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DOES THE INVESTOR ATTENTION MATTER IN PREDICTING THE CNY EXCHANGE RATE? EVIDENCE FROM THE ASYMMETRIC PERSPECTIVE

Abstract. *This paper aims to explore the potential asymmetric effects of positive and negative changes in investor attention and other possible determinants on the CNY exchange rate by utilizing the nonlinear ARDL model. In doing so, we firstly construct a novel investor attention index based on Google Trends by using principal component analysis. The empirical results show substantial asymmetric effects of the underlying determinants on the CNY exchange rate. In particular, we find that the composite investor attention significantly affects the CNY exchange rates, with positive shocks to the composite investor attention leading to appreciating CNY exchange rates. Moreover, the impact of a decrease in investor attention defeats the impact of an increase in the CNY exchange rates. These findings cast new light on the literature that does not consider the role of investor attention and ignores the nonlinear effect of the determinants on CNY exchange rates. The authorities should also take these asymmetric effects into account when trying to stabilize the movement of CNY exchange rates to promote exchange rate marketization.*

Keywords*: Exchange rate, Investor attention, FX markets, NARDL model.*

JEL Classification: F21, F31, G15

1. Introduction

The exchange rate plays a pivotal role in a country's macroeconomic and financial development (Ghura and Grennes, 1993). Around the dynamic determination of foreign exchange rate and macro-and microeconomic effects and other relevant issues, the existing literature has conducted a lot of beneficial

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exploration in the theoretical field (Obstfeld, 1981; Rime et al., 2010; Pourroy, 2012). Especially for developing countries and emerging economies, the exchange rate determination of these countries is still one of the hot topics in macroeconomics of open economy, due to their country-specific foreign exchange management system, monetary policy regulatory framework, and financial market structure (Fidrmuc and Korhonen, 2010; Kohlscheen, 2014).

China is one of the rapidly developing countries in the world, which is undergoing phased changes in the economic and financial system. To defend against external uncertainty and risks, the sustained and stabilized movement of the CNY exchange rate is crucial in the current context. Meanwhile, with the rapid development of China's economy and the increase in the degree of openness to the world, the renminbi (that is, RMB or CNY), as a transaction medium and payment method, has become more and more widely used in China's neighboring countries and Hong Kong and Macao regions. Therefore, the authorities are actively promoting the stabilization of the CNY exchange rate and the internationalization of the RMB. Understanding the determinants of CNY exchange rates and taking initiatives to stabilize the exchange rates are more important than ever.

After the Global Financial Crisis (henceforth, GFC), with the gradual recovery of major developed countries, such as the U.S. and the E.U., China's economy has also begun to increase steadily. The Central Bank of China (PBOC) restarted the market-oriented reform of the RMB exchange rate in June 2010. Moreover, on August 11, 2015, the PBOC once again announced the adjustment of the quotation mechanism for the mid-rate of the RMB exchange rate against the US dollar, which was shifted to the market maker's quotation (Yu et al., 2017). Since then, the marketization of the RMB exchange rate quotation mechanism has gone further after the adjustment of the new quotation method. In December 2015, the International Monetary Fund (henceforth, IMF) officially declared that the RMB would join the Special Drawing Right (SDR) in October 2016, and the internationalization process of the renminbi was pushed forward (Zhou et al., 2020). There is no doubt that as the accelerated pace of RMB internationalization, the stability of the RMB exchange rate, and the marketization of the RMB exchange rate formation mechanism will be the inevitable orientation of future exchange rate policies.

As one of the important variables in a country's macro economy, changes in exchange rates are closely related to a variety of economic and financial factors. The existing literature has found that the determinants of exchange rates mainly include: asset price fluctuations, monetary policy changes, economic growth, international capital flows, economic policy uncertainty, and so on (see, for example, Smith, 1992; Kisaka *et al*., 2014; MacDonald and Nagayasu, 2015; Linnemann and Schabert, 2015; Gelman *et al*., 2015; Afshan *et al*., 2018; Li *et al*., 2020). In recent decades, with the development of behavioral finance and the successful application of market microstructure theory in the securities market, economists have also tried to apply this method to the foreign exchange market to

analyze exchange rate changes and question the classical exchange rate determination theory (see, for example, Manzan and Westerhoff, 2007; Smith, 2012; Peltomäki *et al*., 2018). Among them, does the behavior of investors in the foreign exchange market significantly affect the changes in the CNY exchange rate? What are the characteristics of this influence? Can we utilize this indicator to predict the movement of the CNY exchange rate? Besides, under the background of the phased changes in China's economic and financial system, does the influence of investor attention on the RMB exchange rate has phased non-linear characteristics?

