# Relationships between exchange rates, economic growth and FDI in China: An empirical study based on the TVP-VAR model

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**Abstract**

This paper investigates the relationships between exchange rates, economic growth and foreign direct investment through a time-variant parameter VAR model using monthly data from China for the period 2001-2016. The focus is on the reaction of economic growth to a shock change in exchange rates or foreign direct investment. The dynamic impulse response function showed that the relationships do not instigate great change. A positive shock in the real exchange rate slows down FDI inflows, with no evidence to support the contractionary devaluation theory in China, which suggests that an increase in the real RMB exchange rate generally causes a negative influence on China's economic growth. The empirical results of this research contradict what intuition suggests and indicates that FDI has generated an ambiguous effect on economic growth in the past few years. Before 2008, shock changes in FDI would cause economic growth to lag for one period. Since then, the lag phenomenon has disappeared due to better regulation and a maturing financial market.

**Keywords:** economic growth, exchange rate, FDI, TVP-VAR model.

## Introduction

Foreign direct investment plays an important role in China's economic growth. In recent times, exchange rate reforms in China have seen increased volatility in the RMB exchange rates and a global downturn in FDI caused by a slow recovery in the global economy. How exchange rates affect economic growth and FDI and how FDI affects economic growth has attracted the attention of many scholars.

A large amount of research has been dedicated to exploring the link between exchange rates and foreign direct investment (FDI), however, the various models and empirical studies have produced mixed conclusions. Most studies suggest that currency

depreciation may have a positive effect on FDI inflows. Cushman (1985) analyzed the relationship between exchange rates and foreign direct investment and put forward the theory that currency depreciation stimulates direct investment subject to the lower costs of locally produced goods. Froot and Stein (1991) established an imperfect capital model and found that the depreciation of the domestic currency would induce foreigners to acquire assets at a relatively cheap price, therefore making foreign direct investment more attractive. Blonigen (1997) argued that real currency depreciation was beneficial to acquisition FDI because it involves the transfer of specific assets which generate returns in currencies. Subsequent studies such as Guo and Trivedi (2002), Lee (2013) re-examined Blonigen's hypothesis by using panel data techniques and confirmed it. Many other articles also show that domestic currency devaluation encourages FDI inflows (see Xing 2006; Takagi and Shi 2011; Desatnicov and Akiba 2016). Nevertheless, contrasting opinions put forward in some previous research implies that there may be another mechanism hidden in this link. Campa (1993) showed that multinational corporations have overseas investments based on expected returns, whereby currency appreciation in the host country generates a positive effect on FDI. Benassy-Quere, et al. (2001) pointed out that exchange rates are a determinant of FDI and that currency appreciation in the host country expands the scale of the market, which promotes the inflow of FDI. Pan, et al. (2010, 2012) showed that RMB exchange rates can effectively attract FDI for the purpose of speculative activities.

Previous studies also generated different conclusions about the relationship between exchange rate and economic growth. The traditional view argues that currency appreciation is contractionary in that it raises the relative price of domestic goods which results in a decrease in exports and aggregate demand, which in turn leads to a decline in economic growth. Wei (2006) built a computational general equilibrium model to analyze how RMB appreciation influences China's economic growth. He found that it had an adverse effect on employment and that a large RMB appreciation was a disadvantage to China's economic growth. The results of a VAR model proposed by Shi (2007) supports this point of view. Simliar results were determined by Zhao (2008). In contrast, after the Mexico and Southeast Asian financial crisis, the contractionary devaluation theory put forward by Krugman and Taylor (1978) gradually began to be explored by scholars. Krugman and Taylor (1978) found that depreciation could lead to a recession, whilst appreciation could stimulate economic growth. They argued that if imports exceed exports, currency depreciation would increase the price of traded goods, thereby reducing real domestic incomes, resulting in shrinking aggregate demand; the reverse was also true, namely that currency appreciation would expand aggregate demand if there was a trade surplus. In their examination of 12 developing countries, Edwards (1986) reported that devaluation generated a decline in aggregate output, which therefore provided support for a short-term contractionary devaluation hypothesis. Acar (2000) used data from 18 countries and built a fixed-effect model, of which the estimated results supported Edwards' conclusion. See also Kamin and Rogers (2000) and Yu (2016) for similar studies. Although the contractionary devaluation phenomenon is often

confirmed for developing contries (Kamin and Klau 1998), An, et al. (2014) found, through a VAR model, that it could also apply to developed countries.

