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IS THERE THE J-CURVE EFFECT IN CHINA? – BASED ON NARDL MODEL ANALYSIS

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Abstract. *This paper uses NARDL model to conduct an empirical analysis on the long-term and short-term asymmetry between exchange rate fluctuations and trade balance between the U.S. and China. The results show that: in the long run, the RMB exchange rate has an asymmetric effect, and the depreciation of the RMB can promote China's exports; however, the appreciation of the RMB could not significantly affect the China's exports. In the short run, both appreciation and depreciation of the RMB have little effect on the China's exports. So, based on above analysis, we do not think there is a J-curve effect in China.*
Keywords: RMB exchange rate, NARDL, Import and export trade, J-curve effect

1. **Introduction.** Exchange rate plays a crucial role in determining the volume of trade among nations, many scholars studied the impact of exchange rate on export trade, but did not reach a consistent conclusion. Some research results show that exchange rate fluctuations have no significant impact on import and export trade. In [1], Rose and Yellen studied the relationship between bilateral trade between the United States and G-7 and found that exchange rate fluctuations have no significant impact on export trade between these countries. [2] found there was no significant causal relationship between the RMB exchange rate and the trade deficit between China and the United States. We refer readers to [3], Baek used ARDL model to analyze the J-curve effect of US-Canada trade, and the results showed that the depreciation of the US dollar had no significant impact on US-Canada trade, that is, there was no J-curve effect between the two countries. In [4], Li and Huang analyzed the long-term and short-term impact of the real effective exchange rate of RMB on China's export, and found that the change of the real effective exchange rate did not significantly affect the export. We refer readers to [5], Gan and Yin believed that although China still has some advantages in export, if the RMB continues to appreciate, the advantages of exports will disappear.

Some scholars do not agree with this view. They believe that exchange rate fluctuations can significantly affect import and export trade. We refer readers to [6], Magee first considered the time factor of exchange rate adjustment to trade, and proposed the definition of the J-curve effect. In [7], Meade found J-curve effect was obvious in those countries with flexible exchange rate floating mechanism. [8] used the Rubinstein bargaining model to study the trade balance of South Korea, and the results showed that the J-curve effect was significant and restricted by the price pass-through effect. We refer readers to [9], Boyd et al. used Vector Autoregressive Distributed Lag (VARDL) model to analyze the effect of exchange rate changes on balance of payments in OCED countries, the results showed that exchange rate changes could significantly affect the import and export trade among five countries, so they thought Marshall-Lerner condition is true. [10] found that

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RMB exchange rate fluctuations have some differences in the short-term and long-term impact on trade. In the short-term, exchange rate fluctuations have a negative impact on both imports and exports; compared to exports, exchange rate fluctuations influence the import more heavily. In the long run, exchange rate fluctuations can reduce China's foreign trade surplus. In [11], Yang and Zhong drew the conclusion that the anti-J-curve effect appeared in China based on the export trade data of China from 2007 to 2008. We refer readers to [12], Chiu et al. used the heterogeneous panel co-integration method to study the bilateral trade data between the United States and 97 trading countries from 1973 to 2006, and they found that the depreciation of the dollar would worsen the bilateral trade with 13 trading countries and improve the bilateral trade with 37 trading countries. [13] used the error correction model to conduct an empirical test on whether there is J-curve effect in Nordic countries, and the research results supported the J-curve effect. In [14], Han and Liu used granger causality test to study the trade relations between China and 13 major trading partners, and they found the depreciation of RMB exchange rate would improve China's trade balance with most countries in the long run, which also supported the J-curve effect. We refer readers to [15], Bahmani-Oskooee et al. believed that in the short term, South Korean currency depreciation can promote exports, but this effect was not obvious in the long term. [16] showed that there is a J-curve effect between China and seven economies, and for other six countries, exchange rate depreciation would deteriorate the bilateral trade towards China. In [17], Yazgan and Ozturk found that a real depreciation will be favorable to the home country's trade balance in the long run; however, the results do not support the Marshall-Lerner condition, and there is no evidence for the J-curve effect. We refer readers to [18], Gürtler studied the J-curve phenomenon in the Czech economy, and the real effective exchange rate has a strongly negative effect on trade balance in the short run; however, replaced with a positive one in the long run, thus confirm the J-curve phenomenon.

To sum up, most scholars have studied the relationship between exchange rate and foreign trade from the perspective of symmetry and linearity. However, with the continuous deepening reform of RMB exchange rate, two-way fluctuation of RMB exchange rate is increasingly significant, depreciation and appreciation phenomena appear alternately, exchange rate fluctuations are highly asymmetric, and most of the existing literature on J-curve effect mainly uses the vector autoregression, cointegration and error correction model, ignoring the nonlinear effects. So, we use the NARDL (Nonlinear Autoregressive Distributed Lag, hereinafter referred to as NARDL) model, which is proposed by Shin et al. [19], to study the dynamic effect of the RMB appreciation and depreciation on the import and export between the United States and China, and the research results provide theoretical basis for making the differentiation foreign trade policy.

