The University Of Sheffield.

Department Of Economics.

Sheffield Economic Research Paper Series.

Asymmetric Exchange Rate Exposure of Stock Returns: Empirical Evidence from Chinese Industries

Juan Carlos Cuestas and Bo Tang

ISSN 1749-8368

SERPS no. 2015021

September 2015

www.sheffield.ac.uk/economics

Asymmetric Exchange Rate Exposure of Stock Returns: Empirical Evidence from Chinese Industries☆

Juan Carlos Cuestas, Bo Tang*

Department of Economics, University of Sheffield, Sheffield, S1 4DT, UK

Abstract

This study explores the asymmetric exchange rate exposure of stock returns building upon the capital asset pricing model (CAPM) framework, using monthly returns of Chinese industry indices. In accordance with the existing literature, industry returns are subject to lagged exposure effects, but the asymmetries vary across industries, which could be due to the discrepancies of trade balance and ownership of certain industries. Furthermore, the dynamic multipliers depict that industry returns quickly respond to changes in the exchange rate and correct the disequilibrium within a short time, making the long run exposure to be symmetric or very small. The remaining shocks are mainly explained by the return of market portfolios. This implies that the ongoing restrictions on the RMB daily trading band do indeed protect the Chinese stock market against the effects of currency movements.

Keywords: Asymmetric exchange rate exposure, stock returns, Chinese industries, NARDL.

JEL Codes: C58, F3, G15.

☆We would like to thank Matthew Greenwood-Nimmo, Alberto Montagnoli, Jonathan Perraton, Christoph Thoenissen, Karl Taylor and the participants at the 11th BMRC-DEMS conference (Brunel, London), the Sheffield economics doctoral researcher annual conference, PhD conference in Monetary and Financial Economics (UWE, Bristol), and the 2015 China Youth Economists Forum (Xiamen) for their helpful comments on this study. Juan Carlos Cuestas acknowledges the financial support from the MINECO (Ministerio de Economía y Competitividad, Spain) research grant ECO2014-58991-C3-2-R. The remaining errors are the responsibility of the authors.

* Correspondence: Tel: + 44 114 222 3421. Fax: + 44 114 222 3458.

Emails: j.cuestas@sheffield.ac.uk (J.C. Cuestas), b.tang@sheffield.ac.uk (B. Tang).

1 Introduction

Economic theory predicts that exchange rate changes are associated with stock market performance. This is known as the "flow-oriented" exchange rate model (Dornbusch and Fischer, 1980; Phylaktis and Ravazzolo, 2005), which suggests that changes in exchange rates have a significant impact on international competitiveness and trade balance and, accordingly, affect real income and output. Stock prices respond to exchange rate changes since the current value of firms' future cash flows are expressed and incorporated into stock prices.[1] Complementarily, the existing literature suggests that firm values are exposed to unanticipated changes in the exchange rate (Adler and Dumas, 1984; Jorion, 1990; Dominguez and Tesar, 2001). The literature also finds that exchange rate changes have symmetric effects on stock returns, i.e. depreciations and appreciations have similar effects in magnitude on stock returns (Ajayi and Mougouė, 1996; Nieh and Lee, 2001; Phylaktis and Ravazzolo, 2005). However, there is little reason to believe that stock markets should behave in this way, as appreciations may have different effects in magnitude on stock returns than depreciations. In order to analyse this source nonlinear behaviour, empirical attention is increasingly turning to modelling asymmetric effects of exchange rate changes on stock prices (Miller and Reuer, 1998; Apergis and Rezitis, 2001; Bartram, 2004; Koutmos and Martin, 2007; Hsu *et al.*, 2009). However, these studies did not investigate long run and short run asymmetric exchange rate effects (exposures). Moreover, previous studies mainly used linear regression models to explore the exchange rate exposure. In this paper we seek to shed some light on the analysis of the asymmetric exchange rate exposure of stock returns in China using a nonlinear framework.

The rapid growth of the Chinese economy has increasingly attracted international investors to China. The announcement (November 2014) of the merger of the Shanghai and Hong Kong stock exchanges has promoted Chinese markets.[2] Under the environment of globalisation, the Chinese market has become more attractive, inclusive but vulnerable than before. The Chinese authorities are gradually relaxing currency restrictions; with the expansion of the currency daily trading band of 0.3% in 1994 to 0.5% in 2007, 1% in 2012 and 2% in 2014,[3] the RMB is becoming more flexible and tradable in the foreign exchange market. In conjunction with the traditional "flow-oriented" theory, the resulting currency movements might affect the performance of stock markets, hence understanding the nature of exchange rate exposure is of importance to investors. The extant studies on the interactions between exchange rate and stock prices in China have mainly focused on the market level (Zhang and

[1] According to the fundamental theory of value, the value of a financial asset at any point in time equals the present value of all future cash flows.
[2] See more details about the merger of Shanghai and Hong Kong stock exchanges via the Shanghai stock exchange: www.sse.com.cn or the Hong Kong Exchanges and Clearing Limited: www.hkex.com.hk.
[3] See the RMB history studied by the Australian Centre on China in the World via the link: ww.thechinastory.org/ lexicon / renminbi/. See also, a recent report from the IMF which stated that the Chinese currency was "no longer undervalued" (The Economist, 2015).

Li, 2002; Deng and Shen, 2008; Zhao, 2010). While investors prefer to invest in individual industries with higher returns but fewer risks, these industries are subject to exchange rate changes, which adds an additional source of risk. Taking into consideration this situation, studying asymmetric exchange rate exposure at the industry level could provide new insight into systematic risks for investors.

There is a voluminous literature on the relationship between exchange rate changes and stock prices. We can group this into three main clusters. First, a large volume of studies investigate the spillover effects of exchange rate movements on stock prices and vice versa (Granger et al., 2000; Nieh and Lee, 2002; Homma et al., 2005; Walid et al., 2011).[4] These studies aim to explore the causal relationship between currency markets and stock markets at the market level. Second, some studies have investigated the asymmetric exchange rate spillovers on stock prices (Apergis and Rezitis, 2001; Reyes, 2001; Chkili et al., 2012). Most of them carry out the examination of asymmetric volatility spillovers using a GARCH model. Third, an increasing number of studies examine the exchange rate exposure of firm value, building upon the conventional capital asset pricing model (CAPM) framework (Miller and Reuer, 1998; Dominguez and Tesar, 2001; Bartram, 2004; Dominguez and Tesar, 2006; Chue and Cook, 2008). These researchers test the asymmetric effects of exchange rate movements on stock returns, which are similar to our study but differ in their econometric modelling. Most of them used the linear regression approach to estimate exchange rate risks, without distinguishing between short run and long run effects, while our study estimates the exposure effect using the nonlinear autoregressive distributed lag approach. There is some literature on the asymmetric effects of exchange rate changes specifically on the Chinese stock market (Yeh and Lee, 2001; Miao et al., 2013), but these studies did not investigate the long run and short run asymmetries of exchange rate exposure and some industries were commonly excluded from their samples, such as non-exporting and financial industries.

The main aim of this study is, hence, to investigate the asymmetric exchange rate exposure of stock returns in the Chinese stock market at the industry level. Specifically, we introduce the conventional CAPM for measuring exchange rate exposure. We construct the dynamic nonlinear model to investigate both the long run and short run asymmetric exposure effects, which is carried out by means of estimating a nonlinear autoregressive distributed lag (NARDL) model (Shin et al., 2014).

Building upon the CAPM structure, this paper contributes to a growing literature on the analysis of exchange rate exposure of the Chinese stock market on the following grounds. First, compared with linear regression models, the NARDL model demonstrates its competence and efficiency in estimating the exchange rate exposure. The disparities in the exposure effect depend on the ownership of these companies and the expansion of their global operations. Second, industry returns strongly and

[4] These studies are not very close to our interest in the asymmetric exchange rate exposure, but they have examined the effect of exchange rate changes on stock prices.

quickly respond to exchange rate changes in the very short run, while most of the long run exposures are symmetric or very small. This indicates that the remaining shocks are explained by the return of market portfolios. This further supports the fact that the restriction on the daily trading band of the RMB exchange rate protects the Chinese stock market against the effect of currency movements. Third, this paper also posits a series of hypotheses on the exchange rate exposure of non-exporting industries and financial industries, which were commonly ignored in the existing literature. Our study provides investors with in-depth insight into the nature of exchange rate exposure of Chinese industries. Finally, this study tests the appropriateness of two alternative ways for measuring unexpected changes in the exchange rate change, given that the RMB exchange rate is closely monitored by the government. The remaining sections of this study are organised as follows: The theoretical framework and econometric methods are discussed in Section 2. Section 3 gives details of the dataset and preliminary statistics. Section 4 investigates the exchange rate exposure of Chinese industries using both the linear and nonlinear approaches. The last section concludes the paper.

2 Econometric Modelling

2.1 Theoretical Framework and Hypotheses

In the existing literature, the popular approach for measuring exchange rate exposure is based on the CAPM framework (Jorion, 1990; Dominguez and Tesar, 2001, 2006; Chue and Cook, 2008; Du and Hu, 2012). Testing for exchange rate exposure involves incorporating the changes in the exchange rate on the right hand side of the CAPM and testing the significance of the exposure coefficient. The theoretical model taking the market return into account has the following expression:

$$SR_t^i = \alpha_{1,i} + \beta_{2,i} RM_t + \beta_{3.i} ER_t + \varepsilon_{i,t} \tag{1}$$

Where SR_t^i is the stock return of industry *i* at time *t*, RM_t is the market return and ER_t is the change in the trade-weighted exchange rate. Equation (1) gives the theoretical model of measuring exchange rate exposure of industry returns.[5] To control for macroeconomic conditions, the return of a market portfolio is included in the model. It adjusts the total exposure estimates to remove macroeconomic effects. The examination of exchange rate exposure is to test whether the coefficient $\beta_{3,i}$ is significantly different from zero. $\beta_{3,i}$ is referred as residual exposure elasticity of industry returns.

In this study, both exporting industries and non-exporting industries are included in the sample. Building upon the previous literature, we posit the following hypotheses:

[5] The theoretical model above has no problem of endogeneity, as SR_t^i is industry returns, which is subject to change proportionally to the change in the market portfolio (the CAPM theory). ER_t is the trade-weighted effective exchange rate. The change in exchange rate may affect industry returns, but the fluctuation in industry returns cannot influence the exchange rate, especially under the circumstance of a managed floating exchange rate in China.

(1) H0: Non-exporting industries are subject to exchange rate exposures; H1: Non-exporting industries are not exposed to exchange rate changes.

Industry exchange rate exposure is determined by the industry's activities, i.e. exporting or importing, but an appreciation of the home currency may exhibit little effect on the value of an industry that both invests overseas and uses internationally-priced inputs (Bodnar and Gentry, 1993). In this paper, we pay attention to exposure effects from both exporting and non-exporting industries, since Greenaway and Kneller (2007) point out that exporting and non-exporting industries are subject to different exposures due to different industry characteristics.

(2) H0: Financial industries suffer fewer exposures due to their sophisticated risk management schemes and unique asset structures;[6] H1: No significant evidence shows that financial industries suffer fewer exchange rate exposures.

Financial industries are usually ignored in previous studies due to their unique asset structures and business objectives (Bartram, 2004). However, financial companies might be subject to transaction exposures and translation exposures during their daily operations, especially for those firms which have overseas branches. To get an insight into systematic risks of Chinese industries and provide solid suggestions for investors, we need to further investigate whether Chinese financial industries suffer from exchange rate risks.

(3) H0: Lagged exchange rate changes have significant exposure effects on industry returns; H1: Chinese industries do not suffer from lagged exposure effects.

The extant literature suggests that firm values are also exposed to lagged exchange rate changes (Williamson, 2001; Doukas *et al.*, 2003). This might be particularly true in China due to the implementation of a managed floating exchange rate policy, but we need to assess the evidence.

(4) H0: Industry returns symmetrically respond to changes in the exchange rate; H1: Industry returns asymmetrically respond to exchange rate changes.

There are numerous studies on the interaction between exchange rates and stock returns in the Chinese stock market, but most of them focus on the linear correlation. The main interest of this study is to examine whether the exchange rate exposure is symmetric or asymmetric, and further propose suggestions accordingly.

---

[6] Some studies assume that financial institutions have different asset characteristics and business objectives. Therefore, financial firms are usually excluded from the sample (Bartram, 2004).

2.2 Econometric Methods

We firstly estimate a reduced form vector autoregressive (VAR) and sort the equation by SR_t^i, then hence, the linear exchange rate exposure equation is written in the following form:

$$\mathrm{SR}_t^i = \alpha_{0,i} + \sum_{j=1}^{m} \beta_{1j}\mathrm{SR}_{t-j}^i + \sum_{j=1}^{n} \beta_{2j}\mathrm{RM}_{t-j} + \sum_{j=1}^{q} \beta_{3j}\mathrm{ER}_{t-j} + \varepsilon_{i,t} \quad (2)$$

The above equation is an extension of the conventional CAPM framework for measuring exchange rate exposure, in which lagged regressors are included.[7]

Most studies assume that firm returns responds symmetrically to appreciations and depreciations of the home currency. However, changes in exchange rates might cause asymmetric changes in industry returns both in the long run and short run, which could be positive or negative, i.e. above or below the equilibrium relationship.[8] Therefore, the main aim of this study is to investigate the asymmetric exchange rate exposure of Chinese industries. Following Shin et al. (2014), our study applies the nonlinear autoregressive distributed lag (NARDL) model to estimate the exchange rate exposure of industry returns. One of the main features of this approach is its competence in estimating the long run and short run asymmetries in a coherent manner, regardless of the order of integration of the variables. The simple asymmetric long run regression is expressed as:

$$\mathrm{SR}_t^i = \alpha_{0,i} + \beta^+\mathrm{RM}_t^+ + \beta^-\mathrm{RM}_t^- + \gamma^+\mathrm{ER}_t^+ + \gamma^- ER_t^- + \varepsilon_{i,t} \quad (3)$$

Where $\mathrm{RM}_t = \mathrm{RM}_0 + \mathrm{RM}_t^+ + \mathrm{RM}_t^-$, $\mathrm{ER}_t = \mathrm{ER}_0 + \mathrm{ER}_t^+ + \mathrm{ER}_t^-$. RM_t^+, RM_t^-, ER_t^+ and ER_t^- are the partial sum process of the positive and negative changes in the original series (RM_t and ER_t).