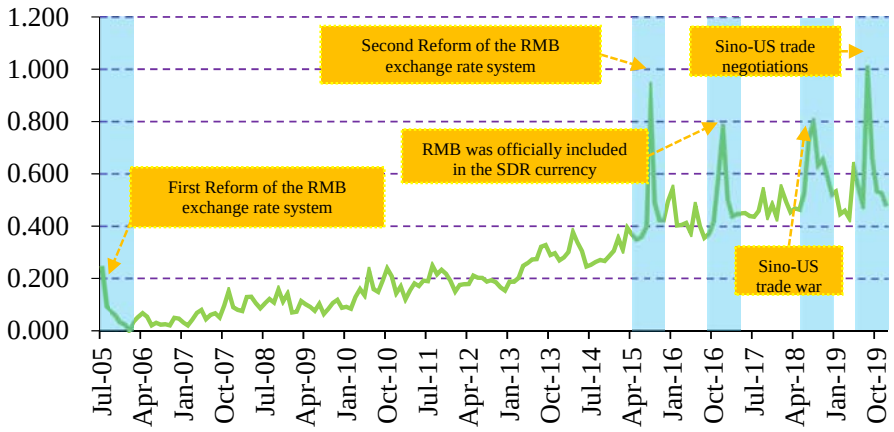


Figure 1. The trend of investor attention between July 2005 and December 2019

Therefore, we are inspired to incorporate the investor attention into other possible determinants we consider and explore whether this indicator can help us forecast the CNY exchange rate. First, considering that there is no official investor attention index in China, based on the Google Trends, aligned investor attention index is built in this paper by the principal component analysis (henceforth PCA) method to comprehensively consider the impact of the investor attention on the CNY exchange rate. Specifically, Figure 1 illustrates the dynamics of the composite investor attention index constructed by the PCA method between July 2005 and December 2019. It is noteworthy that several peaks in the investor attention index concurred with major events that are related to the RMB exchange rate. Such as the *8·11 exchange rate reform* in August 2015, the *Sino-US trade war* in August 2018, and so on. Moreover, the movement of investor attention, in general, is on the rise during the sample period, especially before 2015, which is opposite to the significant unilateral appreciation of the RMB exchange rate. In light of these observations, we could expect an underlying connection between the exchange rate movements and the composite investor attention index.

When detecting the drivers of the CNY exchange rate, the current paper considers the composite investor attention index for the main determinant and

selects the FX intervention, the RMB exchange rate expectations, and the capital flows for control variables. Furthermore, different from previous studies, we explore whether there is an asymmetric impact of these determinants on the CNY exchange rate in the short- and long term. For this purpose, we utilize the non-linear autoregressive distributed lag (NARDL) model proposed by Shin *et al*. (2014). The advantage of the method is that it is not necessary for all included variables to be *I(1)*, as long as they are not *I(2)*, the cointegration test can be examined. Another superiority of the NARDL model is that when conducting this approach in small sample cases, this estimation has higher robustness. Therefore, according to these merits, the NARDL approach is employed in this study to investigate the asymmetric linkages between the CNY exchange rate and their underlying determinants.

Our contribution of this paper to currently existing literature mainly lies in three parts. To begin with, different from previous empirical studies on the exchange rates mainly concerning economic fundamental indicators, such as interest rate, asset price, monetary policy, economic growth, and inflation (Ding *et al*., 2014; Funke *et al*., 2015; Linnemann and Schabert, 2015; Afshan *et al*., 2018), we pay attention to the potential impact of the investor appetite factor (i.e. investor attention) on the exchange rate. To our knowledge, while it has been widely accepted that investor appetite plays a pivotal role in changing market expectations, very few investigations have been carried out to reveal the influence of investor attention on the exchange rate in the FX market (Han *et al*., 2018). Therefore, this study provides fresh evidence on whether investor attention dynamics can explain the CNY exchange rate movements. Second, we rely on the PCA method to construct a novel composite investor attention index based on Google Trends and then attempt to uncover the potential effect of the composite index on the CNY exchange rate. The PCA approach employed in this paper could help us to use dimensionality reduction techniques to replace the original multiple variables with a few comprehensive variables to conduct the exploration of the role of the composite investor attention in the CNY exchange rate movements. Third, to serve the empirical goal of our study, we apply the NARDL model to discover the underlying asymmetric effect of the latent factors on the CNY exchange rate, which casts new light on the existing empirical research merely taking the linear transmission into account. To the best of our knowledge, this study is one of the first studies to utilize a nonlinear estimation to analyze this topic. The asymmetric effects of the latent drivers on the CNY exchange rate explored by this study may enrich the understanding of the CNY exchange rate movements, which would have implications for financial stability and the conduct of monetary policy and meanwhile, help to accelerate the internationalization of the RMB.