In addition, the research focus on the link between FDI and economic growth is quite rich. Almost all existing studies support the view that FDI inflows contribute to economic growth in the host country. Gregorio (1992), based on data from twelve Latin American countries, found that FDI generates a positive effect on economic growth. Similar conclusions were also drawn in other articles (see Sui and Liu 2014; Pegkas 2015). However, little research shows that the relationship between FDI and economic growth is uncertain. Alfaro, et al. (2004) argued that although FDI was benefical to countries with a well-developed financial market, FDI alone had an ambiguous effect on economic growth. Herzer, et al. (2008) analyzed the limitations of existing studies. Their cointegration analysis of 28 developing countries indicated that FDI had neither a long-term nor short-term positive effect on economic growth.

Although the available literature on the links between exchange rates and FDI, exchange rates and economic growth, and FDI and economic growth are quite widespread, very little research has explored these relationships under the combination of all three factors. However, the mechanism between these three factors is quite complicated and comprehensive research therefore needs to be objective. Pan and Guo (2012) studied the dynamic effects between RMB exchange rates, economic growth and FDI, and found, on the basis of a Pesaran bounds test, that a long-term equilibrium relationship existed between them. According to a Markov-Switching VAR model, Lan (2015) found a nonlinearity effect between RMB exchange rates, economic growth and FDI. The result showed that the relationship was influenced by the stage of the business cycle. As mentioned previously, those studies that explored the relationships between any two of the factors under discussion drew different conclusions, whereby neither theoretical nor empirical studies were consistent. One possible reason for this is that the previous research was rarely conducted from a comprehensive perspective. Another reason may be that almost all the studies so far were based on traditional econometric tools and only summarily took nonlinearity into consideration. In addition, there may be issues with the use of only annual or quartely data, which risks neglecting detailed changes, as well as small sample sets that may have reduced the accuracy of the estimations. The aim of this paper is therefore to investigate how exchange rates and FDI influence China's economic growth from a comprehensive point of view, based on an analysis of monthly data from January 2001 through to August 2016 using a time-varying parameter VAR (TVP-VAR) model.

The rest of this paper is organized as follows. Section 2 introduces the methodology and data adopted in this article. The estimation parameters and impulse responses are presented in Section 3. This is followed in Section 4 by an analysis of the impulse response results and the hidden economic mechanism. The conclusions are presented in the final section.

## Materials and Methods

This section provides a brief introduction to the methodology, data and sources.

### Methodology

A TVP-VAR model allows us to capture the underlying structural changes without having to divide the data into several subsamples, which avoids the risk of losing information. According to this model, responses at different points in time are permitted, which makes it very useful for investigating the dynamic relationships between exchange rates, economic growth and FDI. For simplicity, the structural VAR model is defined as follows:

$$\mathrm{A}y_t = F_1 y_{t-1} + F_2 y_{t-2} + \cdots + F_s y_{t-s} + u_t, \quad t = s+1, \cdots, n \quad (1)$$

where $y_t$ is a k×1 vector of observed variables, A, $F_1, \cdots, F_s$ are k×k matrices of coefficients, $u_t$ is a k×1 structural shock and $u_t \sim N(0, \Sigma\Sigma)$, where

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{pmatrix}, A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{k1} & \cdots & a_{k,k-1} & 1 \end{pmatrix}$$