$$RM_t^+ = \sum_{j=1}^{t} \Delta RM_j^+ = \sum_{j=1}^{t} \max(\Delta RM_t, 0), \qquad RM_t^- = \sum_{j=1}^{t} \Delta RM_j^- = \sum_{j=1}^{t} \min(\Delta RM_t, 0) \quad (4)$$

$$ER_t^+ = \sum_{j=1}^{t} \Delta ER_j^+ = \sum_{j=1}^{t} \max(\Delta ER_t, 0), \qquad ER_t^- = \sum_{j=1}^{t} \Delta ER_j^- = \sum_{j=1}^{t} \min(\Delta ER_t, 0) \quad (5)$$

β^+ and β^- are the coefficients for the asymmetric positive and negative market exposures, respectively. γ^+ and γ^- are the coefficients for the asymmetric positive and negative effects of the change in the exchange rate, respectively. $\varepsilon_{i,t}$ is the error term of industry *i*. Schorderet (2003) defines

[7] Some studies estimate the exchange rate exposure in the cointegrated VAR approach, but this approach is not appropriable for our study since the variables are stationary in levels.
[8] Koutmos and Martin (2003) point out that asymmetric effect can be caused by asymmetric pricing-to-market behaviour, hysteretic behaviour and asymmetric heading behaviour.

the asymmetric cointegrating relationship as the linear combination of the partial sum components. Hence in this case, the stationary relationship between industry returns and exchange rate changes is given as:

$$z_{i,t} = \alpha_i^{+}\mathrm{SR}_{i,t}^{+} + \alpha_i^{-}\mathrm{SR}_{i,t}^{-} + \beta_i^{+}\mathrm{RM}_t^{+} + \beta_i^{-}\mathrm{RM}_t^{-} + \gamma_i^{+}\mathrm{ER}_t^{+} + \gamma_i^{-}\mathrm{ER}_t^{-} \quad (6)$$

When $\alpha_i^{+} = \alpha_i^{-}$, $\beta_i^{+} = \beta_i^{-}$ and $\gamma_i^{+} = \gamma_i^{-}$, the long run relationship amongst these series are symmetrically cointegrated. The dynamic framework for modelling exchange rate exposure takes both the long run and short run asymmetries into account. It is straightforward to rewrite equation (3) into the ARDL (p,q) form:

$$\mathrm{SR}_t^{i} = \alpha_{0,i} + \sum_{j-1}^{p} \phi_j \mathrm{SR}_{t-j}^{i} + \sum_{j=0}^{q} \left(\theta_j^{+\prime}\mathrm{RM}_{t-j}^{+} + \theta_j^{-\prime}\mathrm{RM}_{t-j}^{-} + \gamma_j^{+\prime}\mathrm{ER}_{t-j}^{+} + \gamma_j^{-\prime}\mathrm{ER}_{t-j}^{-}\right) + \varepsilon_{i,t} \quad (7)$$

Where $\alpha_{0,i}$ is the constant of industry *i*. ϕ_j is the parameter of lagged industry returns. $\theta_j^{+\prime}, \theta_j^{-\prime}, \gamma_j^{+\prime}$ and $\gamma_j^{-\prime}$ are the asymmetric distributed lag parameters. $\varepsilon_{i,t}$ is the *i.i.d* innovations. Subsequently, we construct the error correction model form of the above equation with the inclusion of both the long run and short run partial asymmetries.

$$\Delta\mathrm{SR}_t^{i} = \rho\mathrm{SR}_{t-1}^{i} + \theta^{+}\mathrm{RM}_{t-1}^{+} + \theta^{-}\mathrm{RM}_{t-1}^{-} + \lambda^{+}\mathrm{ER}_{t-1}^{+} + \lambda^{-}\mathrm{ER}_{t-1}^{-} + \theta_{\omega}\omega_{t-1} + \sum_{j=1}^{p-1}\gamma_i\Delta\mathrm{SR}_{t-j}^{i}$$

$$+ \sum_{j=0}^{q-1}\left(\pi_j^{+}\Delta\mathrm{RM}_{t-j}^{+} + \pi_j^{-}\Delta\mathrm{RM}_{t-j}^{-} + \psi_j^{+}\Delta\mathrm{ER}_{t-j}^{+} + \psi_j^{-}\Delta\mathrm{ER}_{t-j}^{+} + \Omega_{\omega,j}\Delta\omega_{t-j}\right) + \varepsilon_{i,t} \quad (8)$$

Where the long run parameters are ρ, $\theta^{+}, \theta^{-}, \lambda^{+}$ and λ^{-}. π_i^{+}, π_i^{-}, ψ_i^{+} and ψ_i^{-} are the short run parameters. $\beta_i^{+}{=}{-}\theta^{+}/\rho$ and $\beta_i^{-}{=}{-}\theta^{-}/\rho$ are the asymmetric long run elasticises for market returns, $\gamma^{+} = -\lambda^{+}/\rho$ and $\gamma^{-} = -\lambda^{-}/\rho$ are the asymmetric long run exchange rate exposure coefficients. This equation above is called the NARDL model (Shin *et al.*, 2014).

Compared with the existing regime-switching models, the NARDL model can be simply estimated by OLS. Added to that, the model is valid regardless of the integration orders of the variables. The test of long run equilibrium amongst these variables can be easily carried out based on the bounds test (Pesaran *et al.*, 2001): $\rho = \theta^{+} = \theta^{-} = \lambda^{+} = \lambda^{-} = 0$. The long run asymmetries of market returns and exchange rate exposures are examined by testing: $\beta^{+} = \beta^{-} = \beta_i$ (for market returns), and $\gamma^{+} = \gamma^{-} = \gamma_i$ (for exchange rate exposures), respectively. The test of short run asymmetries is testing: $\sum_{j=0}^{q-1} \pi_j^{+} = \sum_{j=0}^{q-1} \pi_j^{-}$ and $\sum_{j=0}^{q-1} \psi_j^{+} = \sum_{j=0}^{q-1} \psi_j^{-}$, respectively. These tests are based on standard Wald tests. If the null is rejected, this indicates the existence of asymmetric effects.

The dynamic multiplier depicts the effects of a unit change in γ^{+} and γ^{-} individually on SR_t^i, which are defined as:[9]

$$mh^{+} = \sum_{j=0}^{h} \frac{\partial SR_t^i}{\partial ER^{+}} = \sum_{j=0}^{h} \lambda_j^{+}, \qquad mh^{-} = \sum_{j=0}^{h} \frac{\partial SR_t^i}{\partial ER^{-}} = \sum_{j=0}^{h} \lambda_j^{-}, \qquad h=0,1,2\ldots \tag{9}$$

Where $h \to \infty$, $mh^{+} \to \gamma^{+}$ and $mh^{-} \to \gamma^{-}$. γ^{+} and γ^{-} designate the asymmetric positive and negative long run parameters, respectively. The dynamic multipliers graphically show the transition between the short run and long run, from disequilibrium towards a new equilibrium. This is extremely useful in interpreting the responsiveness of industry returns to the change in the exchange rate.

3 The Data and Preliminary Analysis

3.1 Dataset

We use a monthly dataset in this empirical investigation, which consist of 31 industry indices spanning the period from August 2006 to February 2015. However, 4 industries have a longer period (November 1996 to February 2015), including the agriculture, forestry, fishing and husbandry (AFFH), transportation, transportation facilities, and education and media industries. As the Chinese stock market consists of the Shanghai and Shenzhen stock markets, both the Shanghai Stock Exchange Composite Index (SHCOMP) and the Shenzhen Stock Exchange Component Index (SICOM) are collected. Stock indices are obtained from the Chinese Dazhihui Securities trading software.[10] Given that most firms export their products to many countries and are exposed to multilateral exchange rates, the trade-weighted exchange rate (TWER) is commonly used in the

[9] Since this study is interested in the examination of asymmetric exchange rate exposure of industry returns, we do not give the dynamic multiplier equations for market returns, and also, we do not report the dynamic multipliers for market returns in the empirical analysis section.

[10] The classification of Chinese industries by the Dazhihui is similar to that of the China Securities Regulatory Commission (CSRC). Although the latter has more detailed sub-industry classifications, this will not affect the results of this study, as the main interest of this paper is to investigate the asymmetric exchange rate exposure.

existing literature (Jorion, 1990; Dominguez and Tesar, 2006; Chue and Cook, 2008).[11] The TWER data are obtained from the Bank for International Settlement (BIS).

Figure 1: TWER of China and the US

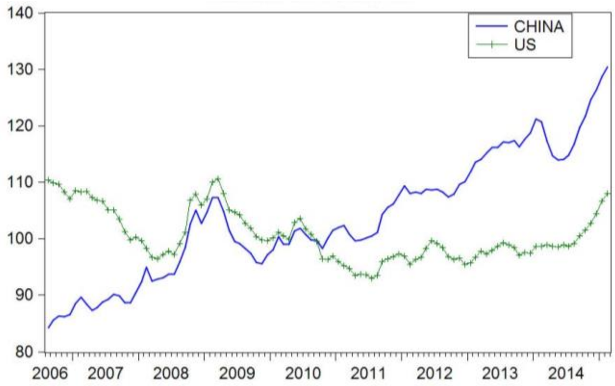
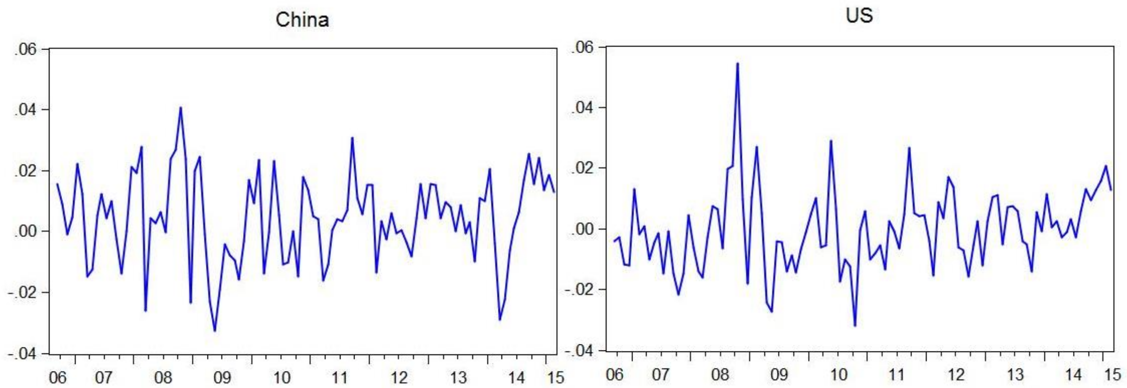


Figure 1 gives the plots of the TWER of China and the US. Since August 2006, China's TWER has increased by 54.86%, while the US TWER only declined by 4.7%. The increase in the TWER implies the strength of the currency against those of trade partners. This will benefit the country's imports but undermines the competitiveness of its exports. Figure 2 represents the returns of the TWER for the two countries. There is no significant evidence supporting that US TWER is more volatile than that of China except for the initial stage of the 2008 world financial crisis. Therefore, it is appropriate to use the TWER to investigate exchange rate exposure in China.

Figure 2: Returns of the TWER in China and the US



11 Real rate of the trade-weighted exchange rate is commonly used in the literature. Tang (2015) also finds that returns of Chinese industries are more likely to be exposed to the trade-weighted exchange rate, rather than the bilateral nominal or real rate of USD/RMB.

3.2 Data Transformation and Preliminary Analysis

In this study, industry returns are defined as the natural logarithmic of the difference between two consecutive closing prices. The change in the exchange rate is also constructed on the same basis:

$$SR_t^i = \ln\left(\frac{p_t^i}{p_{t-1}^i}\right) \qquad ER_t = \ln\left(\frac{twer_t}{twer_{t-1}}\right) \tag{10}$$

Where SR_t^i is the return of industry *i* at time *t*, and ER_t is the change in the TWER. p_t^i and $twer_t$ are the price index of industry *i* and the TWER at time *t*, respectively.

Considering the government intervention in the foreign exchange market, the change in the RMB exchange rate might be expected by investors, since the currency daily trading band is restricted. The classical definition of exchange rate exposure (see equation (1)) refers to the effects from unexpected exchange rate changes (Dominguez and Tesar, 2006; Chue and Cook, 2008). If the change in the RMB exchange rate is completely expected, investors could fully manage and offset their potential exchange rate exposure. Therefore, we propose two alternative ways of measuring the change in the RMB exchange rate. First, we obtain unexpected exchange rate changes from the following linear regression equation:

$$twer_t = \alpha + \beta twer_{t-1} + \varepsilon_t \tag{11}$$

$twer_t$ is the exchange rate (TWER) at time t, $twer_{t-1}$ is the lagged exchange rate. The unexpected exchange rate changes are the error term ε_t. Second, we decompose the series of $twer_t$ into trend and cyclical components using Hodrick–Prescott (HP) filter (Hodrick and Prescott, 1997).

$$\underset{\{gtwer_t\}_{t=-1}^{T}}{Min}\left\{\sum_{t=1}^{T} ctwer_t^2 + \lambda\sum_{t=1}^{T}[(gtwer_t - gtwer_{t-1}) - (gtwer_{t-1} - gtwer_{t-2})]^2\right\} \tag{12}$$

Where $gtwer_t$ and $ctwer_t$ ($ctwer_t = twer_t - gtwer_t$) are the growth component and the cyclical component of $twer_t$ (for t=1,…, T), respectively.[12] The cyclical part $twer_t$ here is the unexpected change in the TWER. In this study, we estimate the NARDL model by incorporating the three different measures of exchange rate changes in order to observe the potential different findings of estimating exchange rate exposure.

Regarding the market return, we define it as the average returns of the SHCOMP and the SICOM:

[12] The smoothing parameter λ is specified as 14,400 for monthly data as evidenced by the literature (Harris and Yilmaz, 2009).

$$MR_t = \frac{MR_t^{SHCOMP} + MR_t^{SICOMP}}{2} \quad (13)$$

Where $\mathrm{MR}_t^{\mathrm{SHCOMP}}$ and $\mathrm{MR}_t^{\mathrm{SICOM}}$ are the returns of the Shanghai stock market and the Shenzhen stock market, respectively. We assume that there is no significant difference in the shocks from the Shanghai market and the Shenzhen market. Hence we give equal weights to the two market indices.

Insert Table 1 about here.

