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How the real exchange rates of RMB and wage ratio changes affect export import industries fluctuations?

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Abstract

Background/Objective: The purpose of this paper is to reveal the effect of real exchange rate changes on export-import proportion and industries' export or import proportion under the average wage ratio change using ARMA. Methods/Statistical analysis: Using ARMA and Panel data Model, after inferring a new formula according to the firms' heterogeneity model and rural-led real exchange rate appreciation (RERA) model. Findings: Given the average changes of wage ratio, the real exchange rate appreciation can lead to the decrease of proportion of export industries, lead to the increase of proportion of import industries, vice versa. Improvement/Application: To further verify these effects, the robust estimations in ARMA and Panel data model using monthly industry-data from manufacturing industry-data (1996-2019, inedible raw material, chemical products and machinery-transportation equipment) and the whole export industry-data (1994-2019) between the U.S. and China suggest the similar results.

Index Terms

Proportional Changes on exports and imports, Real Exchange Rate, Wage Ratio Change, RMB, ARIMA

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I. INTRODUCTION

In earlier theoretical studies, based on the restrictive assumptions--perfectly competitive market and risk aversion etc., Clark (1973) analyzes the negative relationship between trade and real exchange rate changes. However after relaxing these assumptions, McKenzie (1999) and Clark et al. (2004) find that there is no certain relationship between them.

Hondroyiannis (2005) and Altintas (2011) find that real exchange rate changes have no significant influence or positive influence on exports and imports. Baron (1976a) analyzes the increase of real exchange rate changes will reduce the trade level. Dellas and Zilberfarb (1993) find that real exchange rate has positive effect to trade using portfolio selection model.

In theoretical studies, the effects of real exchange rate on trade have no consistent conclusions. Domestic scholars also find similar results for firms' trade using the estimated models. Gu yu and Gao tiemei (2007) suggest that real exchange rate changes have positive effects on exports and imports in long term.

Chen liufu et al. (2007) studies the effects of real exchange rate changes on different firms' trade; he finds that real exchange rate changes have positive or negative shocks to firms' export. These studies also did not obtain consistent conclusions.

Under the assumptions of increasing returns to scale and imperfect competition, Helpman (2006) and Melitz (2003) present the effect of exchange rate movements on trade using firm-heterogeneity models. They also analyze the effect of exchange rate changes on intra-industry productivity.

Furthermore, Cardi and Restout (2015) revise the Balassa-Samuleson model by considering imperfect labor mobility across sectors and physical capital accumulation. They reveal the relationship between wage ratio of tradables to nontradables and real exchange rate changes.

Gordon Menzies and Sylvia Xiao (2016) find that the increase of wage ratio and factor productivity proportion leads to the real exchange rate appreciation by using GEM model. They suggest that the movement of the agriculture to non-agriculture wage ratio attribute around one of third appreciation of the real exchange rate in China.

Hiruyuki (2017) finds that the yen depreciation raises industry-wide productivity with a fixed effects model using firm-level data from the Japanese manufacturing industry. Not all of previous studies consider the relationship between exchange rate volatile and trade changes in the context of wage growth rate.

The purpose of this paper is to reveal the effect of real exchange rate changes on export-import proportion and industries' export or import proportion under the average wage ratio change using ARMA and Panel data Model, after inferring a new formula according to the firms' heterogeneity model and rural-led real exchange rate appreciation (RERA) model.

These effects will be verified by using the U.S.-China trade data and firm-level data. There are two innovations from proportions of export and import in this paper.

From export aspect, real exchange rate appreciation will lead to export increase if average wage ratio keeps positive growth; real exchange rate appreciation will lead to export decrease if average wage ratio keeps negative growth; real exchange rate appreciation will lead to export decrease if average wage ration change from negative to positive, vice versa.

From import aspect, real exchange rate appreciation will lead to import decrease if average wage ratio keeps positive growth; real exchange rate appreciation will lead to import increase if average wage ratio keeps negative growth; real exchange rate appreciation will lead to import increase if average wage ration change from negative to positive, vice versa.

This paper is organized as follows: Section 2 develops the model with trade, real exchange rate changes and wage ratio change. Section 3 empirically examines the effects of real exchange rate changes on import and export proportions. Section 4 presents the conclusions.

II. THE MODEL

In this section, we build the equilibrium trade model with a combination of RERA and firm-heterogeneity model, which is essentially based on that of Hiruyuki (2017) and Gordon Menzies and Sylvia Xiao (2016). In the firm-heterogeneity model, four types of firms (domestic, export, VFDI and HFDI firms) are introduced. The utility maximization functions yield $x_i(v) = p_i(v)^{1-\sigma} P^{\sigma-1}$ and $x_i^*(v) = p_i^*(v)^{1-\sigma} P^{*\sigma-1} E^*$, where σ >1 is the elasticity of substitution between any two goods in terms of the whole exports and three export industries (inedible raw material, chemical products and machinery-transportation equipment) in this paper. p is the price of goods, E is the aggregate expenditure, which is exogenously given, P and P^* are price indexes.