The model (1) can be reduced to the following form:

$$y_t = \mathrm{B}_1 y_{t-1} + \mathrm{B}_2 y_{t-2} + \cdots + \mathrm{B}_s y_{t-s} + A^{-1}\Sigma\varepsilon_t, \ \ \varepsilon_t \sim N(0, I_k) \quad (2)$$

where $\mathrm{B}_i = A^{-1}F_i, \ \ i = 1, \cdots, s.$

The model (2) can be further reduced to the following form:

$$y_t = X_t\beta + A^{-1}\Sigma\varepsilon_t \quad (3)$$

where $X_t = I_s \otimes (y'_{t-1}, \cdots, y'_{t-s})$ , $\otimes$ denotes the Kronecker product, and $\beta(k^2 s \times 1\ vector)$ is obtained by stacking the elements in the rows of $B'_i$s. In model (3), all the parameters are time-invariant, and the expression of this model to TVP-VAR with stochastic volatility is defined as follows:

$$y_t = X_t\beta_t + A_t^{-1}\Sigma_t\varepsilon_t, \quad t = s+1, \cdots, n \quad (4)$$

where $\beta_t, A_t^{-1}$ and $\Sigma_t$ are all time-varying. The TVP-VAR model takes into account specifications according to Primiceri (2005) and Nakajami (2011), such as matrix $A_t$ being of the lower-triangular form,

$$h_t = (h_{1t}, \cdots, h_{kt})' \ with \ h_{jt} = log\sigma_{jt}^2, \ \ j = 1, \cdots, k, \qquad t = s+1, \cdots, n$$

and the assumption that the parameters follow a random walk process as follows:

$$\beta_{t+1} = \beta_t + u_{\beta t}, \ \ a_{t+1} = a_t + u_{at}, \ \ h_{t+1} = h_t + u_{ht},$$

$$\begin{pmatrix} \varepsilon_t \\ u_{\beta t} \\ u_{at} \\ u_{ht} \end{pmatrix} \sim N\left(0, \begin{pmatrix} \sigma_1 & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix}\right), \quad \mathrm{t} = \mathrm{s}+1, \cdots, \mathrm{n}$$

where $\beta_{t+1} \sim N(u_{\beta_0}, \Sigma_{\beta_0}), a_{t+1} \sim N(u_{a_0}, \Sigma_{a_0}), h_{t+1} \sim N(u_{h_0}, \Sigma_{h_0}), \Sigma_a$ and $\Sigma_h$ were assumed to be diagonal matrixes for simplicity´s sake. The specification of the random walk process permits the coefficients to change temporarily or permanently, which helped to determine whether the nonlinearity was generated by a structural break or a gradual change, either of which are often hidden in the economic data generating process.

## Data

To explore the relationships between exchange rates, economic growth and FDI in China, monthly data were used from January 2001 through to August 2016. The analysis was based on the following three time series. The first was for the real effective exchange rate index of China. This index was taken from International Finance Statistics (IFS), which effectively describe the exchange rate fluctuations. The second was for industrial added value as published by the National Bureau of Statistics of China, which is an alternative indicator to GDP for economic growth. Because this data was no longer published after 2006, we calculated the remaining missing data according to the existing data and corresponding industrial added value growth rate, which is accepted practice for adopting such data in research. The third was for foreign direct investment, whereby actual foreign direct investment, as published by the National Bureau of Statistics of China was applied as the indicator. The latter two variables were adjusted by the price index to generate real numbers. The seasonal effects were removed by using the US census bureau X13 seasonal adjustment procedure. All the variables were specified in natural logarithms.

## Results

### Stability of the model

Before estimating the TVP-VAR model, a unit root test was conducted to determine whether the three variables were stationary. The ADF statistics in Table 1 indicate that all the variables are stationary after difference. We therefore used the difference of the real effective exchange rate index (RE), industrial added value (IND) and real foreign direct investment (FDI) to establish the model. This variable set represents the rate of change of the corresponding variables.

Table 1: Unit root test results

| Variables | (C,T,P) | ADF statistics | Conclusion |
|---|---|---|---|
| RE | (C,0,14) | -10.37*** | Stationary |
| IND | (C,0,14) | -25.72*** | Stationary |
| FDI | (C,0,14) | -13.39*** | Stationary |

*Source: Authors*

Note: All three variables are log-difference; ***,**,* means the null hypothesis was rejected at a significance level of 1%, 5% or 10% respectively; (C,T,P) represents the intercept, time trend and max lag order of the tested equations, whereby the lag order was selected according to Schwarz Criterion (SC).