As reported in Table 1, the log returns of industry indices do not exhibit any dramatic changes. The mean and standard deviation of most series are around 0.01 and 0.1. To carry out the dynamic linear modelling, we need to check the order of integration of the variables. The augmented Dickey Fuller (ADF) approach tests the null hypothesis that the series has a unit root (Dickey and Fuller, 1979; Dickey and Pantula, 1987). We also apply the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test (Kwiatkowski et al., 1992), which has more power and less size distortion for small samples. Table 2 reports the two types of unit root tests. All variables appear to be integrated of order zero *I(0)*, as demonstrated by the two tests. This supports the existing evidence that the CAPM can be estimated in levels (Jorion, 1990; Dominguez and Tesar, 2001, 2006).

Insert Table 2 about here

4 Empirical Analysis

4.1 Dynamic Linear Estimation of Exchange Rate Exposure

We first estimate the exchange rate exposure of Chinese industries applying the VAR approach in levels, since the unit root test results suggest that all variables are stationary. The lag length of the VAR model is determined by the Akaike information criteria. Among the 31 industries, two lags are selected for the real estate and securities industries, but only one lag is included in the VAR system for the remaining industries according to the information criteria. Table 3 reports the dynamic linear estimation of exchange rate exposure of industry returns.

Insert Table 3 about here.

As the table shows, the estimated standard errors are very small and almost all of them are not statistically significant, except for the wine and food industry. The adjusted R^2 of each industry is quite low. Some of them are negative as the intercept is constrained in the VAR model, so they are forced to fit worse than the horizontal line. Furthermore, the diagnostics indicate that some models are subject to autocorrelation and heteroscedasticity in the residuals. The goodness of fit of these models in conjunction with the diagnostic tests implies that the dynamic linear modelling of exchange rate exposure of industry returns is problematic. A possible solution could be the application of nonlinear modelling.

4.2 Dynamic Nonlinear Modelling of Exchange Rate Exposure

In order to address those issues raised from the dynamic linear modelling exchange rate exposure, we carry on the estimation using the NARDL approach. Table 4 reports the dynamic asymmetric modelling of exchange rate exposure of industry returns. One dominant feature is that the nonlinear modelling significantly improves the goodness of fit of each model. The adjusted R^2 ranges from 0.78 to 0.94 as demonstrated in the table, which are much larger than those for the dynamic linear estimates. Very few diagnostic tests are rejected. The majority of the parameters are statistically significant. This further proves that the dynamic nonlinear modelling of exchange rate exposure is much more competent and efficient than the linear approach, which also indicates that exchange rate exposure of industry returns are genuinely asymmetric. This is consistent with the empirical evidence from Japanese industries (Hsu *et al.*, 2009), US industries (Koutmos and Martin, 2007), and Australian industries (Brooks *et al.*, 2010).

Insert Table 4 about here.

As demonstrated in the table, the F_{PSS} statistics are statistically significant, which test the null hypothesis: $\rho = \theta^{+} = \theta^{-} = \lambda^{+} = \lambda^{-} = 0$. This indicates the existence of a long run relationship among industry returns, market returns and exchange rate changes, regardless of model specification. Industry returns receive exposure from the fluctuations of market returns and exchange rate changes. Twenty industries are exposed to asymmetric exchange rate exposures, which accounts for 64.5% of the total number of industries in China.[13] Eighteen of them are subject to asymmetric effects both from the fluctuations of market returns and exchange rate changes, which include two financial industries (banking and securities), two service industries (tourism and hotel, commercial chains), education and media industry, as well as fifteen manufacturing industries. Further, five industries only receive asymmetric market exposures, including AFFH, chemical, construction materials, insurance and iron industries. This implies that these industries mainly sell products to domestic customers although there has been an increase in the exports of these industries. Exports only account for a small proportion of their total output. This is particularly evidenced by the iron industry. According to a report from the General Administration of Customs of China,[14] China has been the largest iron exporter in the world since 2006, but the iron exports in 2014 made up no more than 10% of the total outputs. There is no doubt that these industry returns exhibit little or no correlation with asymmetric

[13] The industry classification in this study has referred to the industry classification citation of the China Securities Regulatory Commission (CSRC).
[14] For more details, please see the General Administration of Customs of China and the paper by Wei *et al.* (2007).

exchange rate exposures. In addition, the table reveals that six industries are not exposed to asymmetric effects from market returns and exchange rate changes, namely coal and petrol, electricity, estate, nonferrous metals, textile and garment, and transportation industries. A possible reason for this could be that most firms within these industries are state-owned companies, such as in the coal and petrol, electricity and nonferrous metals industries. These listed firms are closely monitored by the authorities.

Looking into the identified asymmetric effects of exchange rate exposures, sixteen industry returns are exposed to asymmetric long run and two industries present short run exchange rate exposures. There are two industries (banking, wine and food industries) characterised by long run and short run asymmetries simultaneously. In response to the proposed hypotheses, the empirical analysis gives us the following results:

(1) Not all the non-exporting sectors are resistant to exchange rate exposures. Although the returns of most state-dominated industries exhibit little or no correlation with exchange rate changes, such as coal and petrol, electricity and nonferrous metals industries, some non-exporting industries still suffer from exchange rate changes, such as water and gas, education and media industries, since these industries are heavily reliant on the import of relevant resources.

(2) There is no evidence supporting the hypothesis that financial industries are immune to exchange rate exposures. This supports the idea that financial industries are still subject to exchange rate risks, since financial industries benefit from a strong home currency and maintain net long domestic currency positions (Koutmos and Martin, 2003; Muller and Verschoor, 2006; Hsu *et al.*, 2009).[15] In contrast, the banking industry is exposed to both the long run and short run asymmetric exposure effects, which may be attributed to asymmetric hedging. This might also be explained by the fact that there has been an increase in overseas operations of Chinese banks, as Chinese banks are actively pushing RMB internationalisation through a wide range of activities, such as offering overseas loans, investing in the global financial market and issuing offshore RMB bonds. These activities are no doubt putting Chinese banks at the risk of currency movements.

(3) Lagged exchange rate changes have significant exposure effects on industry returns. As Table 4 reveals, some of the lagged short run exchange rate parameters are statistically significant. This is consistent with the evidence in the existing literature (Williamson, 2001; Doukas *et al.*, 2003; Martin and Mauer, 2003a, b), which suggests that stock returns are subject to both contemporaneous and lagged exchange rate movements.

[15] Figure 1 shows that the Chinese currency is becoming strong, which benefits Chinese financial industries.

(4) It is apparent that industry returns respond asymmetrically to changes in the exchange rate. The dynamic linear estimates show that those VAR models are severely misspecified, while the dynamic nonlinear estimates show that the exposure effects of exchange rate changes on industry returns are asymmetric.

In Table 4, the estimated asymmetric exchange rate exposure coefficients are given by L_{ER}^{+} and L_{ER}^{-}. To interpret the asymmetric exposure effects, we select three industries as examples, the chemical, electronics and machinery industries. Irrespective of the significance of the coefficients, the long run coefficients are -0.091 and -0.352 for chemical industry, -0.690 and -0.303 for electronics industry, respectively. This means that an upturn of exchange rate fluctuations of 10.99% reduces returns of chemical industry by 1%,[16] while the downturn of just 2.84% in exchange rate changes increases industry returns by 1%. For the electronics industry, the upsurge of exchange rate changes of 1.45% increases industry returns by 1%, but the decline of 3.30% increases industry returns by 1%. Likewise, the long run coefficients for the machinery industry are -0.098 and -0.716. Therefore the values convert into an upturn of exchange rate changes of 10.30% increases industry returns by 1% but a downturn of 1.40% reaches the opposite.

4.3 Asymmetric Exchange Rate Exposure of Industry Returns: Evidence from Two Alternative Ways of Measuring Unanticipated Exchange Rate Changes

Considering the managed floating exchange rate in China, the daily fluctuation range of the RMB exchange rate is expected;[17] we need to separate expected and unexpected exchange rate changes, as firm returns are only subject to the unanticipated component. We initially calculate unexpected changes in the exchange rate using the regression approach and the HP filter (see equation (11) and (12)), and then estimate the exchange rate exposure of industry returns using the same NARDL model.

Insert Table 5 about here.

Table 5 reports the asymmetric exchange rate exposure of industry returns based on alternative ways of measuring unexpected changes in the exchange rate. When we include the "real sense" of unanticipated changes in the exchange rate in the NARDL framework, that are obtained from the simple regression approach, the model estimates show that twelve industries are subject to long run asymmetric exchange rate exposure and four industries are exposed to short run asymmetric exchange rate exposure. Compared with the estimates in Table 4, where the exchange rate variable is measured

[16] The long run coefficients are very small and the explained relative changes which cause the changes of industry returns by 1% are very large, such as the electronics industry (1098.90% and 284.09%). This is true since the changes in industry returns and the exchange rate are expressed as natural logs. A small change in the monthly exchange rates will cause a large percentage change in the log return.

[17] Since March 2014, the daily trading band of RMB/USD is restricted at 2%. Based on the current rate, the next day's rate is expected. Investors can adjust their investments according to the expected change in the exchange rate.

as log returns, the long run asymmetric exchange rate exposure captured in six industries (in Table 4) does not appear in Table 5, including banking, chemical, computer, electronic equipment, machinery, tourism and hotel industries. These industries are exporting industries, which are exposed to transaction and translation exposure. Although the long run relationship amongst these variables exists, as confirmed by F_{PSS} statistics, some long run asymmetric exchange rate coefficients become insignificant.

Insert Table 6 about here.

Table 6 gives the asymmetric exchange rate exposure estimates using the NARDL approach with the inclusion of a cyclical component of the exchange rate that is calculated from the HP filter method. There are eight industries exhibiting long run asymmetric exposures but none of industry returns suffer from short run asymmetries. The iron industry has been found to suffer from long run asymmetric effects. This is opposite to both the evidence shown in Table 4 and Table 5. The model estimates seem to be much worse than the results shown in Table 5. A possible reason for this could be the artificial way of separating the growth component and the cyclical component of the exchange rate. Therefore, we are inclined to conclude that the conventional way for calculating unanticipated changes in the exchange rate is appropriate for measuring exchange rate exposures.

4.4 Dynamic Multipliers

The dynamic multipliers depict the adjustment of industry returns responding to exchange rate changes from initial equilibrium to a new equilibrium over horizon, which graphically represent the cumulative effects of unanticipated changes in the exchange rate on industry returns according to equation (9). Figure 3 represents the dynamic multipliers with restrictions on the short run and long run asymmetries, which are identified in the NARDL estimates in Table 4.[18] The long run symmetric restrictions for market returns and exchange rate changes are $\theta^+ = \theta^-$ and $\lambda^+ = \lambda^-$, respectively. The short run symmetric restrictions for market returns and exchange rate exposures are $\sum_{t=0}^{q-1} \pi_t^+ = \sum_{t=0}^{q-1} \pi_t^-$ and $\sum_{t=0}^{q-1} \psi_t^+ = \sum_{t=0}^{q-1} \psi_t^-$, respectively.

Insert Figure **3** about here.

As demonstrated in the graphs, the asymmetric effects vary across industries. Generally, eleven industries exhibit no correlation with the asymmetric exchange rate exposures, but five of them show resistance to exchange rate changes, including the coal and petrol, electricity, estate, insurance and iron industries. Only three of them (coal and petrol, electricity, estate) are non-exporting industries, the other two are exporting industries. The dynamic multipliers also show that six industries are

[18] Dynamic multipliers are calculated according to the NARDL estimates in Table 4, which is based on the conventional way of calculating exchange rate changes (log returns), since the estimates in Table 5 and Table 6 are less likely to be accepted.

subject to asymmetries in the very short run, namely the AFFH, chemical, construction materials, nonferrous metals, textile and garment, transportation industries. Essentially, industry returns quickly respond to exchange rate changes and adjust towards a new equilibrium within six months. Some of them are much shorter, around two months. The majority of these asymmetries are dominated by negative exchange rate shocks.

The depicted dynamic multipliers in Figure 3 are in accordance with the identified asymmetric exchange rate exposures. If only short run asymmetric exchange rate exposure is confirmed by the NARDL estimations, the dynamic multiplier indicates that industry returns swiftly respond to exchange rate shocks and adjust towards a new equilibrium within a couple of months,[19] such as communication and logistics industries. If long run asymmetric exchange rate exposures are identified, the dynamic multipliers show that more than 50% of the disequilibrium could be adjusted within five months, but the correction towards long run equilibrium takes a very long time.[20] If the long run and short run exposure effects are symmetric, the dynamic multipliers show that the asymmetry line is maintained at the level of zero, and the negative and positive changes in the exchange rate are completely symmetric.

In conjunction with identified asymmetries, we could draw a general conclusion that exporting industries are commonly subject to asymmetric exchange rate exposures, especially when their overseas operations account for a large proportion of their businesses, such as banking, commercial chains and the majority of manufacturing industries. Nonetheless, if the state-owned enterprises dominate the industry, industry returns are mainly affected by market returns but face less exposure from exchange rate changes, such as coal and petrol, communication, electricity, estate, insurance, iron, nonferrous metals, transportation industries. These findings seem to suggest that the managed floating exchange rate policy has benefited the Chinese economy in terms of market intervention. The restrictions on the daily floating range of the RMB exchange rate have protected the Chinese economy against exchange rate shocks. This is also revealed by the portrayed dynamic multipliers. When there is a shock from the foreign exchange rate market, firms strongly and quickly respond to the shock within a short period. In the likely case that the shock continues, these firms have already made appropriate changes to the adverse shock. The restrictions on the daily currency trading band at least offer extra time for firms to adjust to exchange rate changes. However, recent progress of RMB internationalization imply that the Chinese currency is becoming more flexible and tradable in the

[19] Pursuant to the conventional CAPM framework, industry returns are largely dependent on market returns, while this study mainly discusses the shocks from exchange rate changes. The equilibrium mentioned here refers to the equilibrium relationship between exchange rate changes and industry returns.

[20] The long run asymmetric exchange rate exposures exist in eighteen industries, including banking, building construction, commercial chains, computer, education and media, electronic equipment, electronic information, electronics, machinery, medicine, papermaking and printing, securities, tourism and hotel, trade, transportation facilities, water and gas, wine and food, miscellaneous industries.

foreign exchange market, which might strengthen the exchange rate exposure of industry returns and reduce the effects of market portfolios.