2. **Model Selection and Setting.** This paper constructs the following long-term import and export demand models by Goldstein and Khan [20]:

$$\ln IM = \alpha + \beta_1 \ln REX + \beta_2 \ln Y \tag{1}$$

$$\ln EX = \alpha^* - \beta_1^* \ln REX + \beta_2^* \ln Y^* \tag{2}$$

where IM and EX respectively represent China's import and export, REX is the real exchange rate between the United States and China, Y represents the real income of China, Y^* is the real income of the United States, β_1 and β_1^* respectively represent China and the United States' price elasticity of imports and exports, β_2 and β_2^* respectively represent China and the United States' income elasticity of imports and exports, and if TB represents the change of China's trade towards to the United States, then

$$TB = IM/(EX * REX) \tag{3}$$

Taking the logarithm of both sides, we can get

$$\ln TB = \ln IM - \ln EX - \ln REX \tag{4}$$

Substituting (1) and (2) into (4), get

$$\ln TB = (\alpha - \alpha^*) + (\beta_1 + \beta_1^* - 1)\ln REX + \beta_2 \ln Y - \beta_2^* \ln Y^* \tag{5}$$

The coefficient of $\ln REX$, namely $\beta_1 + \beta_1^* - 1$, is the Marshall-Lerner condition, if the sum of the elasticity of import and export demand is more than 1, the depreciation of RMB will be good for China's export, if simplifying model (5), we can get model (6):

$$\ln TB_t = a + b \ln Y_t + c \ln Y_t^* + d \ln REX_t + \varepsilon_t \tag{6}$$

If the coefficient d gradually changes from negative to positive in Equation (6), it indicates J-curve effect exists. Model (6) describes the long-term relationship among the variables; however, model (6) could not test the short-term effect among these variables. Considering the short-term effect, model (6) can be adjusted as follows:

$$\begin{aligned} \Delta \ln TB_t = {} & a + \sum_{j=1}^{n} b_{t-j} \Delta \ln TB_{t-j} + \sum_{j=0}^{n} c_{t-j} \Delta \ln Y_{t-j} + \sum_{j=0}^{n} d_{t-j} \Delta \ln Y_{t-1}^* \\ & + \sum_{j=0}^{n} \pi_{t-j} \Delta \ln REX_{t-1} + \lambda_0 \ln TB_{t-1} + \lambda_1 \ln Y_{t-1} + \lambda_2 \ln Y_{t-1}^* \\ & + \lambda_3 \ln REX_{t-1} + \mu_t \end{aligned} \tag{7}$$

In order to test whether there is a co-integration relationship between variables, Pesaran et al. [21] proposed the F test for joint significance of lag level variables for the large sample. However, the asymmetric effects of RMB appreciation and depreciation are not taken into account in model (7), so we decompose the RMB exchange rate into two parts: appreciation and depreciation, $\Delta \ln REX^+$ and $\Delta \ln REX^-$ respectively represent the change of RMB appreciation and RMB depreciation, and we can get two new variables:

$$POS = \ln REX_t^+ = \sum_{j=1}^{t} \Delta \ln REX^+ = \sum_{j=1}^{t} \max(\Delta \ln REX, 0) \tag{8}$$

$$NEG = \ln REX_t^- = \sum_{j=1}^{t} \Delta \ln REX^- = \sum_{j=1}^{t} \min(\Delta \ln REX, 0) \tag{9}$$

where POS and NEG represent the total part of RMB appreciation and depreciation respectively. The nonlinear autoregressive distributed lag model can be obtained by using POS and NEG to substitute REX of Equation (10):

$$\begin{aligned} \Delta \ln TB_t = {} & a' + \sum_{j=1}^{n} b_j' \Delta \ln TB_{t-j} + \sum_{j=0}^{n} c_j' \Delta \ln Y_{t-j} + \sum_{j=0}^{n} d_j' \Delta \ln Y_{t-j}^* \\ & + \sum_{j=0}^{n} e_j' \Delta \ln POS_{t-j} + \sum_{j=0}^{n} f_j' \Delta \ln NEG_{t-j} + \theta_0 \ln TB_{t-1} \\ & + \theta_1 \ln Y_{t-1} + \theta_2 \ln Y_{t-1}^* + \theta_3 POS_{t-1} + \theta_4 NEG_{t-1} + \xi_t \end{aligned} \tag{10}$$

According to model (10), we can analyze the long-term and short-term asymmetric effects of RMB appreciation and depreciation on China's import and export trade. If the coefficients are different, it means that RMB appreciation and depreciation have long-term asymmetric effects. If the sizes and lag orders of ΔPOS and ΔNEG coefficients are different, then it indicates that there would be short-term asymmetry of import and export trade between RMB appreciation and depreciation.