All the variables were stationary. As a result, a three-variable TVP-VAR model could be established and estimated. In order to estimate the parameters of the TVP-VAR model, the following priors were assumed:

$$\left(\Sigma_\beta\right)_i^{-2} \sim Gamma(40,0.02), (\Sigma_\alpha)_i^{-2} \sim Gamma(40,0.02), (\Sigma_h)_i^{-2} \sim Gamma(40,0.02)$$

where $\left(\Sigma_\beta\right)_i$ is the i-th element in the covariance matrices, and the initial values of the set parameters were: $\mu_{\beta_0} = \mu_{\alpha_0} = \mu_{h_0} = 0, \Sigma_{\beta_0} = \Sigma_{\alpha_0} = \Sigma_{h_0} = 10 \times I$. The lags for this TVP-VAR model were 2. The Markov Chain Monte Carlo (MCMC) algorithm was applied to compute the estimation. In total, 10,000 samples were acquired after the first 1,000 samples were burned-in. All the procedures were run in MATLAB. The estimation results are presented in Table 2. The results shows that the null hypothesis of convergence to the posterior distribution could not be rejected according to Geweke convergence diagnostics statistics (CD statistics), and that almost all the inefficiency factors were less than 100, which shows the effectiveness of the MCMC algorithm. Although the inefficiency factors of $(\Sigma_h)_2$ is more than 100, we also had about 200(=20000/100.08) unrelated samples, which is sufficient for posterior inference. Figure 1 presents the results of sample paths, which show the volatility of the clustering phenomena and the convergence of all the parameters towards the mean value in Table2, which implies that the MCMC algorithm efficiently generates posterior draws.

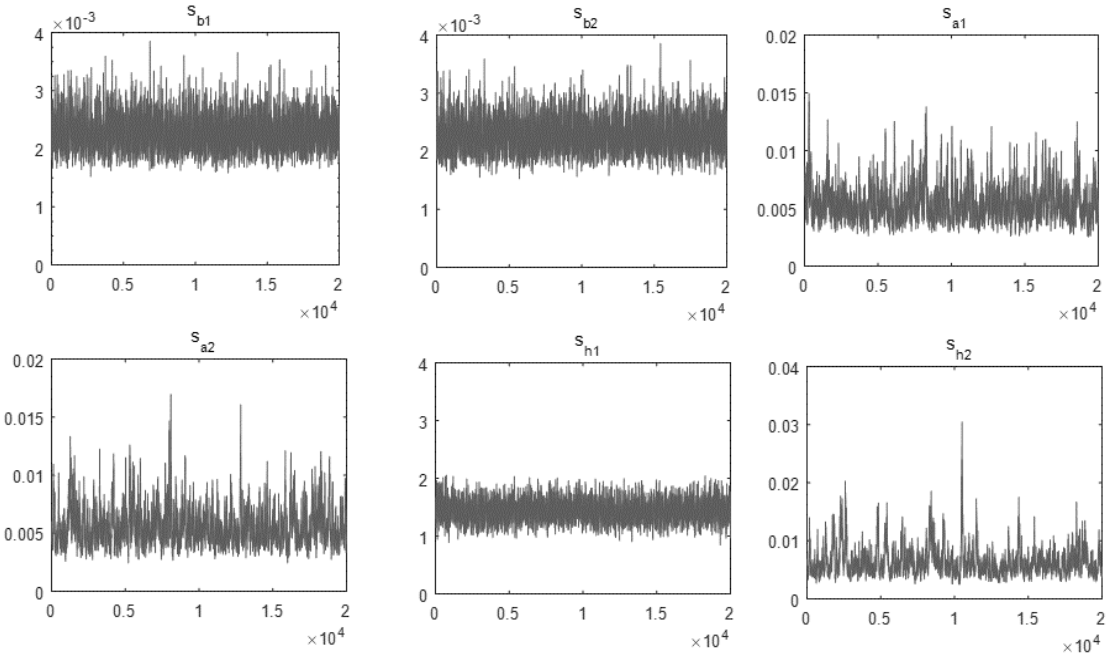
Table 2. Estimation results for the parameters in the TVP-VAR model