The balance of this study is organized as follows. First, the employed methodology is introduced in Section 2. Besides, Section 3 shows the corresponding data. Then, Section 4 discusses the empirical results. Finally, Section 5 concludes this paper.

2. Methodology

This study utilizes the NARDL approach developed by Shin *et al*. (2014) to investigate the asymmetric short-run and long-run relationships between the CNY exchange rate and a set of driving determinants. Specifically, we can obtain the asymmetric long-run equilibrium by decomposing the independent variables into their partial cumulative sum of the negative and the positive changes and the equation can be written as follows:

$$y_t = \beta^+ x_t^+ + \beta^- x_t^- + \varepsilon_t \tag{1}$$

where parameters (β^+ and β^-) denote asymmetric long-run changes, the random error term is represented by ε_t, the dependent variable is indicated by y_t and x_t is a $k \times 1$ vector of explanatory variables that can be rewritten as:

$$x_t = x_0 + x_t^+ + x_t^- \tag{2}$$

where the partial cumulative sum processes of the negative and the positive changes in x_t are respectively expressed as x_t^- and x_t^+, which can be calculated as follows:

$$x_t^+ = \sum_{j=1}^{t} \Delta x_j^+ = \max(\Delta x_j, 0), x_t^- = \sum_{j=1}^{t} \Delta x_j^- = \min(\Delta x_j, 0) \tag{3}$$

By embedding equation (1) into an unrestricted linear ARDL (*p, q*) model, we can obtain the following asymmetric error correction model:

$$\begin{aligned} \Delta y_t = {} & \alpha_0 + r y_{t-1} + \theta^+ x_{t-1}^+ + \theta^- x_{t-1}^- + \sum_{j=1}^{p-1} \tau_j \Delta y_{t-j} + \\ & \sum_{j=0}^{q-1} (\pi_j^+ \Delta x_{t-j}^+ + \pi_j^- \Delta x_{t-j}^-) + e_t \end{aligned} \tag{4}$$

The NARDL model above can be utilized to capture the asymmetric relationship between x_t and y_t. $\sum_{j=0}^{q-1} \pi_j^+$ and $\sum_{j=0}^{q-1} \pi_j^-$ represent the short-term asymmetric dynamics of Δx_t. The asymmetric long-run coefficients of x_t are measured as follows:

$$\beta^+ = -\theta^+ / r \,,\ \beta^- = -\theta^- / r \tag{5}$$

Moreover, *Wald* statistics are utilized to test the short- and long-run asymmetry. W_{SR} is used to examine the short-term symmetry under the null hypothesis of $\sum_{j=0}^{q-1} \pi_j^+ = \sum_{j=0}^{q-1} \pi_j^-$, and W_{LR} for the long-run symmetry under the null hypothesis of $\theta^+ = \theta^-$.

Considering the objects of our research, the specific NARDL equation in this paper can be written as follows:

$$\begin{aligned}\Delta CNY_t = {} & \alpha_0 + rCNY_{t-1} + \beta^{+'} IA^+_{t-1} + \beta^{-'} IA^-_{t-1} \\ & + \gamma^{+'} INTV^+_{t-1} + \gamma^{-'} INTV^-_{t-1} + \theta^{+'} NDF^+_{t-1} \\ & + \theta^{-'} NDF^-_{t-1} + \eta^{+'} CF^+_{t-1} + \eta^{-'} CF^-_{t-1} \\ & + \sum_{j=1}^{p-1} \tau_j \Delta CNY_{t-j} + \sum_{j=0}^{q-1} (\xi_j^{+'} \Delta IA^+_{t-j} + \xi_j^{-'} \Delta IA^-_{t-j}) \\ & + \sum_{j=0}^{q-1} (\chi_j^{+'} \Delta INTV^+_{t-j} + \chi_j^{-'} \Delta INTV^-_{t-j}) \\ & + \sum_{j=0}^{q-1} (\zeta_j^{+'} \Delta NDF^+_{t-j} + \zeta_j^{-'} \Delta NDF^-_{t-j}) \\ & + \sum_{j=0}^{q-1} (\delta_j^{+'} \Delta CF^+_{t-j} + \delta_j^{-'} \Delta CF^-_{t-j}) + e_t\end{aligned} \tag{6}$$

where $IA^+, INTV^+, NDF^+$ and CF^+ represent the positive movements in the investor attention, the FX intervention, the RMB exchange rate expectations, and the capital flow, while $IA^-, INTV^-, NDF^-$ and CF^- indicate negative movements in the four concerned determinants.