To verify the asymmetry effect between RMB exchange rate and international trade, different constraints can be imposed on the parameters of model (10), which can be divided into the following four models:

1) Long-term and short-term symmetric model: $\sum e' = \sum f'$ and $\theta_3 = \theta_4$;
2) Short-term symmetric and long-term asymmetric models: $\sum e' = \sum f'$;
3) Short-term asymmetric and long-term symmetric models: $\theta_3 = \theta_4$;
4) Short-term and long-term asymmetric model, namely unconstrained model.

3. **Empirical Test and Analysis.** As the United States is the largest trade partner of China, we use NARDL model to study the effect of RMB exchange rate fluctuations on Sino-US trade. This paper uses the monthly data from January 1999 to December 2017 as the sample. As the GDP is the quarterly or annual data, we use industrial production index as the proxy variable of income level, data on exchange rates, foreign trade and income levels are all from the CEIC database. In this paper, all the data are seasonally adjusted. Meanwhile, in order to reduce heteroscedasticity of time series data, all the data are logarithmically processed.

All variables should be as I (0) or I (1) in NARDL model, so we should conduct the unit root test of all variables before the empirical analysis. Table 1 shows all variables to reject the null hypothesis under 5% significance level, it means that all variables are I (0) or I (1), and it satisfies the assumptions of the NARDL model. Before the empirical test, the model needs to determine the lag order of the variables, Shin et al. [20] suggested we should choose more lags as we could, when using NARDL model, so we set p and q as 12 respectively, and then eliminate the lag variables which are not significant on the 5% level.

Table 1. Unit root test results

Sample	Variable	The lags	t-value	P-value
China	$\ln Y$	0	-5.983	0.000
U.S.	$\ln TB$	0	-6.651	0.000
U.S.	$\ln Y$	0	-2.865	0.049
U.S.	$\ln REX$	0	-0.834	0.809
U.S.	$\ln REX$	1	-11.441	0.000

In Table 2, according to the test, the t_BDM coefficient is significant at the statistical level of 5%, which means that there is a long-term co-integration relationship between RMB exchange rate fluctuations and Sino-US trade, the long-term Wald test coefficient of the United States is 36.35, which is significant at the statistical level of 1%, while the short-term Wald test coefficient does not pass the significance test, indicating that the RMB exchange rate fluctuations have long-term and short-term symmetric effects on Sino-US trade.

In Table 3, the coefficient of the negative RMB fluctuations is significantly positive, it indicates that the long-term depreciation of the RMB is conducive to the trade surplus between China and the United States, however, the coefficient of positive exchange rate

Table 2. Asymmetry test of NARDL model

Asymmetric co-integration test		**Short-long term asymmetry test**	
t_BDM	-11.202***	W_{LR}	36.35***
F_PSS	25.465***	W_{SR}	0.857

Note: W_{LR} and W_{SR} Wald test, represent long-term asymmetry and short-term asymmetry respectively. *, ** and *** respectively indicate that the null hypothesis is rejected at the significance level of 10%, 5% and 1%.

is not significant, and it shows that the long-term appreciation of the RMB could not affect Sino-US trade. In the short term, we find that neither the appreciation of nor the depreciation of the RMB has significant impact on China-US trade. That is to say, the expectation of exchange rate will affect Sino-US trade, while the short-term exchange rate fluctuations will not significantly affect Sino-US trade.

Table 3. The estimation results of NARDL model

Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
$\ln TB_{t-1}$	-0.621^{***} (-11.20)	$\Delta \ln TB_{t-7}$	-0.125^{**} (-2.33)	$\Delta \ln Y^-_{t-2}$	-2.309^{**} (-2.37)
$\ln Y^+_{t-1}$	0.576^{***} (2.84)	$\Delta \ln TB_{t-8}$	-0.101^{*} (-1.76)	$\Delta \ln Y^-_{t-5}$	3.109^{***} (3.60)
$\ln Y^-_{t-1}$	0.078 (0.37)	$\Delta \ln TB_{t-10}$	-0.149^{***} (-2.86)	C	0.386^{***} (8.26)
POS_{t-1}	0.054 (0.27)	$\Delta \ln Y^+_{t-2}$	3.910^{***} (4.54)		
NEG_{t-1}	1.526^{***} (6.05)	$\Delta \ln Y^+_{t-8}$	-2.195^{***} (-3.00)		
$Adj - R^2$			0.642		
$RESET$			0.479		
AIC			-14.062^{*}		
SIC			-13.638^{*}		

Notes: *, ** and *** indicate significance levels of 10, 5 and 1 percent respectively, and C indicates the constant.

4. **Conclusion.** This paper uses NARDL model to conduct an empirical analysis on the long-term and short-term asymmetry between exchange rate fluctuations and trade balance between China, and find that in the long term the depreciation of the RMB can promote China's exports; however, the appreciation of the RMB could not significantly affect the China's exports. In the short run, both appreciation and depreciation of the RMB have little effect on the China's exports. So, we do not think there is a J-curve effect in China.

Generally speaking, the sensitive degree of exchange rate on different industries and enterprises is different, however, this paper does not analyze the specific impact of exchange rate on trade from the perspective of industries and enterprises, and we will study and test how the different industries are responsive to exchange rate in the future.

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