| Parameter | Mean | St.dev. | 95 percent interval | CD statistics | Inefficiency |
|---|---|---|---|---|---|
| $(\Sigma_\beta)_1$ | 0.0023 | 0.0003 | [0.0018, 0.0029] | 0.002 | 9.03 |
| $(\Sigma_\beta)_2$ | 0.0023 | 0.0003 | [0.0018, 0.0029] | 0.960 | 7.51 |
| $(\Sigma_\alpha)_1$ | 0.0054 | 0.0015 | [0.0034, 0.0092] | 0.269 | 56.62 |
| $(\Sigma_\alpha)_2$ | 0.0056 | 0.0016 | [0.0034, 0.0094] | 0.538 | 57.74 |
| $(\Sigma_h)_1$ | 1.4312 | 0.1669 | [1.1136, 1.7736] | 0.302 | 13.72 |
| $(\Sigma_h)_2$ | 0.0064 | 0.0024 | [0.0035, 0.0130] | 0.753 | 100.08 |

*Source: Authors*

Note: The estimates of $\Sigma_\beta$ and $\Sigma_\alpha$ are multiplied by 100.

Figure 1: Estimation results for the parameters in the TVP-VAR model




*Source: Authors*

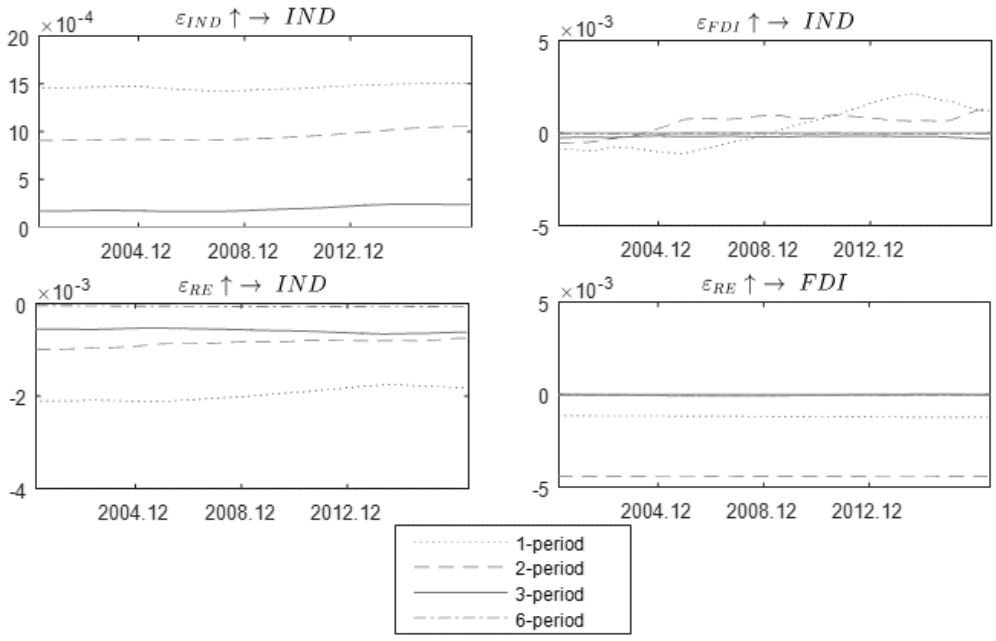
**Impulse response results**

Under the TVP-VAR model, the impulse response can be drawn at all points in time, whilst the standard VAR model with constant parameters can only capture the impulse response for each variable.

Figure 2 shows the time-varying impulse response of economic growth following a shock change in the real exchange rate and foreign direct investment (the response of FDI to the

real exchange rate is also presented). The time-variant responses to the shock are presented for one month, two months, a quarter and half a year. As is evident, the trend in the four curves in Figure 2 are relatively stationary. This means that there was not a structural break in the relationships between exchange rates, economic growth and FDI and there is a long-term equilibrium between them. These results are consistent with those in previous research (Pan et al., 2012). It is clear that there is a decline in economic growth when a positive shock from real exchange rates is experienced. Our results therefore support the traditional view that currency appreciation has a contractionary effect. If the results of previous research based on Chinese data are taken into consideration, we do not therefore believe that the contractionary devaluation phenomena (Krugman 1978) has been experienced in China yet. What has been noticeable is that the negative effect has been lower in recent years when the shock occured, which may be due to the gradual maturing of China's financial market. What is also evident is that the FDI inflows also decrease after a shock change in exchange rates, which are consistent with the popular view. Unlike intuition suggests, FDI has generated an ambiguous effect on economic growth in the past few years. Before 2008, a shock change in FDI would see output lag in one period, only for FDI to then go on to stimulate economic growth. However, this lag phenomenon has disappeared in recent years, whereby an increase in FDI is always conducive to economic growth.