Besides, this study also applies the dynamic multiplier to uncover the influence of a unit change in x_t^+ and x_t^- on y_t. Based on the research of Shin et al. (2014), we can extract the asymmetric cumulative multipliers, which are represented by m_h^+ (positive effect) and m_h^- (negative effect). The calculation is as follows:

$$m_h^+ = \sum_{j=0}^{h} \frac{\partial CNY_{t+j}}{\partial x_t^+}, \quad m_h^- = \sum_{j=0}^{h} \frac{\partial CNY_{t+j}}{\partial x_t^-}, h = 0,1,2,\cdots \tag{7}$$

We can use the above-mentioned dynamic multiplier effect to draw the duration of dynamic adjustment from the disequilibrium to a new equilibrium state. Moreover, each confidence interval of the m_h^+ and m_h^- can be given through bootstrapping 10000 times.

3. Data

In this study, the dependent variable is the onshore CNY/USD exchange rate (the CNY exchange rate, thereafter), which is expressed in the direct quotation, and thus a decrease (or an increase) in the CNY exchange rate suggests appreciation (depreciation) of the Chinese Yuan against the U.S. dollar. Besides, independent variables in the paper are the novel investor attention index based on the Google Trends by using the PCA method, the foreign exchange (FX) intervention, the exchange rate expectations, and the capital flow. The different types of original investor attention indices are obtained from the Google Trends website (https://trends.google.com/trends/explore?hl=en-US) and the other datasets are acquired from the PBOC and Wind Info Economic Database of China. The sampling period begins from July 2005 to December 2019, which includes the *Global Financial Crisis*, the *European Debt Crisis*, the *China stock market crash*, and the *Sino-US trade war*. Each set of data in the current paper is at the monthly frequency.

Table 1 represents the statistics of each variable. It can be found that the standard deviation of the FX intervention is the largest, meaning that the FX intervention fluctuates sharply during the sample period. The skewness of investor attention is positive, implying the investor attention has been on the rise during the sample period. Moreover, each variable involved in this paper both meets the requirements of the cointegration test and the NARDL model, since that the results of the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test suggest that variables are *I* (0) or *I* (1) processes.

Table 1. Statistical properties of the research variables.

Variables	***CNY***	***IA***	***INTV***	***NDF***	***CF***
Mean	6.788	0.271	0.779	-0.339	6.752
Max.	8.222	1.000	4.809	0.86	7.841
Min.	6.104	0.000	-2.81	-6.541	6.113
Std. Dev.	0.568	0.197	1.351	0.961	0.449
Skew.	0.977	0.912	0.603	-3.76	0.818
Kurt.	3.088	3.659	3.509	21.773	2.878
J-B stats.	27.726***	27.246***	12.415***	2965.176***	19.501***
ADF (Level)	-2.670	-1.222	-3.015**	-1.805	-2.514
PP (Level)	-2.336	-1.442	-4.600***	-3.508	-2.345
ADF (First Difference)	-7.668***	-9.780***	-22.239***	-17.686***	-8.663***
PP (First Difference)	-7.663***	-29.453***	-66.464***	-19.527***	-8.605***

*Note: This paper utilizes the logarithmic difference of the foreign exchange reserves as a proxy for the foreign exchange intervention (FX), and uses a 3-month non-deliverable forward (NDF) rate for the RMB against the U.S. Dollar as the proxy for the exchange rate expectations. In addition, we employ the difference among foreign exchange reserves, foreign direct investments, and trade surplus for the short-term capital flow (CF). The best-suited specifications for the underlying variables to conduct ADF and PP unit root tests are proved to be the ones with a constant and no-time trend. *** and ** indicates significance at 1% and 5% levels.*

4. Empirical result

Table 2 registers the corresponding statistics and diagnostic results of the model selection. Several findings can be observed. First, the F_{PSS} statistics surpass the upper threshold critical value in the long-run symmetry and short-run asymmetric case and the long- and short-run asymmetric case, implying that there are stable long-term relationships between the CNY exchange rate and their possible factors in both scenarios. Second, among the four alternative models, it can be found that the *Wald* statistics are more significant in the short-run and long-

run asymmetric cases. Third, the adjusted R^2 also achieves the maximum in this case. Based on these observations, both considering long- and short-run asymmetries in the NARDL model is best suited to examine the dynamic impacts of the underlying determinant on the CNY exchange in this study.

Table 2. Bounds test for cointegration and the NARDL model selection.

