.31)	(-0.47)
DE	-0.0612	-0.0620*	-0.0449	0.0265	0.0256	0.0152
	(-1.28)	(-1.97)	(-0.83)	(0.94)	(0.91)	(0.46)
BM	-0.3605***	-0.3589***	-0.3520***	-0.2141***	-0.2135***	-0.1874***
	(-10.35)	(-11.20)	(-9.07)	(-11.04)	(-11.06)	(-8.86)
Controls	YES	YES	YES	YES	YES	YES
Observations	18,934	18,934	18,934	18,892	18,892	18,892
R-squared	0.257	0.257	0.257	0.091	0.091	0.092

Note: This table reports the effect of separation between cash flow rights and controls rights on the relationship between exchange rate exposure and the variables associated to firm's operation and hedging activities. *D* is a dummy variable that takes the value of one if a firm has a separation of control and cash flow rights, and zero otherwise. Independent variables reported include firm size (size), foreign sales ($FSales^+$, $FSales^-$), subsidiary (Subsidiary), foreign loans (FLoans), leverage (Leverage), quick ratio (QR), long-term debt ratio (DE), book to market ratio (BM), industry dummy, year dummy and constant are included but not reported. Coefficient and robustness t-statistics for firm characteristics are reported in the table. Column (I)-(III) and Column (IV)-(VI) show the results of USD and INDEX exchange rate exposure, respectively. Significant level: ***1 percent; ** 5 percent; * 10 percent.

6. Conclusion

This paper investigates foreign exchange rate exposure and its determinants for all Chinese listed firms since China's first major exchange rate reform in 2005. We find significantly linear and nonlinear exposures to bilateral as well as multilateral foreign exchange rates, and 5.6 percent more Chinese public firms are found to show greater sensitivity to nonlinear exposure. And in terms of timeline, considerably more firms were exposed to exchange rate fluctuations after the August 2015 reform. Our temporal study further shows that 26.2 percent of firms were exposed to nonlinear risks of the USD after the 811 Reform, whereas a mere 1.4 percent had been exposed to such risks before the reform.

In regards to the determinants of exposures, we find a mere effect of international operations in explaining a firm's exposure, in specific foreign sales ratio as its proxy only marginally positively correlates with exposures. However, a firm's exposure can be explained by its hedging costs. For example, smaller firms, or firms with high leverage ratio or greater growth opportunity, tend to be limited in hedging, and thus tend to have a greater exposure.

Last but not least, we examine the impact of the separation of control and cash flow rights in determining a firm's foreign exchange rate exposure. Our empirical results show that entrenched firms, i.e. firms with the separation of control and cash flow rights, are less likely to hedge than other firms and as such, are more exposed to exchange rate fluctuations when they are more leveraged or have greater growth opportunities.

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Appendix Variable definition

Variables	Definitions
size	Natural logarithm of firm asset.
$FSales^{+}$	The difference between firm's foreign sales ratio (foreign sales/total sales) and the average value in the industry during the year if it has above average foreign sales and zero otherwise.
$FSales^{-}$	The difference between firm's foreign sales ratio (foreign sales/total sales) and the average value in the industry during the year if it has below average foreign sales and zero otherwise.
Subsidiary	A dummy variable takes the value of 1 if the firm has foreign subsidiary and 0 otherwise.
FLoan	Non-RMB loan/ total loan
Leverage	Total liabilities divided by total assets
QR	Current asset/current liability
DE	Long-term debt/ total debt
BM	The balance sheet value of the equity divided by the market value of the equity