The revenue functions of export (r=px) are shown as follows:

$r^*_{export} = \left(\frac{\tau\omega}{eP^*\rho\theta}\right)^{1-\sigma} E^*$, where e is nominal exchange rate, ω is home wage. if $e^r = 1/\frac{eP^*}{P}$ is the real exchange rate, we obtain

$$r^*_{exort} = \left(\frac{\tau\omega e^r}{P\rho\theta}\right)^{1-\sigma} E^* \qquad (1)$$

According to the RERA model, the production functions for the tradable and nontradable sector as follow:

$$Y_T = A_T K_T^{\alpha_T} L_T^{1-\alpha_T}$$
$$Y_N = A_N K_N^{\alpha_N} L_N^{1-\alpha_N}$$

α_i is the total factor productivity parameters, K_i is the capital input, L_i is labor input, and where $i = \{T,N\}$. The labor supply is normalized to unity, $L_T + L_N = 1$.

For a representative agent, the utility function is, $U= C_N^{\theta} C_T^{1-\theta}$, where nontradable consumption is a share θ of total labor income while tradable consumption is a share of 1- θ of total labor income.

Let s be the norminal exchange rate and an increase in s is an appreciation. The real exchange CPI rate is sp/p^*, where p and p^* are the local price and foreign price level. Let both p and p^*be a cobb-douglas price index: $p = P_T^{\mu} P_N^{1-\mu}$ and $p^* = (P_T^*)^{\mu}(P_N^*)^{1-\mu}$. Suppose the law of one price holds for trade goods and the foreign price is fixed, the real exchange rate can be relative price $p=P_N$, which is equivalent to e^r.

Using these formulas, we have

$$e^r = \varphi^{1-\alpha_N} \frac{A_T^{(1-\alpha_N)/(1-\alpha_T)} \gamma^{(\alpha_N-\alpha_T)/(1-\alpha_T)}}{A_N} * \left[\frac{(1-\alpha_T)\alpha_T^{\alpha_T/(1-\alpha_T)}}{(1-\alpha_N)\alpha_N^{\alpha_N/(1-\alpha_N)}}\right]^{1-\alpha_N} \qquad (2)$$

Where $\varphi = \frac{W_N}{W_T}$ is the wage ratio between nontradable and tradable, γ is marginal products of tradable capital, $0< \alpha_N, \alpha_T < 1$.

From export industries level, we differentiate the formula (1),

$$\partial r^*_{export} / r^*_{export} \Big/ \partial\varphi/\varphi = (1-\sigma)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda/e^r < 0 \qquad (3)$$

Where

$$\lambda = \frac{A_T^{(1-\alpha_N)/(1-\alpha_T)} \gamma^{(\alpha_N-\alpha_T)/(1-\alpha_T)}}{A_N} * \left[\frac{(1-\alpha_T)\alpha_T^{\alpha_T/(1-\alpha_T)}}{(1-\alpha_N)\alpha_N^{\alpha_N/(1-\alpha_N)}}\right]^{1-\alpha_N} > 0, \text{ and}$$

$(1-\sigma)(1-\alpha_N) < 0$.

Supposed that other conditions are unchanged and $\sigma > 1$, if ${e_1}^r$ increases to ${e_2}^r$ (home currency appreciation),

$$(1-\sigma)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda/{e_1}^r - (1-\sigma)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda/{e_2}^r = (1-\sigma)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda({e_2}^r-{e_1}^r)/{e_1}^r{e_2}^r < 0,$$

The increase of e^r leads to the increase of formula (3). This leads to an increase of the proportions of whole exports and three export firms with a positive and constant change of wage ratio, and leads to a decrease of the proportions of whole exports and three export firms with a negative and constant change of wage ratio.

The following recommendations can be drawn:

Proposition 1: if a positive and constant change of wage ratio exists, real exchange rate appreciation raises the proportions of the whole exports and three export firms, vice versa.

Proposition 2: if a negative and constant change of wage ratio exists, real exchange rate appreciation lowers the proportion of the whole exports and three export firms, vice versa.

Proposition 3: if a negative and constant change of wage ratio converts to a positive and constant one, real exchange rate appreciation lowers the proportion of the whole exports and three export firms, vice versa.