SR and LR Symmetry		**LR Asymmetry and SR Symmetry**		**LR Symmetry and SR Asymmetry**		**LR and SR Asymmetry**	
F_{PSS}	3.135	F_{PSS}	2.760	F_{PSS}	9.879***	F_{PSS}	12.173***
				W_{SR}^{INTV}	0.045 (0.832)	W_{SR}^{INTV}	28.911*** (0.000)
		W_{LR}^{INTV}	3.798* (0.053)			W_{LR}^{INTV}	0.231 (0.632)
				W_{SR}^{IA}	0.168 (0.683)	W_{SR}^{IA}	30.611*** (0.000)
		W_{LR}^{IA}	0.704 (0.403)			W_{LR}^{IA}	14.757*** (0.000)
				W_{SR}^{NDF}	0.001 (0.972)	W_{SR}^{NDF}	7.536*** (0.008)
		W_{LR}^{NDF}	1.439 (0.232)			W_{LR}^{NDF}	0.199 (0.657)
				W_{SR}^{CF}	9.704*** (0.003)	W_{SR}^{CF}	14.454*** (0.000)
		W_{LR}^{CF}	0.094 (0.759)			W_{LR}^{CF}	3.493* (0.066)
$Adj.\ R^2$	0.759	$Adj.\ R^2$	0.525	$Adj.\ R^2$	0.843	$Adj.\ R^2$	0.845
AIC	-4.424	*AIC*	-3.741	*AIC*	-4.706	*AIC*	-4.678
SC	-3.995	*SC*	-3.313	*SC*	-3.220	*SC*	-3.114

*Note: F_{PSS} is the F-statistic that is used to test cointegration among variables and the critical values are 3.52 (10%), 4.01 (5%), and 5.06 (1%) when k = 4. Besides, W_{SR} is tested for the short-term symmetry and W_{LR} is the Wald statistic for the long-term symmetry. ***, ** and * represent significance at 1%, 5% and 10% level. The p-values are shown in parentheses.*

Table 3 presents the final result of the NARDL estimation as in Equation (6) for the underlying factors of the CNY exchange rate. The lag order of the estimation model is selected by stepwise regression. When the lag order is set to 12, the CUSUM diagnostic test shows that the parameter diagnosis of the estimated model has significant stability. Therefore, we adopt the lag order of 12 to obtain the following empirical results. Besides, the error correction coefficient in Table 3 shows that the NARDL estimation is stable as it is negative and statistically significant.

Table 3. Estimation result of the NARDL approach for the determinants of the CNY exchange rate.

Long-term coefficient		**Short-term coefficient**							
Const.	1.490*** [4.974]	ΔER_{t-1}	-0.302*** [-4.808]	ΔIA_{t-10}^{-}	-0.158*** [-4.230]	$\Delta INTV_{t-6}^{-}$	0.039*** [-4.757]	ΔCF_{t-8}^{+}	0.028*** [2.908]
ER_{t-1}	-0.235*** [-6.222]	ΔIA_{t-1}^{+}	-0.324*** [5.906]	ΔIA_{t-11}^{-}	-0.168*** [-4.069]	ΔNDF_{t-3}^{+}	0.289*** [-3.488]	ΔCF_{t-9}^{+}	0.018** [2.045]
IA_{t-1}^{+}	-0.315*** [-6.950]	ΔIA_{t-3}^{+}	0.093** [2.144]	$\Delta INTV_{t-2}^{+}$	0.046*** [-4.496]	ΔNDF_{t-5}^{+}	-0.374*** [-5.026]	ΔCF_{t-1}^{-}	0.061*** [3.311]
IA_{t-1}^{-}	-0.398*** [-7.084]	ΔIA_{t-6}^{+}	-0.108*** [3.029]	$\Delta INTV_{t-3}^{+}$	0.050*** [-5.282]	ΔNDF_{t-6}^{+}	0.209*** [-2.892]	ΔCF_{t-3}^{-}	0.036** [2.304]
$INTV_{t-1}^{+}$	0.076*** [5.609]	ΔIA_{t-7}^{+}	-0.091** 2.662]	$\Delta INTV_{t-5}^{+}$	0.025** [-3.341]	ΔNDF_{t-1}^{-}	0.229*** [-2.715]	ΔCF_{t-5}^{-}	-0.046*** [3.267]
$INTV_{t-1}^{-}$	0.077*** [6.116]	ΔIA_{t-8}^{+}	-0.198*** [-5.140]	$\Delta INTV_{t-6}^{+}$	0.012** [-2.058]	ΔNDF_{t-2}^{-}	-0.302*** [-3.646]	ΔCF_{t-6}^{-}	-0.032** [2.590]
NDF_{t-1}^{+}	0.205*** [6.408]	ΔIA_{t-2}^{-}	0.143*** [2.795]	$\Delta INTV_{t-12}^{+}$	0.007* [1.849]	ΔNDF_{t-5}^{-}	0.261*** [3.227]	ΔCF_{t-7}^{-}	-0.025** [2.240]
NDF_{t-1}^{-}	0.218*** [5.878]	ΔIA_{t-3}^{-}	-0.149*** [3.072]	$\Delta INTV_{t-1}^{-}$	0.064*** [-5.008]	ΔNDF_{t-6}^{-}	0.208*** [2.859]		
CF_{t-1}^{+}	-0.067*** [-3.600]	ΔIA_{t-4}^{-}	0.089* [1.876]	$\Delta INTV_{t-3}^{-}$	0.068*** [-6.280]	ΔCF_{t-4}^{+}	-0.045*** [3.006]		
CF_{t-1}^{-}	-0.073*** [-3.955]	ΔIA_{t-9}^{-}	-0.170*** [-4.899]	$\Delta INTV_{t-4}^{-}$	0.054*** [-4.850]	ΔCF_{t-7}^{+}	-0.030*** [2.999]		
Long-term transmission effect									
	L_{IA}^{+}	-1.337***	L_{INTV}^{+}	0.323***	L_{NDF}^{+}	0.873***	L_{CF}^{+}	-0.286***	
	L_{IA}^{-}	-1.691***	L_{INTV}^{-}	0.327***	L_{NDF}^{-}	0.925***	L_{CF}^{-}	-0.309***	
Model statistics and diagnosis									
	F_{PSS}	12.173*** (0.000)		***Adj.*** R^2	0.845		***AIC***	-4.678	
	t_{BDM}	-6.222*** (0.000)		χ^2_{SC}	1.459 (0.164)		***SC***	-3.114	
	W_{SR}^{IA}	30.611*** (0.000)	W_{SR}^{INTV}	28.911*** (0.000)	W_{SR}^{NDF}	7.536*** (0.008)	W_{SR}^{CF}	14.454*** (0.000)	
	W_{LR}^{IA}	14.757*** (0.000)	W_{LR}^{INTV}	0.231 (0.632)	W_{LR}^{NDF}	0.199 (0.657)	W_{LR}^{CF}	3.493* (0.066)	