5 Concluding Remarks

This paper has explored the asymmetric exchange rate exposure of stock returns based on the evidence of Chinese industries. Unlike previous literature in estimating exposure using a simple static regression model, this study first estimates the exchange rate exposure using the dynamic linear approach building upon the CAPM framework. The dynamic linear estimations are carried out using a linear VAR model, which shows severe model misspecifications. In contrast, the dynamic nonlinear model estimates demonstrate that exchange rate exposures of industry returns are essentially asymmetric. Given that the RMB exchange rate is monitored by the authorities, the RMB exchange rate has expected and unexpected parts because of the restrictions on the currency's daily trading band. Since only unanticipated exchange rate changes will affect firm returns, we use two alternative ways to calculate the "unexpected" change in the exchange rate: simple regression and the HP filter, in order to get robust estimates. Nevertheless, the results from the inclusion of the two alternative approaches for measuring exchange rate changes are less than satisfactory. A possible reason for this could be the artificial approach of separating the expected (growth) and unexpected (cyclical) component of the exchange rate series, which might have removed some useful information about the change in the exchange rate.

The NARDL model estimates (Table 4) suggest that some of the non-exporting industries are subject to exchange rate exposures, which could be due to the higher proportion of their net imports. However, some state-dominated industries exhibit little correlation with exchange rate changes. Given the hypothesis that financial institutions might have unique asset structures and sophisticated risk management schemes, financial industries are still exposed to exchange rate changes. In accordance with the established fact, we also find that industry returns display lagged exposure effects. Furthermore, the dynamic multipliers reveal that industry returns quickly respond to exchange rate changes and make swift adjustments towards a new equilibrium within a short period (around five months), making the long run exposure to be symmetric or very small. The remaining shocks on industry returns are explained by the return of market portfolios. This implies that the managed floating exchange rate policy indeed helps protect the Chinese stock market from the effects of currency movements. As for investment strategies, investors could make short-term investments in the Chinese market without taking into consideration the exchange rate exposure. For long-term investments, the asymmetric exchange rate exposure should be closely monitored. Nonetheless, the recent progress of RMB internationalisation might also accelerate the speed of the Chinese currency becoming more flexible and tradable in the foreign exchange market. Added to the fact that an increasing number of Chinese enterprises are increasingly expanding their businesses overseas, the potential asymmetric exchange rate exposure could swell. Therefore, Chinese firms need to shift significantly into hedging currency exposures rather than relying heavily upon managing market exposures.

References

Adler, M., Dumas, B., 1984. Exposure to currency risk: definition and measurement. *Financial management*, 41-50

Ajayi, R.A., Mougouė, M., 1996. On the dynamic relation between stock prices and exchange rates. *Journal of Financial Research,*19(2), 193-207

Apergis, N., Rezitis, A., 2001. Asymmetric Cross - market Volatility Spillovers: Evidence from Daily Data on Equity and Foreign Exchange Markets. *The Manchester School,*69(s1), 81-96

Bartram, S.M., 2004. Linear and nonlinear foreign exchange rate exposures of German nonfinancial corporations. *Journal of international Money and Finance,*23(4), 673-699

Bodnar, G.M., Gentry, W.M., 1993. Exchange rate exposure and industry characteristics: evidence from Canada, Japan, and the USA. *Journal of international Money and Finance,*12(1), 29-45

Brooks, R.D., Di Iorio, A., Faff, R.W., Fry, T., Joymungul, Y., 2010. Asymmetry and time variation in exchange rate exposure: An investigation of Australian stocks returns. *International Journal of Commerce and Management,*20(4), 276-295

Chkili, W., Aloui, C., Nguyen, D.K., 2012. Asymmetric effects and long memory in dynamic volatility relationships between stock returns and exchange rates. *Journal of International Financial Markets, Institutions and Money,*22(4), 738-757

Chue, T.K., Cook, D., 2008. Emerging market exchange rate exposure. *Journal of Banking & Finance,*32(7), 1349-1362

Deng, C., Shen, Y., 2008. An empirical Study on the Relationship between Stock Price and Exchange Rate in China *Journal of Financial Research,*1, 2005

Dickey, D.A., Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American statistical association,*74(366a), 427-431

Dickey, D.A., Pantula, S.G., 1987. Determining the order of differencing in autoregressive processes. *Journal of Business & Economic Statistics,*5(4), 455-461

Dominguez, K.M., Tesar, L.L., 2001. A Reexamination of Exchange-Rate Exposure. *American Economic Review,*91(2), 396-399

Dominguez, K.M., Tesar, L.L., 2006. Exchange rate exposure. *Journal of International Economics,*68(1), 188-218

Dornbusch, R., Fischer, S., 1980. Exchange rates and the current account. *The American Economic Review*, 960-971

Doukas, J.A., Hall, P.H., Lang, L.H., 2003. Exchange rate exposure at the firm and industry level. *Financial Markets, Institutions & Instruments,*12(5), 291-346

Du, D., Hu, O., 2012. Exchange rate risk in the US stock market. *Journal of International Financial Markets, Institutions and Money,*22(1), 137-150

Granger, C.W., Huangb, B.-N., Yang, C.-W., 2000. A bivariate causality between stock prices and exchange rates: evidence from recent Asianflu. *The Quarterly Review of Economics and Finance,*40(3), 337-354

Greenaway, D., Kneller, R., 2007. Firm heterogeneity, exporting and foreign direct investment. *The Economic Journal,*117(517), F134-F161

Harris, R.D., Yilmaz, F., 2009. A momentum trading strategy based on the low frequency component of the exchange rate. *Journal of Banking & Finance,*33(9), 1575-1585

Hodrick, R.J., Prescott, E.C., 1997. Postwar US business cycles: an empirical investigation. *Journal of Money, credit, and Banking*, 1-16

Homma, T., Tsutsui, Y., Benzion, U., 2005. Exchange rate and stock prices in Japan. *Applied Financial Economics,*15(7), 469-478

Hsu, C.-C., Yau, R., Wu, J.-Y., 2009. Asymmetric exchange rate exposure and industry characteristics: Evidence from Japanese data. *Hitotsubashi Journal of Economics,*50(1), 57-69

Jorion, P., 1990. The exchange-rate exposure of US multinationals. *Journal of business*, 331-345

Koutmos, G., Martin, A.D., 2003. Asymmetric exchange rate exposure: theory and evidence. *Journal of international Money and Finance,*22(3), 365-383

Koutmos, G., Martin, A.D., 2007. Modeling time variation and asymmetry in foreign exchange exposure. *Journal of Multinational Financial Management,*17(1), 61-74

Kwiatkowski, D., Phillips, P.C., Schmidt, P., Shin, Y., 1992. Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root? *Journal of Econometrics,*54(1), 159-178

Martin, A.D., Mauer, L.J., 2003a. Exchange rate exposures of US banks: a cash flow-based methodology. *Journal of Banking & Finance,*27(5), 851-865

Martin, A.D., Mauer, L.J., 2003b. Transaction versus economic exposure: which has greater cash flow consequences? *International Review of Economics & Finance,*12(4), 437-449

Miao, B., Zhou, S., Nie, J., Zhang, Z., 2013. Renminbi exchange rate exposure: evidence from Chinese industries. *Journal of Chinese Economic and Business Studies,*11(4), 229-250

Miller, K.D., Reuer, J.J., 1998. Asymmetric corporate exposures to foreign exchange rate changes. *Strategic Management Journal,*19(12), 1183-1191

Muller, A., Verschoor, W.F., 2006. Asymmetric foreign exchange risk exposure: Evidence from US multinational firms. *Journal of Empirical Finance,*13(4), 495-518

Nieh, C.-C., Lee, C.-F., 2001. Dynamic relationship between stock prices and exchange rates for G-7 countries. *The Quarterly Review of Economics and Finance,*41(4), 477-490

Nieh, C.-C., Lee, C.-F., 2002. Dynamic relationship between stock prices and exchange rates for G-7 countries. *The Quarterly Review of Economics and Finance,*41(4), 477-490

Pesaran, M.H., Shin, Y., Smith, R.J., 2001. Bounds testing approaches to the analysis of level relationships. *Journal of applied econometrics,*16(3), 289-326

Phylaktis, K., Ravazzolo, F., 2005. Stock prices and exchange rate dynamics. *Journal of International Money and Finance,*24(7), 1031-1053

Reyes, M.G., 2001. Asymmetric volatility spillover in the Tokyo stock exchange. *Journal of Economics and Finance,*25(2), 206-213

Schorderet, Y., 2003. Asymmetric cointegration. Université de Genève/Faculté des sciences économiques et sociales.

Shin, Y., Yu, B., Greenwood-Nimmo, M., 2014. Modelling asymmetric cointegration and dynamic multipliers in a nonlinear ARDL framework. In: Festschrift in Honor of Peter Schmidt. Springer, pp. 281-314.

Tang, B., 2015. Exchange Rate Exposure of Chinese Firms at the Industry and Firm Level. *Review of Development Economics,*19(3), 592-607

The Economist, 2015. Feeling valued, the IMF changes its tune on China's currency.

Walid, C., Chaker, A., Masood, O., Fry, J., 2011. Stock market volatility and exchange rates in emerging countries: A Markov-state switching approach. *Emerging Markets Review,*12(3), 272-292

Wei, Y.-M., Liao, H., Fan, Y., 2007. An empirical analysis of energy efficiency in China's iron and steel sector. *Energy,*32(12), 2262-2270

Williamson, R., 2001. Exchange rate exposure and competition: evidence from the automotive industry. *Journal of financial economics,*59(3), 441-475

Yeh, Y.-H., Lee, T.-S., 2001. The interaction and volatility asymmetry of unexpected returns in the greater China stock markets. *Global Finance Journal,*11(1), 129-149

Zhang, B., Li, Y., 2002. Do the Exchange Rates Matter for Chinese Stock Market: Evidence from ARDL-ECM Estimation *Journal of Finance,*7

Zhao, H., 2010. Dynamic relationship between exchange rate and stock price: Evidence from China. *Research in International Business and Finance,*24(2), 103-112

Table 1: Descriptive statistics

	Mean	Max	Min	Std.Dev	Skewness	Kurtosis	JB	P-value
AFFH	0.01	0.179	-0.217	0.083	-0.275	2.88	0.976	0.614
Banking	0.012	0.246	-0.313	0.08	-0.141	6.557	39.251	0.000
Building construction	0.011	0.356	-0.223	0.087	0.42	5.681	24.339	0.000
Chemical	0.012	0.201	-0.23	0.088	-0.31	3.367	1.602	0.449
Coal and petrol	0.008	0.242	-0.295	0.09	-0.202	4.869	11.279	0.004
Commercial chains	0.01	0.184	-0.219	0.078	-0.172	3.302	0.645	0.724
Communication	0.011	0.171	-0.206	0.08	-0.286	2.789	1.144	0.564
Computer	0.024	0.202	-0.177	0.094	-0.093	2.34	1.45	0.484
Construction materials	0.013	0.194	-0.257	0.095	-0.357	2.919	1.593	0.451
Education and media	0.015	0.299	-0.226	0.092	0.132	3.348	0.589	0.745
Electricity	0.009	0.226	-0.226	0.072	-0.056	4.606	7.992	0.018
Electronic equipment	0.011	0.206	-0.207	0.08	-0.226	3.078	0.651	0.722
Electronic information	0.02	0.234	-0.178	0.09	-0.167	2.714	0.597	0.742
Electronics	0.02	0.178	-0.158	0.076	-0.006	2.566	0.58	0.748
Estate	0.014	0.241	-0.21	0.092	0.007	3.041	0.006	0.997
Insurance	0.013	0.393	-0.334	0.108	0.415	5.285	18.225	0.000
Iron	0.005	0.308	-0.364	0.099	-0.384	5.357	18.956	0.000
Logistics	0.011	0.204	-0.217	0.088	0.036	3.198	0.137	0.934
Machinery	0.014	0.228	-0.228	0.089	-0.178	2.998	0.391	0.822
Medicine	0.018	0.123	-0.165	0.07	-0.725	3.083	6.503	0.039
Nonferrous metals	0.011	0.308	-0.297	0.115	-0.138	3.573	1.247	0.536
Paper-making and printing	0.014	0.188	-0.224	0.084	-0.393	3.157	1.982	0.371
Securities	0.013	0.432	-0.414	0.143	0.098	4.41	6.248	0.044
Textile and garment	0.013	0.213	-0.251	0.085	-0.454	3.716	4.122	0.127
Tourism and hotel	0.017	0.182	-0.198	0.079	-0.219	2.995	0.591	0.744
Trade	0.015	0.214	-0.298	0.102	-0.355	3.531	2.423	0.298
Transportation	0.015	0.257	-0.346	0.115	-0.684	3.898	11.374	0.003
Transportation facilities	0.012	0.307	-0.179	0.08	0.497	4.632	11.263	0.004
Water and gas	0.013	0.343	-0.302	0.111	-0.333	3.768	4.387	0.112
Wine and food	0.013	0.228	-0.29	0.09	-0.484	3.922	7.601	0.022
Miscellaneous	0.018	0.235	-0.256	0.095	-0.481	3.604	3.982	0.137
Market return	0.008	0.191	-0.254	0.082	-0.247	3.566	1.743	0.418
ER	0.003	0.031	-0.033	0.014	-0.378	2.807	1.875	0.392

Note: AFFH designates the agriculture, forestry, fishing and husbandry industry. ER indicates the changes in the trade-weighted exchange rate. The sample ranges from November 1996 to February 2015 in AFFH, transportation, transportation facilities, and education and media industries. While the sample for the remaining variables cover the period from August 2006 to February 2015. JB designates the Jarque–Bera test for normality, and the associated p-values are reported in the last column.

Table 2: Unit root tests

	ADF	KPSS		ADF	KPSS
AFFH	-14.75(0)***	0.08(5)	Logistics	-9.34(0)***	0.12(7)
Banking	-8.22(0)***	0.14(7)	Machinery	-4.84(1)***	0.11(7)
Building construction	-10.56(0)***	0.11(7)	Medicine	-10.16(0)***	0.11(7)
Chemical	-9.79(0)***	0.11(7)	Nonferrous metals	-9.40(0)***	0.10(7)
Coal and petrol	-9.57(0)***	0.12(6)	Paper-making and printing	-9.95(0)***	0.08(7)
Commercial chains	-9.21(0)***	0.12(6)	Securities	-10.59(0)***	0.16(5)
Communication	-11.02(0)***	0.11(7)	Textile and garment	-9.93(0)***	0.12(6)
Computer	-10.43(0)***	0.11(7)	Tourism and hotel	-5.33(1)***	0.07(7)
Construction materials	-9.71(0)***	0.14(7)	Trade	-9.87(0)***	0.13(6)
Education and media	-15.27(0)***	0.06(4)	Transportation	-13.66(0)***	0.07(7)
Electricity	-10.37(0)***	0.12(7)	Transportation facilities	-14.63(0)***	0.05(6)
Electronic equipment	-10.50(0)***	0.13(6)	Water and gas	-5.64(1)***	0.08(7)
Electronic information	-10.36(0)***	0.06(6)	Wine and food	-9.77(0)***	0.18(7)
Electronics	-8.80(0)***	0.08(7)	Miscellaneous	-10.71(0)***	0.08(6)
Estate	-8.83(0)***	0.10(7)	Market return	-8.37(1)***	0.05(7)
Insurance	-8.13(0)***	0.22(2)	ER	-10.68(0)***	0.27(3)
Iron	-9.83(0)***	0.14(7)			

Note: Both the ADF test and KPSS test are carried out with the inclusion of intercept. The lag length selection criteria are the Schwarz information Criterion (SIC) and the Newey-West Bandwidth, respectively. The critical values for the ADF test with an intercept restriction are -3.459, -2.874 and -2.573 at the 1%, 5% and 10% levels, respectively. The critical values for the KPSS test with a constant restriction are 0.739, 0.463 and 0.347 at the 1%, 5% and 10% levels, respectively. Numbers in parentheses are lag length. *** suggests the rejection of null hypothesis at the 1% level.