Figure 2. Impulse responses for different periods

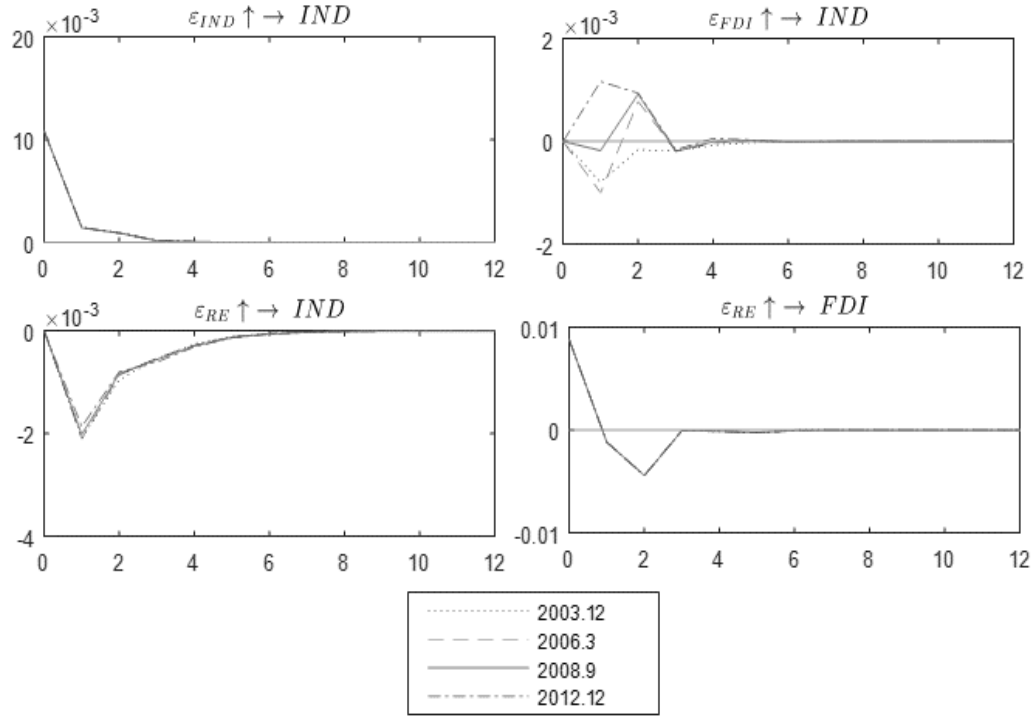



*Source: Authors*

Furthermore, the robustness of our results was evidenced through complete impulses at different points of time. Figure 3 presents the equidistant impulse responses. Taking into

consideration that China implemented exchange rate reforms in 2005, as well as the onslaught of the financial crisis in 2007, we choose December 2003, March 2006, September 2008, and December 2012 as the representative points at which to determine whether a structural break was hidden in the equilibrium. The convergence of these four curves reflects the preceding results and also implies robustness.

Figure 3: Impulse responses at specific points in time




*Source: Authors*

## Discussion

The empirical results produced by the TVP-VAR model do not exactly reflect those in previous studies. Where Pan and Guo (2012) showed that the appreciation of the RMB exchange rate has a significant effect on the inflow of FDI and has a strong tightening effect on economic growth, our research draws the conclusion that exchange rate appreciation is disadvantageous to FDI inflows. We believe that this inconsistency is a consequence of the different research framework and that the TVP-VAR model could therefore reflect the dynamic mechanism hidden in the economic phenomenon.