*Note: The superscripts "–" and "+" represent the negative component and positive component of the underlying factors. The numbers in brackets are the t-values and the numbers in parentheses are the p-values. *, ** and *** represent significance at 10%, 5% and 1% level.*

First of all, as shown in Table 3, the estimated long-term coefficients of investor attention are significant and show negative signs, implying that CNY exchange rates are positively affected by the composite investor attention. Besides, the long-term impact of a decrease in investor attention defeats the impact of an increase, suggesting that CNY exchange rates are more vulnerable to negative

fluctuations in investor attention in the long term. This may be because continuous negative changes can easily lead to damage to investors' interests, and on this basis, it is easier to magnify the panic in the market. Similarly, in the short term, the cumulative impact coefficients show negative signs, which indicates that the CNY exchange rates are also negatively affected by investor attention in the short term. However, different from the result of the long-term, the effect of positive shocks on investor attention is pronounced than that of negative shocks, indicating that the CNY exchange rate shows a stronger response to investor attention rising in the short-run. An interpretation for these findings is that under the context of soaring investor attention in the short run, the FX market trading will become more active. Consequently, *Ceteris paribus*, increasing investor attention might cause international investments into China to become more vigorous than other emerging countries, which may finally result in an appreciation of the CNY exchange rates in this context.

Second, the FX interventions also exert an obvious asymmetric long-run impact on the CNY exchange rates and we also notice that the long-run effect of the decrease in the FX interventions slightly defeats the effect of the increase (purchases of foreign exchange), suggesting that the CNY exchange rates are more vulnerable to negative fluctuations in the FX interventions (oversells of foreign exchange) in the long term. From the short-run perspective, a significant lag effect also exists concerning the influence of negative and positive shocks on the CNY exchange rates. The short cumulative effect of the FX interventions in the negative shock beats the positive shock that is the same as the long-term effect. The result of the empirical research indicates that the oversells of foreign exchange by PBOC play more important roles in affecting the CNY exchange rates in the long term. One possible explanation is that when the PBOC carries out continuing negative FX interventions, it would release a strong signal that the CNY exchange rate has pressure to depreciate. This foreign exchange market operation may be a consequence of large-scale capital outflows that is the fact of China after the stock market crash in 2015 (Li et al., 2020). Although the RMB exchange rate system has undergone major reforms since 2005, the differential management between current and capital accounts, the restrictions of the number of foreign exchange holdings, and the limits of exchange rate fluctuations still exist in the onshore CNY market (Li *et al.*, 2020). These facts can explain to some extent the asymmetric responses of the CNY exchange rate to the FX intervention.