Table 3: Dynamic linear estimation of exchange rate exposure

Var.	SR(-1)	SR(-2)	RM(-1)	RM(-2)	ER(-1)	ER(-2)	Const.	$\bar{R}^2$	DW	χ^2_N	χ^2_{LM}	χ^2_{ARCH}
AFFH	-0.086 (0.113)		0.124 (0.118)		-0.086 (0.432)		0.005 (0.006)	-0.008	1.94	4.759 [.092]	4.937 [.085]	16.653 [.000]
Banking	0.279 (0.188)		-0.134 (0.192)		-0.991 (0.721)		0.014 (0.011)	0.032	1.952	6.092 [.048]	3.227 [.199]	2.285 [.319]
Building construction	-0.215 (0.229)		0.182 (0.246)		0.461 (0.784)		0.012 (0.011)	-0.019	1.981	3.260 [.196]	4.045 [.132]	1.351 [.509]
Chemical	-0.273 (0.190)		0.357 (0.204)		-0.281 (0.763)		0.011 (0.010)	0.004	2.035	2.656 [.265]	4.626 [.099]	5.423 [.066]
Coal and petrol	-0.295 (0.211)		0.416 (0.250)		-1.169 (0.012)		0.013 (0.012)	0.016	2.058	12.643 [.002]	6.199 [.045]	6.800 [.033]
Commercial chains	0.098 (0.170)		-0.524 (0.709)		-0.026 (0.172)		0.011 (0.010)	-0.017	2.011	1.783 [.410]	1.275 [.529]	1.358 [.507]
Communication	-0.397 (0.171)		0.358 (0.170)		0.514 (0.704)		0.008 (0.010)	0.026	1.944	11.882 [.003]	4.103 [.129]	11.656 [.003]
Computer	-0.187 (0.144)		0.200 (0.158)		0.292 (0.791)		0.023 (0.012)	-0.011	1.982	1.284 [.526]	4.187 [.123]	7.728 [.021]
Construction materials	0.075 (0.214)		-0.073 (0.269)		-0.157 (0.905)		0.015 (0.013)	-0.029	2.005	3.155 [.207]	3.823 [.148]	2.397 [.302]
Education and media	-0.059 (0.134)		0.034 (0.117)		0.061 (0.469)		0.010 (0.007)	-0.012	1.941	12.327 [.002]	5.841 [.054]	11.265 [.004]
Electricity	-0.239 (0.193)		0.225 (0.188)		0.461 (0.711)		0.009 (0.010)	-0.013	2.002	3.945 [.139]	4.912 [.086]	8.148 [.017]
Electronic equipment	-0.153 (0.157)		0.135 (0.162)		0.580 (0.738)		0.011 (0.010)	-0.017	2.006	1.840 [.399]	5.764 [.056]	3.334 [.189]
Electronics information	-0.176 (0.159)		0.197 (0.184)		-0.205 (0.829)		0.013 (0.012)	-0.016	1.997	6.973 [.031]	2.433 [.296]	7.801 [.020]
Electronics	0.198 (0.186)		-0.094 (0.188)		-0.130 (0.722)		0.016 (0.011)	-0.013	2.049	3.084 [.214]	4.718 [.095]	5.675 [.059]
Estate	0.411 (0.246)	0.610 (0.241)	-0.410 (0.285)	-0.423 (0.268)	0.642 (0.904)	0.705 (0.907)	0.002 (0.012)	0.055	1.984	0.997 [.307]	3.485 [.175]	3.557 [.169]
Insurance	0.390 (0.217)		-0.540 (0.289)		0.553 (0.949)		0.009 (0.013)	0.021	1.892	11.681 [.003]	4.219 [.121]	3.624 [.163]
Iron	-0.296 (0.267)		0.409 (0.337)		-0.582 (0.910)		0.008 (0.013)	-0.006	2.023	4.267 [.118]	3.748 [.154]	3.077 [.215]
Logistics	-0.003 (0.222)		0.083 (0.251)		-0.054 (0.813)		0.009 (0.012)	-0.026	2.038	5.564 [.062]	6.667 [.036]	1.987 [.370]
Machinery	-0.345 (0.250)		0.424 (0.290)		0.052 (0.832)		0.014 (0.012)	-0.008	1.956	7.733 [.021]	13.116 [.001]	5.534 [.063]
Medicine	-0.152 (0.145)		0.164 (0.140)		-0.660 (0.684)		0.022 (0.010)	-0.002	2.007	2.282 [.320]	2.376 [.305]	9.629 [.008]
Nonferrous metals	0.026 (0.235)		0.041 (0.332)		-0.368 (0.015)		0.010 (0.015)	-0.026	2.028	4.393 [.111]	7.039 [.030]	2.979 [.225]
Paper-making and printing	-0.105 (0.170)		0.143 (0.197)		-0.388 (0.830)		0.011 (0.012)	-0.022	2.017	14.175 [.001]	1.152 [.562]	6.934 [.031]
Securities	-0.090 (0.204)	-0.716 (0.224)	-0.043 (0.335)	1.277 (0.374)	0.454 (1.303)	1.342 (1.196)	0.005 (0.017)	0.086	2.081	4.828 [.089]	4.332 [.115]	8.136 [.017]
Textile and garment	-0.071 (0.174)		0.099 (0.200)		-0.118 (0.830)		0.013 (0.012)	-0.028	1.995	6.661 [.036]	6.217 [.045]	6.562 [.038]
Tourism and hotel	0.103 (0.194)		-0.008 (0.198)		-0.047 (0.744)		0.011 (0.011)	-0.021	2.039	8.465 [.015]	4.560 [.102]	7.720 [.021]
Trade	-0.099 (0.221)		0.159 (0.303)		-0.240 (0.987)		0.017 (0.015)	-0.027	2.009	13.718 [.001]	3.719 [.156]	2.542 [.281]
Transportation	0.066 (0.138)		0.012 (0.152)		-0.018 (0.455)		0.007 (0.007)	-0.008	1.991	20.880 [.000]	8.596 [.014]	5.351 [.069]
Transportation facilities	-0.053 (0.143)		0.073 (0.140)		0.041 (0.405)		0.007 (0.006)	-0.013	1.931	23.913 [.000]	9.230 [.010]	3.342 [.188]
Water and gas	-0.420 (0.204)		0.445 (0.228)		0.374 (0.791)		0.013 (0.012)	0..013	2.000	5.075 [.079]	4.664 [.097]	12.064 [.002]
Wine and food*	-0.317 (0.175)		0.323 (0.156)		-1.194 (0.628)		0.019 (0.009)	0.046	2.076	6.161 [.046]	5.347 [.069]	4.538 [.103]
Miscellaneous	-0.237 (0.174)		0.222 (0.201)		-0.373 (0.822)		0.017 (0.012)	-0.009	1.972	7.358 [.025]	2.420 [.298]	7.572 [.023]

Notes: The dynamic linear estimation of exchange rate exposure is carried out by industry according to equation (2). The lag length selection of each unrestricted VAR model is determined by the information criterion. SR, RM, ER indicate the stock returns, market returns and exchange rate changes, respectively. AIC designates the Akaike information criterion. DW is the Durbin-Watson statistic. χ^2_N, χ^2_{LM} and χ^2_{ARCH} denote the test of normality, autocorrelation, ARCH effects of error terms, respectively. Standard errors are reported in parentheses. Numbers in square brackets are p-values.

Table 4: Dynamic asymmetric modelling of exchange rate exposure

Var.	AFFH	Banking	Building construction	Chemical	Coal and petrol	Commercial chains	Communication	Computer	Construction materials	Education and media
SR_{t-1}	-0.955	-1.006	-1.110	-0.876	-1.029	-1.015	-1.671	-1.117	-0.812	-1.080
	(0.069)	(0.097)	(0.095)	(0.106)	(0.106)	(0.100)	(0.214)	(0.103)	(0.105)	(0.069)
RM_{t-1}^{+}	0.943	0.804	0.935	0.920	1.016	0.936	2.169	1.195	0.899	0.868
	(0.089)	(0.114)	(0.121)	(0.130)	(0.142)	(0.131)	(0.290)	(0.171)	(0.154)	(0.098)
RM_{t-1}^{-}	0.934	0.891	1.039	0.872	1.001	0.819	2.055	1.035	0.851	0.839
	(0.0872)	(0.115)	(0.121)	(0.117)	(0.133)	(0.115)	(0.274)	(0.149)	(0.140)	(0.094)
ER_{t-1}^{+}	0.043	-0.079	1.467	-0.080	-0.923	-0.790	1.145	0.487	-0.583	0.290
	(0.338)	(0.422)	(0.420)	(0.535)	(0.536)	(0.528)	(0.687)	(0.707)	(0.535)	(0.397)
ER_{t-1}^{-}	0.108	-0.813	0.545	0.309	-0.754	0.210	1.768	1.754	-0.235	0.498
	(0.337)	(0.411)	(0.402)	(0.538)	(0.555)	(0.530)	(0.667)	(0.725)	(0.511)	(0.393)
ΔSR_{t-i}	0.134	0.184	0.139				0.340		0.066	0.088
	(0.054)	(0.048)	(0.050)				(0.178)		(0.032)	(0.033)
ΔRM_{t-1}^{+}	0.974	0.556	1.036	1.086	0.910	0.907	1.179	0.888	1.369	0.910
	(0.072)	(0.081)	(0.081)	(0.108)	(0.109)	(0.106)	(0.162)	(0.147)	(0.100)	(0.084)
ΔRM_{t-1}^{-}	0.702	1.057	0.903	0.824	1.049	0.668	0.599	0.705	0.885	0.749
	(0.065)	(0.074)	(0.071)	(0.088)	(0.086)	(0.087)	(0.118)	(0.116)	(0.060)	(0.076)
ΔER_{t-1}^{+}	0.098	2.636	0.888	-0.410	0.002	-0.887	3.090	0.798	0.352	-0.306
	(0.520)	(0.655)	(0.635)	(0.830)	(0.831)	(0.809)	(1.111)	(1.100)	(0.718)	(0.618)
ΔER_{t-1}^{-}	0.517	-1.538	-0.434	0.444	-1.034	0.494	-0.473	0.102	-0.056	0.782
	(0.413)	(0.533)	(0.520)	(0.700)	(0.694)	(0.681)	(0.802)	(0.943)	(0.631)	(0.491)
Const.	0.124	-0.068	-0.168	0.227	0.273	0.435	0.037	0.436	0.161	0.150
	(0.019)	(0.101)	(0.098)	(0.125)	(0.140)	(0.130)	(0.211)	(0.171)	(0.119)	(0.022)
L_{ER}^{+}	0.045	-0.078	1.322	-0.091	-0.897	-0.778	0.685	0.436	-7.18	0.269
	(0.354)	(0.420)	(0.377)	(0.610)	(0.517)	(.519)	(0.431)	(0.633)	(0.662)	(0.367)
L_{ER}^{-}	-0.113	0.809	-0.491	-0.352	0.733	-0.207	-1.058	-1.570	0.289	-0.461
	(0.352)	(0.406)	(0.359)	(0.619)	(0.524)	(0.522)	(0.418)	(0.647)	(.636)	(0.363)
$\bar{R}^2$	0.835	0.910	0.934	0.861	0.890	0.835	0.891	0.779	0.933	0.799
χ_N^2	22.76	1.587	2.971	3.114	7.479	0.704	1.335	2.72	0.226	9.964
	[.000]	[.452]	[0.226]	[.211]	[.024]	[.704]	[.513]	[.257]	[.893]	[.007]
χ_{LM}^2	0.105	0.000	0.025	2.431	0.251	0.316	0.082	0.497	0.467	0.057
	[.746]	[.984]	[.875]	[.119]	[.617]	[.574]	[.775]	[.481]	[.494]	[.811]
χ_{ARCH}^2	8.533	0.740	1.294	0.062	0.677	0.451	0.906	0.303	0.205	2.009
	[.004]	[.390]	[.255]	[.803]	[.411]	[.502]	[.341]	[.582]	[.651]	[.156]
F_{pss}	45.45	22.45	29.72	18.23	21.90	22.04	18.35	23.96	14.37	41.79
	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]
W_{LR}^{RM}	0.74	4.89	8.01	1.05	0.08	6.16	3.20	6.27	1.02	4.71
	[.391]	[.030]	[.006]	[.308]	[.772]	[.015]	[.079]	[.014]	[.316]	[.031]
W_{SR}^{RM}	7.02	16.64	1.24	2.89	0.81	2.53	6.86	0.78	10.90	1.78
	[.009]	[.000]	[.268]	[.093]	[.370]	[.115]	[.012]	[.379]	[.002]	[.173]
W_{LR}^{ER}	0.73	4.90	8.80	0.94	0.15	6.15	1.29	5.50	0.82	5.11
	[.394]	[.030]	[.004]	[.334]	[.702]	[.015]	[.261]	[.021]	[.369]	[.025]
W_{SR}^{ER}	0.31	18.55	1.94	0.47	0.70	1.30	4.88	0.18	0.14	1.49
	[.580]	[.000]	[.167]	[.493]	[.405]	[.257]	[.032]	[.676]	[.707]	[.223]

Notes: The dynamic asymmetric estimations of exchange rate exposure are carried out by industry based on the NARDL framework, see equation (8). The lag length selection for the NARDL model is the general–to-specific approach (starting from 12 lags). The table above only reports the long run parameters (SR_{t-1}, RM_{t-1}^{+},RM_{t-1}^{-}, ER_{t-1}^{+}, ER_{t-1}^{-}) and the first-order short run parameters (ΔRM_{t-1}^{+}, ΔRM_{t-1}^{-}, ΔER_{t-1}^{+}, ΔER_{t-1}^{-}) for market returns and exchange rate changes, as well as the first significant short run parameters for stock returns (ΔSR_{t-i}). The remaining short run parameters are not represented in this table to save space. L_{ER}^{+} and L_{ER}^{-} are the long run and short run coefficients of exchange rate exposure, respectively. The long run and short run coefficients for market returns are not reported here since we are particularly interested in the exchange rate exposure. χ_N^2, χ_{LM}^2 and χ_{ARCH}^2 denote the diagnostics for normality, serial correlation and heteroscedasticity, respectively. F_{PSS} designates the PSS F-statistic testing the null hypothesis $\rho = \theta^{+} = \theta^{-} = \gamma^{+} = \gamma^{-} = 0$. W_{LR}^{RM} and W_{SR}^{RM} are the test for long run and short run asymmetries of market returns, respectively. W_{LR}^{ER} and W_{SR}^{ER} are the test for long run and short run asymmetries of exchange rate exposure, respectively. Numbers in parentheses are the associated standard errors. Numbers in square brackets are p-values.