As the impulse response results show in the previous section, the impulse responses for economic growth to a positive real exchange rate shock support the traditional view that currency appreciation is contractionary and has been relevant to China since the early 2000s. On the one hand, even though it is clear that international trade plays an important role in China's economic growth, as evidenced by the large trade surplus, economic theory

tells us that a positive exchange rate shock would generate negative effects on net exports, which would reduce economic growth. However, in reality, China exports mainly two categories of products, namely primary products and processed products. Whereas a real increase in the exchange rate would reduce the exports of the former, it would have little effect on the latter because the production of these types of products requires the import of intermediate products. During the financial crisis, the RMB exchange rate continued to appreciate, resulting in the closing down of many export focused businesses located in coastal areas, which had a negative impact on economic growth. In turn, this change in economic growth had an effect on domestic consumption and imports, which resulted in a feedback effect on the exchange rate. On the other hand, as the figure above shows, the increase in the exchange rate led to a decline in foreign direct investment, whilst FDI is generally considered to be beneficial to economic growth. According to our research, these multiplier effects would see a positive real exchange rate shock producing a negative impact on economic growth, which would last for approximately six months. In reality, a real exchange rate shock may also have influenced hot money, which may in turn have further affected the domestic financial market, however, this did not happen because China implemented rigid capital controls on foreign capital. As a result, our model did not focus on this impact and mainly studied the direct and indirect influence on FDI when economic growth receives a positive real exchange rate shock.

Our research supports the argument that currency appreciation decreases FDI inflows, which is conducive with previous theory (Cushman 1985; Froot and Stein 1991), whereby slowing economic growth caused by currency appreciation weakens the attractiveness of FDI. Finally, the empirical results show that FDI has generated an ambiguous effect on economic growth in the past few years. As previously mentioned, a positive FDI shock has a negative impact on economic growth in the form of lag in one period. We believe that this phenomenon can be explained for two reasons. Firstly, China implemented many policies to attract FDI, whereby some local governments gave very preferential terms to foreign businesses during negotiations. As the foreign capital flowed into China, local industries lost their advantage, which resulted in a short-term negative effect on economic growth. However, capital driven FDI inflows can have a positive impact on the host country's economic growth as local industries begin to benefit from the positive impact of increased production. This was confirmed by Liang (2017) using data from China's manufacturing firms. It is therefore possible to state that FDI inflows are generally benefical to China's economic growth. However, as Alfaro, et al. (2004) argue, without a well developed financial market the host country would not be able to effectively utilize the foreign investment. Through an empirical analysis, Adams and Opoku (2015) also founded that FDI only generated a significant growth effect if effective regulations are in place. It is for this reason, the advent of stringent regulation and a more effective financial market, that the phenomenon has disappeared in recent years.

The results of the TVP-VAR model reveal a dynamic time-varying effect between the real RMB exchange rate, FDI and economic growth. The real exchange rate not only had a contractionary effect by affecting imports and exports, but also by negatively impacting

on FDI, which impacted further on economic growth, even though FDI inflows have been generally advantageous to economic growth since 2008. Although many other factors are hidden in the economic mechanism, these were not included in the model for simplicity´s sake. The results of the VAR model could even be regarded as the final outcome generated by these hidden factors.

## Conclusion

This paper investigates the relationships between real exchange rates, economic growth and foreign direct investment in China. According to the TVP-VAR model, there is no great change between these three variables. Even though the negative effect became gradually lower when economic growth received a positive shock from changes in the real exchange rate, there is no evidence to support the contractionary devaluation theory in China i.e. currency appreciation is still disadvantageous to economic growth and FDI inflows. Unlike intuition suggests, FDI has generated an ambiguous effect on economic growth in the past few years. Before 2008, an FDI shock would cause economic growth to lag by one period. We believe that this is the result of positive government policies, which may have hurt local industries in the short-term, and the theoretical principle that without a well developed financial market host countries are not able to effectively utilize foreign investment (Alfaro et al,, 2004). However, as regulation became more stringent and the financial market more effective, this phenomenon has disappered in recent years. We tried to analyze how exchange rates and FDI affect China's economic growth from a comprehensive point of view, however, the real world is much more complicated and requires the consideration of a large number of variables. This shortcoming in this research is also where future research opportunities lie.

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