Besides, the estimated long-run coefficients of RMB exchange rate expectations are significant and show positive signs, indicating that the CNY exchange rates are positively affected by the RMB exchange rate expectations in the long term. This finding signifies that the CNY exchange rate has a self-reinforcing anticipation mechanism. Moreover, the long-term impact of the decrease in the RMB exchange rate expectations dominates the impact of the increase, suggesting that the CNY exchange rates are more sensitive to the RMB exchange rate appreciation expectations in the long run. The main reason is the

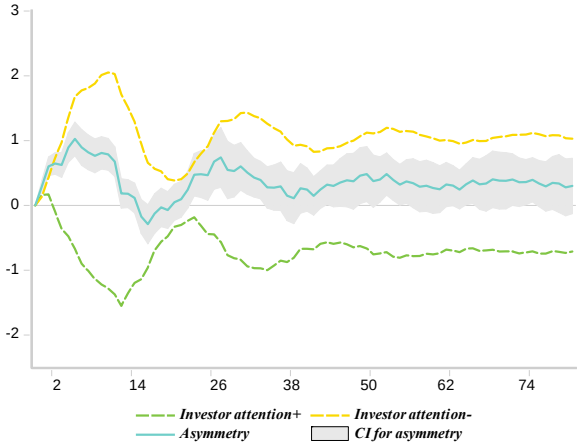
unilateral appreciation of the CNY exchange rate for a long time. In contrast, the CNY exchange rates show a stronger response to the RMB depreciation expectation in the short term. That's because that when investors expect the CNY to depreciate in the short-run, it will cause a whacking panic in the market, resulting in investors increasing their expectations of the continuous depreciation of the CNY exchange rates, which in turn induces irrational movements of the CNY exchange rates.

Last, from the results of Table 3, we can notice that the asymmetric long-run coefficient of the capital flows shows a negative sign. Besides, the response of the CNY exchange rates to negative shocks in the capital flows is stronger and more significant than positive shocks, suggesting that the capital outflow has a greater impact on the devaluation of the CNY exchange rate in the long term. Besides, in the short term, the impact of the capital flows on the CNY exchange rates is significantly lagged. However, we find that the short cumulative effect of the capital flows in the positive shock defeats the negative shock, indicating that the capital inflow has a more significant effect on the appreciation of the CNY exchange rates in the short term. The underlying reason might be the recent scenario of the FX market in China that short-term capital inflow and long-term capital outflow coexist. Moreover, appreciations of CNY exchange rates are more vulnerable to positive fluctuation to capital inflows in the short term. When capital inflows increase, all else equal, the demands for foreign exchange increase too, and the exchange rate of the domestic currency will appreciate, compared to foreign currency. However, the advantages of low labor costs, low land costs, and low environmental costs are not there in China. The pressure of capital outflow is greater than the pressure of capital inflow. Therefore, devaluations of the CNY exchange rate are more vulnerable to negative fluctuations in capital outflows in the long run.

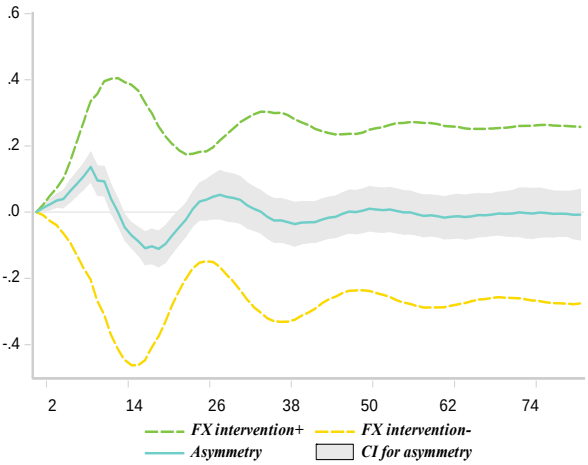
Furthermore, based on equation (7), this paper also draws the dynamic multipliers that indicate the adjustment speed of the latent factors for CNY exchange rates from the short-dated disequilibrium to a new long-standing equilibrium. Figure 2 shows the estimation result of dynamic multipliers. The broken yellow line means the negative change and the broken green line represents the positive change, which indicates the adjustments of the underlying factors to one-unit negative shock and positive shock to the CNY exchange rates. Moreover, the continuous blue line means the asymmetry curve, which reflects a linear combination of the dynamic positive and negative multipliers. Besides, the light grey bands are the 95% confidence areas.