Table 4 continued

Var.	Electricity	Electronic equipment	Electronic information	Electronics	Estate	Insurance	Iron	Logistics	Machinery	Medicine	Nonferrous metals
SR_{t-1}	-1.087	-0.942	-1.039	-1.531	-1.220	-0.727	-0.955	-1.728	-1.303	-1.451	-0.860
	(0.103)	(0.102)	(0.108)	(0.185)	(0.089)	(0.114)	(0.097)	(0.204)	(0.107)	(0.183)	(0.111)
RM_{t-1}^{+}	0.743	0.884	1.129	1.781	1.236	0.576	0.994	2.003	1.464	1.072	1.101
	(0.117)	(0.134)	(0.160)	(0.231)	(0.127)	(0.186)	(0.127)	(0.254)	(0.144)	(0.146)	(0.168)
RM_{t-1}^{-}	0.793	0.777	0.979	1.597	1.246	0.655	1.019	2.037	1.329	0.892	1.074
	(0.110)	(0.116)	(0.136)	(0.209)	(0.122)	(0.187)	(0.124)	(0.251)	(0.131)	(0.134)	(0.160)
ER_{t-1}^{+}	1.377	0.400	-0.457	-1.057	0.073	0.716	0.757	1.183	-0.127	-2.029	0.344
	(0.484)	(0.562)	(0.696)	(0.489)	(0.403)	(0.663)	(0.424)	(0.401)	(0.483)	(0.588)	(0.574)
ER_{t-1}^{-}	0.960	1.279	0.740	0.464	-0.074	0.018	0.568	0.857	0.932	-0.518	0.607
	(0.480)	(0.567)	(0.696)	(0.519)	(0.401)	(0.716)	(0.422)	(0.447)	(0.434)	(0.603)	(0.579)
ΔSR_{t-i}				0.495	0.087	-0.360		0.686	-0.126	0.403	0.059
				(0.158)	(0.032)	(0.112)		(0.167)	(0.037)	(0.151)	(0.033)
ΔRM_{t-1}^{+}	0.712	1.078	1.121	1.148	1.004	0.893	0.970	1.076	1.140	0.820	1.253
	(0.095)	(0.113)	(0.138)	(0.096)	(0.084)	(0.130)	(0.082)	(0.088)	(0.092)	(0.119)	(0.114)
ΔRM_{t-1}^{-}	0.900	0.599	0.812	0.633	1.015	1.268	1.296	1.094	0.996	0.442	1.332
	(0.078)	(0.099)	(0.113)	(0.080)	(0.071)	(0.117)	(0.068)	(0.073)	(0.077)	(0.099)	(0.095)
ΔER_{t-1}^{+}	0.741	-0.220	-0.196	0.136	-0.236	0.142	1.643	1.705	0.985	-1.306	-1.078
	(0.748)	(0.882)	(1.075)	(0.691)	(0.609)	(1.088)	(0.645)	(0.623)	(0.678)	(0.924)	(0.891)
ΔER_{t-1}^{-}	0.712	0.523	0.368	-0.049	-1.287	-1.611	0.152	-1.014	-0.473	0.901	1.100
	(0.628)	(0.759)	(0.917)	(0.618)	(0.520)	(0.970)	(0.539)	(0.511)	(0.565)	(0.728)	(0.816)
Const.	0.007	0.322	0.408	0.650	0.070	-0.131	0.126	0.152	0.401	0.581	0.288
	(0.115)	(0.137)	(0.165)	(0.153)	(0.092)	(0.151)	(0.099)	(0.137)	(0.127)	(0.148)	(0.133)
L_{ER}^{+}	1.266	0.425	-0.440	-0.690	0.059	0.985	0.792	0.684	-0.098	-1.398	0.400
	(0.442)	(0.600)	(0.666)	(0.308)	(0.331)	(0.903)	(0.439)	(0.225)	(0.371)	(0.422)	(0.675)
L_{ER}^{-}	-0.883	-1.358	-0.713	-0.303	0.061	-0.024	-0.595	-0.496	-0.716	0.357	-0.707
	(0.445)	(0.609)	(0.673)	(0.341)	(0.328)	(.984)	(0.445)	(0.254)	(0.325)	(0.413)	(0.693)
$\bar{R}^2$	0.870	0.840	0.808	0.890	0.936	0.888	0.939	0.940	0.950	0.846	0.906
χ_N^2	3.194	1.319	3.663	13.92	1.669	3.337	3.058	2.257	1.458	1.81	2.444
	[.203]	[.517]	[.160]	[.000]	[0.434]	[.189]	[.217]	[.324]	[.483]	[.405]	[.295]
χ_{LM}^2	0.019	0.289	0.120	2.577	0.428	1.865	0.745	0.039	0.759	4.805	0.523
	[.889]	[.591]	[.729]	[.108]	[0.513]	[.172]	[.388]	[.844]	[.384]	[.028]	[.470]
χ_{ARCH}^2	3.269	0.281	3.452	0.017	0.053	0.007	0.220	1.767	0.553	0.350	1.575
	[.071]	[.596]	[.063]	[.898]	[0.818]	[.933]	[.639]	[.184]	[.457]	[.554]	[.210]
F_{pss}	23.81	19.49	21.41	17.09	37.68	6.09	22.33	17.94	35.19	20.86	15.17
	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]
W_{LR}^{RM}	1.30	4.45	5.90	13.55	0.08	1.55	0.45	0.63	9.30	11.73	0.27
	[.258]	[.038]	[.017]	[.000]	[.775]	[.219]	[.503]	[.430]	[.003]	[.000]	[.602]
W_{SR}^{RM}	1.92	8.14	2.43	13.87	0.01	4.26	7.64	0.02	1.22	4.85	0.23
	[.169]	[.005]	[.123]	[.000]	[.928]	[.044]	[.007]	[.886]	[.275]	[.031]	[.633]
W_{LR}^{ER}	1.27	4.13	5.19	12.64	0.24	1.85	0.35	0.76	8.01	11.47	0.38
	[.262]	[.045]	[.025]	[.001]	[.627]	[.179]	[.554]	[.386]	[.006]	[.001]	[.540]
W_{SR}^{ER}	0.00	0.31	0.12	0.03	1.30	1.11	2.39	8.62	1.97	2.74	2.54
	[.979]	[.580]	[.729]	[.862]	[.258]	[.297]	[.126]	[.004]	[.166]	[.102]	[.115]

Notes: The dynamic asymmetric estimations of exchange rate exposure are carried out by industry based on the NARDL framework, see equation (8). The lag length selection for the NARDL model is the general–to-specific approach (starting from 12 lags). The table above only reports the long run parameters (SR_{t-1}, RM_{t-1}^{+},RM_{t-1}^{-}, ER_{t-1}^{+}, ER_{t-1}^{-}) and the first-order short run parameters (ΔRM_{t-1}^{+}, ΔRM_{t-1}^{-}, ΔER_{t-1}^{+}, ΔER_{t-1}^{-}) for market returns and exchange rate changes, as well as the first significant short run parameters for stock returns (ΔSR_{t-i}). The remaining short run parameters are not represented in this table to save space. L_{ER}^{+} and L_{ER}^{-} are the long run and short run coefficients of exchange rate exposure, respectively. The long run and short run coefficients for market returns are not reported here since we are particularly interested in the exchange rate exposure. χ_N^2, χ_{LM}^2 and χ_{ARCH}^2 denote the diagnostics for normality, serial correlation and heteroscedasticity, respectively. F_{PSS} designates the PSS F-statistic testing the null hypothesis $\rho = \theta^{+} = \theta^{-} = \lambda^{+} = \lambda^{-} = 0$. W_{LR}^{RM} and W_{SR}^{RM} are the test for long run and short run asymmetries of market returns, respectively. W_{LR}^{ER} and W_{SR}^{ER} are the test for long run and short run asymmetries of exchange rate exposure, respectively. Numbers in parentheses are the associated standard errors. Numbers in square brackets are p-values.

Table 4 continued

Var.	Paper-making and printing	Securities	Textile and garment	Trade	Transportation	Transportation facilities	Water and gas	Wine and food	Miscellaneous
SR_{t-1}	-1.031	-1.015	-1.008	-1.238	-0.939	-0.920	-1.972	-1.112	-1.195
	(0.100)	(0.117)	(0.106)	(0.143)	(0.072)	(0.070)	(0.252)	(0.096)	(0.107)
RM^+_{t-1}	1.199	1.212	0.988	1.484	0.830	0.801	2.076	1.046	1.318
	(0.164)	(0.219)	(0.150)	(0.175)	(0.100)	(0.074)	(0.271)	(0.132)	(0.157)
RM^-_{t-1}	1.081	1.347	0.938	1.389	0.819	0.784	1.936	0.969	1.132
	(0.139)	(0.216)	(0.135)	(0.161)	(0.098)	(0.073)	(0.254)	(0.117)	(0.139)
ER^+_{t-1}	-0.125	0.998	0.420	0.702	0.072	0.242	-0.253	-0.895	-1.063
	(0.624)	(0.808)	(0.623)	(0.606)	(0.297)	(0.251)	(0.504)	(0.457)	(0.629)
ER^-_{t-1}	0.820	-0.120	0.985	1.618	0.139	0.360	0.899	-0.218	0.443
	(0.649)	(0.764)	(0.641)	(0.663)	(0.295)	(0.248)	(0.554)	(0.499)	(0.621)
ΔSR_{t-i}			0.098	0.206	-0.121	0.062	0.782	-0.184	-0.091
			(0.054)	(0.100)	(0.066)	(0.037)	(0.206)	(0.079)	(0.052)
ΔRM^+_{t-1}	1.130	1.387	0.957	1.274	0.983	0.875	1.025	0.710	1.189
	(0.128)	(0.165)	(0.129)	(0.112)	(0.071)	(0.052)	(0.108)	(0.097)	(0.121)
ΔRM^-_{t-1}	0.840	1.458	0.984	1.300	0.886	0.869	0.868	0.683	0.841
	(0.105)	(0.142)	(0.106)	(0.095)	(0.057)	(0.047)	(0.085)	(0.082)	(0.105)
ΔER^+_{t-1}	0.870	2.236	0.408	-1.020	0.329	0.569	-1.129	0.391	-0.079
	(0.973)	(1.199)	(0.978)	(0.857)	(0.467)	(0.395)	(0.822)	(0.675)	(0.969)
ΔER^-_{t-1}	-0.251	-0.479	-0.401	1.049	0.120	-0.053	-0.161	-1.568	-0.180
	(0.821)	(1.019)	(0.829)	(0.751)	(0.373)	(0.309)	(0.653)	(0.586)	(0.853)
Const.	0.370	-0.076	0.360	0.629	0.111	0.131	0.635	0.360	0.535
	(0.164)	(0.174)	(0.153)	(0.159)	(0.020)	(0.015)	(0.169)	(0.141)	(0.148)
L^+_{ER}	-0.121	0.983	0.416	0.567	0.077	0.264	-0.128	-0.805	-0.890
	(0.606)	(0.769)	(0.620)	(0.494)	(0.317)	(0.274)	(0.255)	(0.407)	(0.524)
L^-_{ER}	-0.795	0.118	-0.977	-1.308	-0.149	-0.391	-0.456	0.196	-0.371
	(0.632)	(0.756)	(0.643)	(0.564)	(0.315)	(0.271)	(0.285)	(0.446)	(0.519)
$\bar{R}^2$	0.838	0.895	0.847	0.918	0.883	0.880	0.920	0.908	0.873
χ^2_N	7.35	41.85	1.012	5.884	33.67	494.2	1.048	1.29	19.08
	[.025]	[.000]	[.135]	[.053]	[.000]	[.000]	[.592]	[.525]	[.000]
χ^2_{LM}	0.074	0.381	0.091	0.036	0.000	0.774	5.329	4.838	0.001
	[.785]	[.537]	[.763]	[.850]	[.986]	[.379]	[.021]	[.028]	[.971]
χ^2_{ARCH}	0.772	0.093	8.173	2.685	11.044	0.000	0.122	0.668	0.390
	[.380]	[.761]	[.004]	[.101]	[.001]	[.998]	[.727]	[.414]	[.532]
F_{pss}	24.53	14.71	19.87	22.47	31.23	40.14	16.27	30.24	27.22
	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]	[.000]
W^{RM}_{LR}	3.85	3.56	1.19	2.82	1.36	4.41	7.03	2.78	9.96
	[.053]	[.063]	[.278]	[.097]	[.244]	[.037]	[.001]	[.101]	[.002]
W^{RM}_{SR}	2.38	0.08	0.02	0.02	1.00	0.01	1.11	0.04	3.81
	[.126]	[.784]	[.888]	[.875]	[.318]	[.942]	[.296]	[.845]	[.055]
W^{ER}_{LR}	3.38	3.55	1.42	3.63	1.04	4.61	6.37	2.87	9.41
	[.069]	[.063]	[.236]	[.060]	[.310]	[.033]	[.014]	[.096]	[.003]
W^{ER}_{SR}	0.59	2.31	0.31	2.45	0.10	1.19	0.67	3.68	0.00
	[.443]	[.133]	[.581]	[.121]	[.758]	[.276]	[.416]	[.060]	[.947]

Notes: The dynamic asymmetric estimations of exchange rate exposure are carried out by industry based on the NARDL framework, see equation (8). The lag length selection for the NARDL model is the general–to-specific approach (starting from 12 lags). The table above only reports the long run parameters (SR_{t-1}, RM^+_{t-1},RM^-_{t-1}, ER^+_{t-1}, ER^-_{t-1}) and the first-order short run parameters (ΔRM^+_{t-1}, ΔRM^-_{t-1}, ΔER^+_{t-1}, ΔER^-_{t-1}) for market returns and exchange rate changes, as well as the first significant short run parameters for stock returns (ΔSR_{t-i}). The remaining short run parameters are not represented in this table to save space. L^+_{ER} and L^-_{ER} are the long run and short run coefficients of exchange rate exposure, respectively. The long run and short run coefficients for market returns are not reported here since we are particularly interested in the exchange rate exposure. χ^2_N, χ^2_{LM} and χ^2_{ARCH} denote the diagnostics for normality, serial correlation and heteroscedasticity, respectively. F_{PSS} designates the PSS F-statistic testing the null hypothesis $\rho = \theta^+ = \theta^- = \lambda^+ = \lambda^- = 0$. W^{RM}_{LR} and W^{RM}_{SR} are the test for long run and short run asymmetries of market returns, respectively. W^{ER}_{LR} and W^{ER}_{SR} are the test for long run and short run asymmetries of exchange rate exposure, respectively. Numbers in parentheses are the associated standard errors. Numbers in square brackets are p-values.