Figure 2 (*a.2*) shows the response of the CNY exchange rates to one-unit shock (positive or negative) in the investor attention. The graph shows that there is a clear inverse linkage between investor attention and the CNY exchange rates. Moreover, we can also notice that the effect of negative shock in the investor attention beats that of a positive shock, which is consistent with the asymmetric long-run coefficients from the NARDL model. In addition, a new long-run

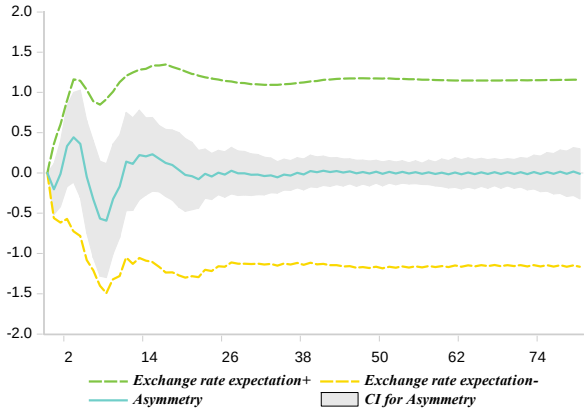
equilibrium of the CNY exchange rates will be reached approximately 36-38 months. In a similar vein, the dynamic reaction of the CNY exchange rates to a unit shock (positive or negative) in the FX intervention is presented in Figure 2 (*b.2*), which indicates that there is a positive relationship between the CNY exchange rates and the FX intervention both in the short- and long-term. Besides, the new stability will be achieved after about 36-38 months.



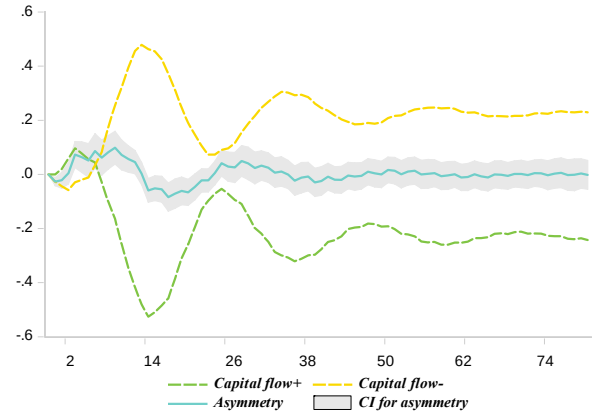
(*a.2*) Cumulative dynamic multipliers for *IA*



(*b.2*) Cumulative dynamic multipliers for *INTV*



(*c.2*) Cumulative dynamic multipliers for *NDF*



(*d.2*) Cumulative dynamic multipliers for *CF*

Figure 2. (a.2-d.2) The dynamic multipliers for each underlying determinant.

Figure 2 (*c.2*) illustrates the response of the CNY exchange rates to one-unit shock (positive or negative) in the RMB exchange rate expectations. The graph displays a positive linkage between the CNY exchange rates and the RMB exchange rate expectations. The influence of a negative shock in the RMB exchange rate expectations dominates that of a positive shock. In addition, after approximately 20-24 months, the CNY exchange rates achieve a new equilibrium, which is the faster adjustment speed among other latent determinants. Last, Figure 2 (*d.2*) shows the dynamic adjustment of the CNY exchange rates to a unit shock (positive or negative) in the capital flows. The negative relationship between the CNY exchange rates and the capital flows is also found and the CNY exchange

rates reach a new long-run balance after approximately 34-36 months. Overall, the dynamic multipliers calculated from equation (7) further verify the asymmetric influence of underlying factors on the CNY exchange rates.

5. Conclusion

This paper detects the influences of latent drivers on the CNY exchange rates, considering the possible asymmetric impacts of each factor. Specifically, we attempt to explore whether the investor attention changes affect the CNY exchange rate movements. In particular, based on the Google Trends, we build a novel investor attention index by using the PCA method, and then incorporate the composite index into the other determinants we consider, that is, the FX intervention, the exchange rate expectations, and the capital flows. Under the NARDL model estimation, the empirical results show that positive shocks to the composite investor attention will lead to appreciating CNY exchange rates. This implies that the aligned investor attention shocks can give beneficial information to help policymakers and investors predict the CNY exchange rate movements. The results also uncover significant asymmetric influences of the relevant factors on the CNY exchange rates, suggesting that the linear approaches performed by previous researches are unsuitable to seize the actual response process of the CNY exchange rates. We also find that the FX interventions, the exchange rate expectations, and capital flows play pivotal roles in the nonlinear adjustment of the CNY exchange rates.

The findings provide several important implications. First, for authorities, to accelerate the RMB internationalization, the Chinese government should further reduce interventions in the FX markets and stabilize the movement of CNY exchange rates to promote exchange rate marketization. Second, investors can better use the dynamics of the novel investor attention index to help them to predict the movement of CNY exchange rates and to alter asset allocation in time depending on the fluctuations of the financial conditions. Besides, the CNY exchange rate expectation has a self-reinforcing anticipation mechanism. Excessive expectations are not conducive to the stability of the CNY exchange rates. Therefore, to maintain the steady movement of CNY exchange rates, the market regulators and policymakers should take initiatives and manage the exchange rate expectations of the public.

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