Table 5: Asymmetric exchange rate exposure of industry returns: evidence from unexpected exchange rate changes

Industries	F_{PSS}	L_{ER}^{+}	L_{ER}^{-}	W_{LR}^{ER}	W_{SR}^{ER}
AFFH	44.45[.000]***	0.002[.673]	-0.003[.447]	1.32[.253]	0.56[.450]
Banking	33.58[.000]***	0.000[.972]	0.000 [.962]	0.01[.904]	26.08[.000]***
Building construction	35.01[.000]***	0.011[.002]***	-0.005[.163]	8.16[.005]***	2.13[.148]
Chemical	20.30[.000]***	0.000 [.995]	-0.003[.632]	0.63[.430]	0.27[.605]
Coal and petrol	24.56[.000]***	-0.006[.205]	0.008[.104]	0.51[.475]	0.53[.469]
Commercial chains	24.82[.000]***	-0.005[.294]	-0.001[.805]	4.09[.046]**	0.84[.361]
Communication	28.00[.000]***	0.007[.152]	-0.009[.068]*	0.62[.432]	0.19[.662]
Computer	26.25[.000]***	0.006[.318]	-0.012[.080]*	1.83[.179]	0.18[.674]
Construction materials	15.50[.000]***	-0.000[.977]	-0.004[.422]	1.32[.255]	1.73[.193]
Education and media	57.53[.000]***	0.003[.456]	-0.006[.136]	6.26[.013]**	1.22[.271]
Electricity	26.64[.000]***	0.010[.014]**	-0.008[.073]*	0.85[.359]	0.01[.929]
Electronic equipment	24.75[.000]***	0.006[.242]	-0.010[.071]*	1.41[.239]	0.00[.960]
Electronic information	24.43[.000]***	-0.002[.792]	-0.008[.209]	6.18[.015]**	0.02[.884]
Electronics	15.18[.000]***	-0.005[.131]	-0.002[.594]	7.87[.006]***	0.15[.699]
Estate	41.90[.000]***	0.000[.883]	0.002[.660]	0.92[.339]	1.31[.255]
Insurance	57.22[.000]***	0.008[.248]	0.000[.978]	2.28[.136]	3.34[.072]*
Iron	24.69[.000]***	0.006[.163]	-0.004[.361]	0.42[.518]	2.03[.157]
Logistics	24.44[.000]***	0.008[.000]***	-0.003[.094]*	8.21[.006]***	9.46[.003]***
Machinery	29.03[.000]***	0.004[.236]	-0.006[.143]	0.33[.567]	0.09[.769]
Medicine	23.28[.000]***	-0.004[.484]	-0.001[.827]	4.75[.032]**	2.11[.150]
Nonferrous metals	15.16[.000]***	-0.005[.418]	0.000[.911]	1.34[.250]	0.33[.566]
Paper-making and printing	27.52[.000]***	0.000[.941]	-0.007[.245]	2.95[.090]*	0.73[.394]
Securities	17.71[.000]***	0.009[.220]	0.000[.978]	3.56[.063]*	3.97[.050]**
Textile and garment	19.78[.000]***	0.001[.856]	-0.003[.668]	0.18[.670]	0.14[.713]
Tourism and hotel	26.46[.000]***	-0.003[.519]	-0.001[.800]	2.01[.160]	0.06[.805]
Trade	23.92[.000]***	0.004[.236]	-0.007[.111]	1.03[.313]	0.54[.466]
Transportation	47.19[.000]***	-0.000[.901]	-0.001[.668]	3.97[.048]***	0.27[.601]
Transportation facilities	44.20[.000]***	0.002[.428]	-0.003[.237]	1.97[.162]	0.62[.431]
Water and gas	13.18[.000]***	0.004[.135]	-0.009[.015]**	3.39[.069]*	0.08[.775]
Wine and food	29.46[.000]***	-0.010[.012]**	0.010[.015]**	0.00[.986]	0.08[.774]
Miscellaneous	27.45[.000]***	-0.004[.450]	-0.003[.558]	4.53[.036]**	0.01[.934]

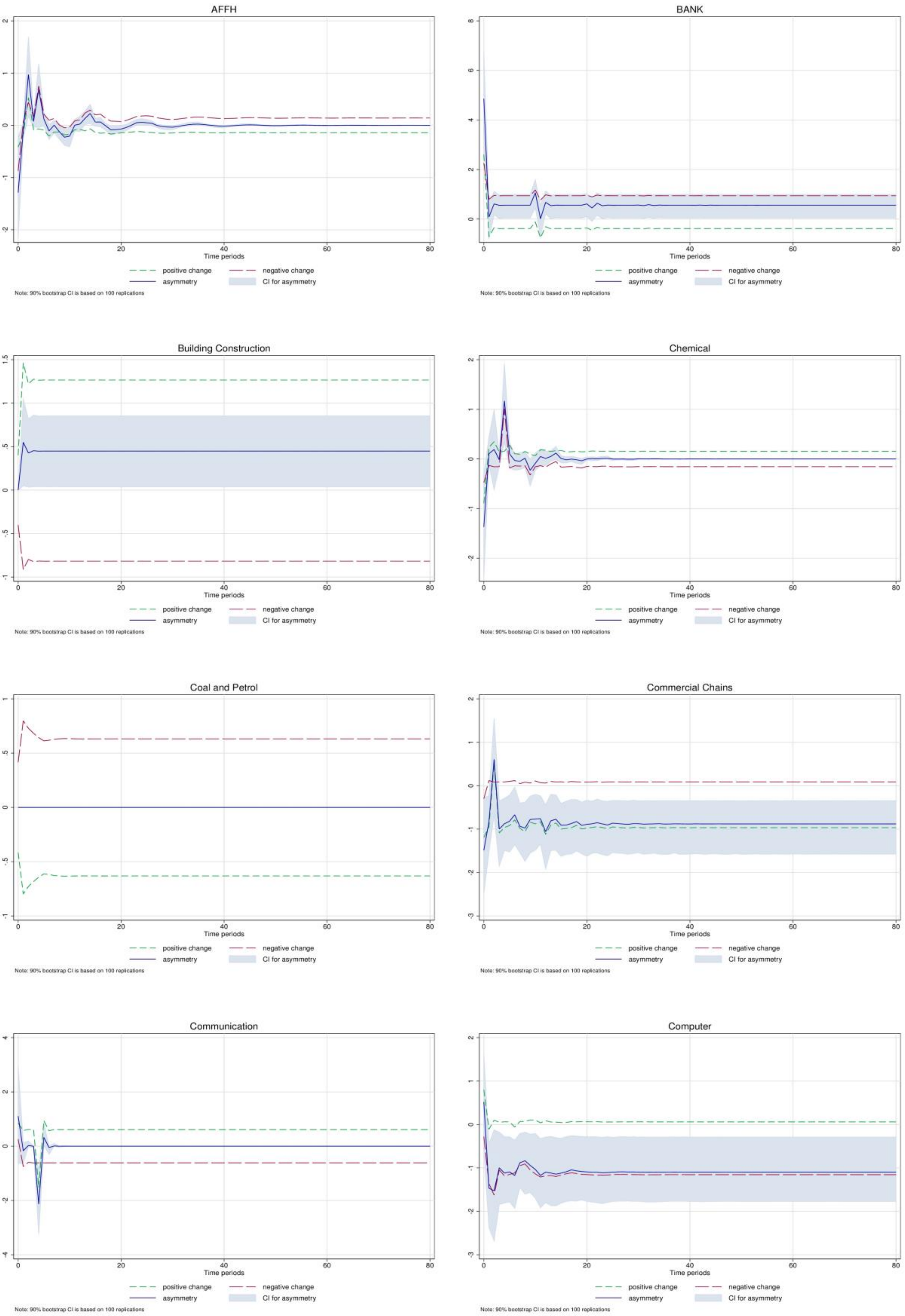
Note: This table reports the asymmetric exchange rate exposure of industry returns based on equation (8). Different from Table 4, unanticipated changes in the exchange rate are calculated from equation (11). Only the PSS statistics, asymmetric long run coefficients, long run and short run asymmetry test statistics are reported. Other parameters are not reported for saving space. F_{PSS} designates the PSS F-statistic testing the null hypothesis $\rho = \theta^{+} = \theta^{-} = \lambda^{+} = \lambda^{-} = 0$. W_{LR}^{ER} and W_{SR}^{ER} are the test for long run and short run asymmetries of exchange rate exposure, respectively. Numbers in square brackets are p-values.

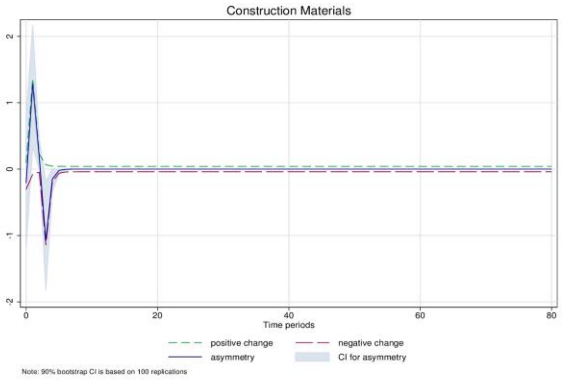
Table 6: Asymmetric exchange rate exposure of industry returns: evidence from the cyclical component of exchange rate changes

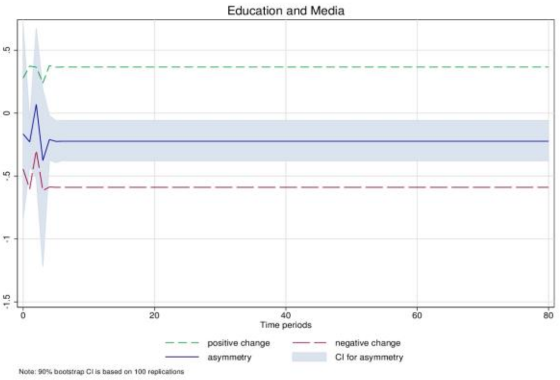
Industries	F_{PSS}	L_{ER}^{+}	L_{ER}^{-}	W_{LR}^{ER}	W_{SR}^{ER}
AFFH	42.65[.000]***	-0.003[.106]	-0.000[.945]	3.31[.070] *	0.25[.620]
Banking	32.53[.000] ***	-0.003[.355]	0.004[.043] **	0.12[.728]	0.30[.586]
Building construction	249.78[.000] ***	0.002[.295]	0.007[.000] ***	20.38[.000] ***	1.43[.237]
Chemical	22.39[.000] ***	-0.004[.268]	-0.001[.718]	1.51[.222]	0.23[.632]
Coal and petrol	30.09[.000] ***	-0.003[.393]	0.000[.952]	0.58[.449]	0.16[.689]
Commercial chains	34.11[.000] ***	0.015[.000] ***	-0.013[.000] ***	0.19[.664]	0.94[.337]
Communication	27.51[.000] ***	0.000[.937]	-0.002[.293]	0.29[.592]	0.66[.417]
Computer	27.08[.000]***	0.003[.470]	-0.006[.037] ***	0.33[.565]	0.08[.781]
Construction materials	19.72[.000]***	-0.005[.144]	-0.001[.664]	2.41[.124]	1.93[.168]
Education and media	61.87[.000] ***	-0.002[.365]	-0.002[.105]	5.57[.019] **	0.06[.813]
Electricity	26.41[.000] ***	0.001[.762]	0.001[.592]	0.34[.564]	0.52[.473]
Electronic equipment	23.90[.000] ***	0.001[.860]	-0.003[.153]	0.45[.504]	0.38[.537]
Electronic information	23.67[.000] ***	-0.001[.765]	-0.005[.066] *	1.78[.185]	0.99[.323]
Electronics	25.67[.000] ***	0.003[.449]	-0.005[.024] **	0.38[.538]	0.56[.456]
Estate	42.45[.000] ***	0.002[.268]	-0.001[.706]	0.63[.429]	0.97[.327]
Insurance	15.51[.000] ***	0.012[.006] ***	0.001[.636]	8.47[.005] ***	0.40[.531]
Iron	11.39[.000] ***	0.002[.057] *	0.003[.003] ***	8.57[.005] ***	0.58[.449]
Logistics	14.91[.000] ***	-0.003[.348]	-0.002[.291]	1.96[.166]	2.13[.149]
Machinery	28.09[.000] ***	-0.002[.352]	0.000[.979]	0.70[.407]	0.02[.902]
Medicine	21.90[.000] ***	-0.003[.511]	0.000[.906]	0.27[.605]	1.22[.273]
Nonferrous metals	24.78[.000] ***	-0.002[.477]	-0.001[.632]	0.92[.341]	0.01[.919]
Paper-making and printing	29.21[.000] ***	-0.004[.256]	-0.001[.749]	1.36[.248]	0.14[.707]
Securities	19.16[.000] ***	-0.003[.494]	0.005[.102]	0.14[.710]	0.00[.980]
Textile and garment	25.99[.000] ***	0.007[.091] *	-0.005[.219]	0.19[.663]	0.88[.352]
Tourism and hotel	27.77[.000] ***	-0.000[.889]	-0.006[.005] ***	3.07[.084] *	0.55[.461]
Trade	25.61[.000] ***	-0.001[.791]	-0.003[.125]	1.32[.253]	2.12[.149]
Transportation	51.80[.000] ***	0.001[.377]	-0.003[.006] ***	2.08[.151]	0.00[.986]
Transportation facilities	43.21[.000] ***	-0.000[.789]	-0.001[.258]	1.76[.186]	0.03[.857]
Water and gas	14.77[.000] ***	-0.001[.664]	-0.003[.014] **	3.21[.077] *	0.02[.877]
Wine and food	32.55[.000] ***	-0.003[.304]	0.005[.009] ***	0.51[.477]	1.52[.221]
Miscellaneous	27.10[.000] ***	-0.005[.198]	-0.002[.305]	3.02[.085] *	0.04[.833]

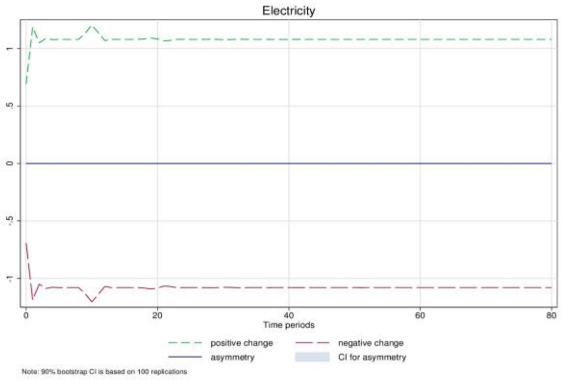
Note: This table reports the asymmetric exchange rate exposure of industry returns based on equation (8). Different from Table 4, unanticipated changes in the exchange rate are calculated from equation (12). Only the PSS statistics, asymmetric long run coefficients, long run and short run asymmetry test statistics are reported. Other parameters are not reported for saving space. F_{PSS} designates the PSS F-statistic testing the null hypothesis $\rho = \theta^{+} = \theta^{-} = \lambda^{+} = \lambda^{-} = 0$. W_{LR}^{ER} and W_{SR}^{ER} are the test for long run and short run asymmetries of exchange rate exposure, respectively. Numbers in square brackets are p-values.

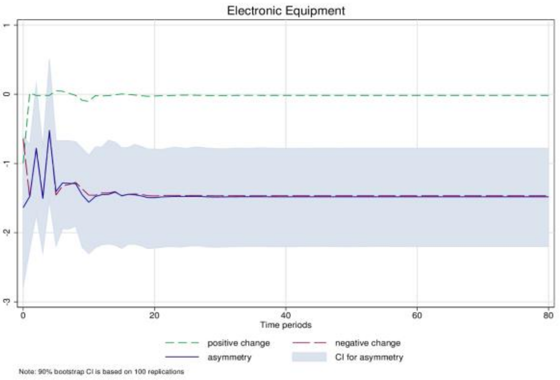
Figure 3: Dynamic multipliers for asymmetric exchange rate exposure of industry returns

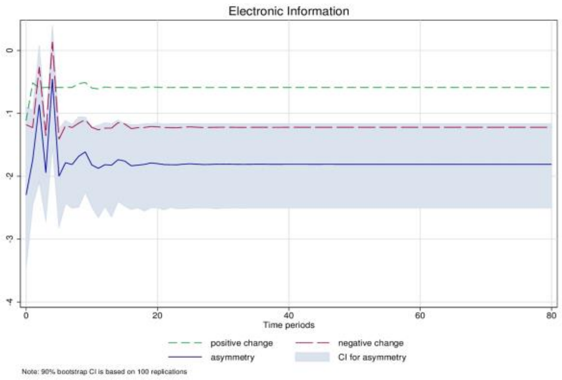


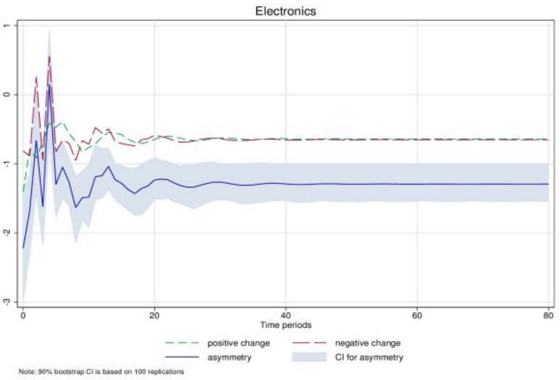

Construction Materials
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications

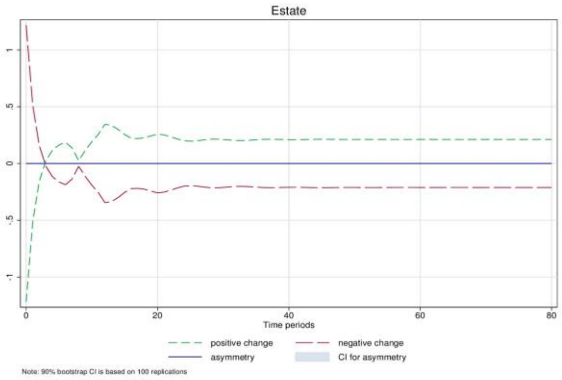

Education and Media
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications

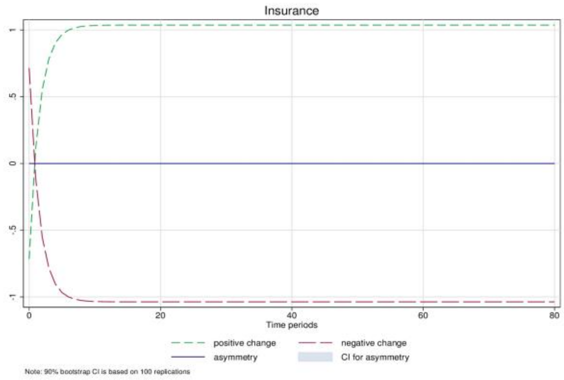

Electricity
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications

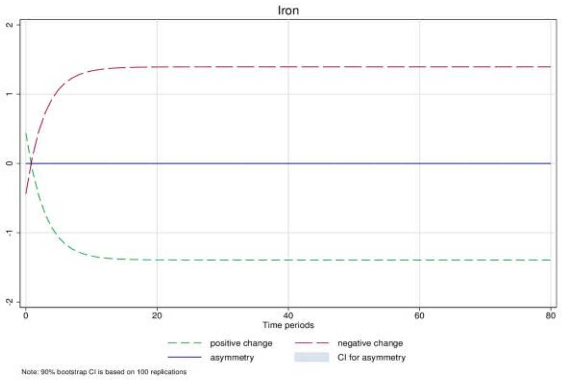

Electronic Equipment
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications


Electronic Information
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications


Electronics
Time periods
positive change
negative change
asymmetry
CI for asymmetry
Note: 90% bootstrap CI is based on 100 replications

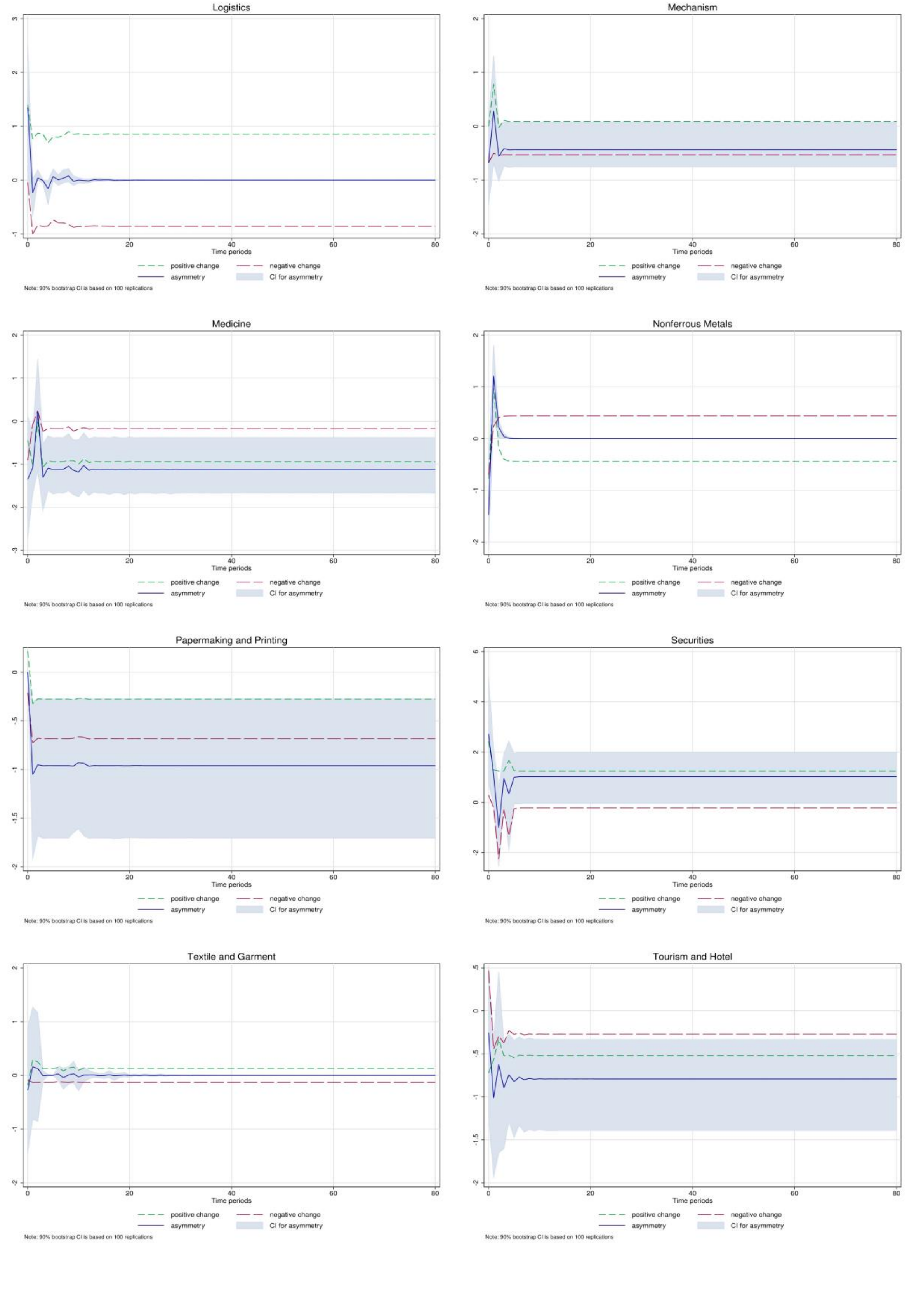


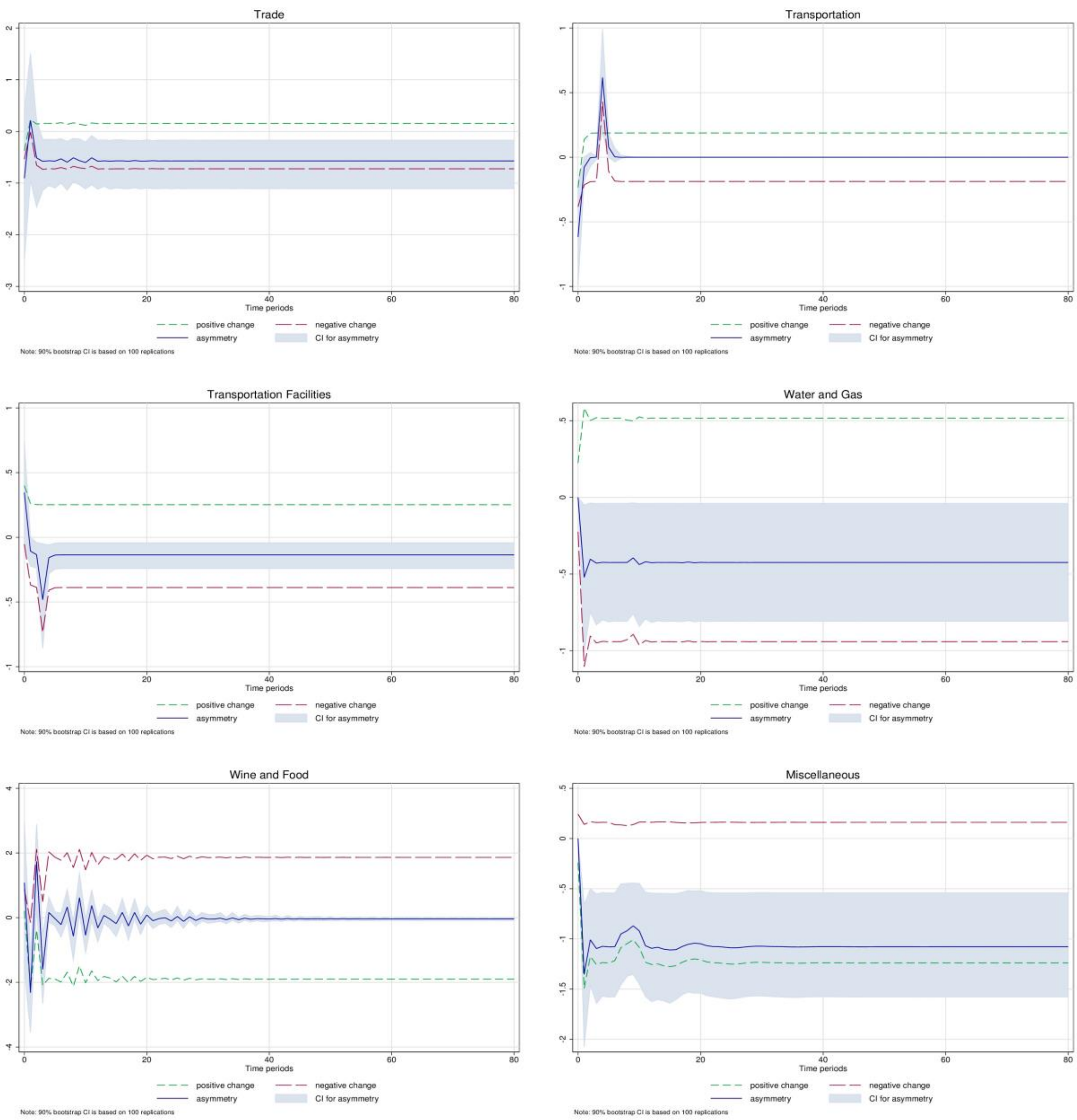




Note**:** These graphs above give the cumulative effects of positive and negative output shocks on industry returns. Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the identified asymmetries in Table 4.

Figure 3 continued





Note: These graphs above give the cumulative effects of positive and negative output shocks on industry returns. Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the identified asymmetries in Table 4.