The revenue functions of import are shown as follows:

$r_{import} = \left(\frac{\tau e\omega^*}{P\rho\theta}\right)^{1-\sigma} E$, where e is nominal exchange rate, ω^* is foreign wage. If $e^r = 1/\frac{eP^*}{P}$ is the real exchange rate, we obtain

$$r_{import} = \left(\frac{\tau\omega^*}{e^r P^*\rho\theta}\right)^{1-\sigma} E \qquad (4)$$

From import industries level, we differentiate the

formula (4),

$$\partial r_{import}/r_{import} \Big/ \partial\varphi/\varphi = (\sigma-1)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda/e^r > 0 \quad (5)$$

Where

$$\lambda = \frac{A_T^{(1-\alpha_N)/(1-\alpha_T)}\gamma^{(\alpha_N-\alpha_T)/(1-\alpha_T)}}{A_N} * \left[\frac{(1-\alpha_T)\alpha_T^{\alpha_T/(1-\alpha_T)}}{(1-\alpha_N)\alpha_N^{\alpha_N/(1-\alpha_N)}}\right]^{1-\alpha_N} > 0,$$

And $(\sigma-1)(1-\alpha_N) > 0$.

We set $(\sigma-1)(1-\alpha_N)\varphi^{1-\alpha_N}\lambda = \beta$, then $\frac{\beta}{e_1^r} - \frac{\beta}{e_2^r} = \frac{\beta(e_2^r - e_1^r)}{e_1^r e_2^r} > 0.$

Supposed that other conditions are unchanged and $\sigma > 1$, if e_1^r increases to e_2^r (home currency appreciation), the following recommendations also can be drawn:

Proposition 4: if a positive and constant change of wage ratio exists, real exchange rate appreciation lowers the proportions of the whole imports and three import firms, vice versa.

Proposition 5: if a negative and constant change of wage ratio exists, real exchange rate appreciation raises the proportion of the whole imports and three import firms, vice versa.

Proposition 6: if a negative and constant change of wage ratio converts to a positive and constant one, real exchange rate appreciation raises the proportion of the whole imports and three import firms, vice versa.

III. Empirical Investigation

The ambiguous results in section 2 motivates us to further examine the linkage of real exchange rate and export industries with a constant change of wage ratio between the U.S. and China empirically. This section presents the estimated results, which are obtained from the ARMA and Panel data model using the whole import-export from January 1994 to October 2019 and firm-level import-export data from January 1996 to October 2019.

Data source: the Wind database and China Statistical Yearbook (1997-2020). In this paper, we focus on the import-export firms of China: inedible raw material, chemical products and machinery-transportation equipment. We estimate the following specification:

$$\log(import_{i,t} \text{ or } export_{i,t}) = \beta_0 + \beta_{i,t}\log(reer_{i,t}) + \delta_i + \varepsilon_{i,t} \quad (6)$$

Where i is a firm's individual identification code, $export_{i,t}$ is the exports of industry i in month t; $import_{i,t}$ is the imports of industry i in month t, $reer_{i,t}$ (it is defined as $reer_{i,t} = s_{i,t}p_{i,t}/p^*_{i,t}$, where $s_{i,t}$ is the nominal exchange rate, $p_{i,t}$ is the weighted CPI for China, $p^*_{i,t}$ is the weighted CPI for the U.S.) is the real exchange rate between the U.S. and China. Generally, the increase in $reer_{i,t}$ represents a real appreciation in currency.

The δ_i is a firm's fixed effects, and $\varepsilon_{i,t}$ is the disturbance term. If we estimate ARMA model using the whole export data, the subscript i will be disappeared in formula (4).

Considering a change of wage ratio, the ratio between rural and urban per capita disposable income is presented in Figure 1, which is viewed as a measure of wage ratio. We find that the changes of wage ratio keep stable; it has ranged from -3% to +3.4%. The average change of wage ratio is about -0.39% from 1994 to 2005, but is about 0.58% from 2006 to 2019.

Under the average change of wage ratio, the linkage between real exchange rate and export trade is further estimated using the ARMA and Panel data model.

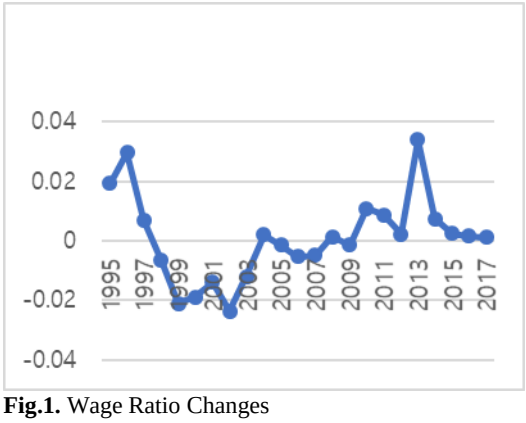

Fig.1. Wage Ratio Changes

First, the heteroscedasticity test suggests that the null hypothesis is rejected (Probability>Chi=0.003). We adopt the robust estimation in ARMA model; the results are shown in Table 1. The coefficient β is

2.016 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise the whole exports proportion from 1994 to 2005.

Table 1. Results of Robust Estimation of Export in the ARMA Model (1994-2005)

NO. of obs= 144

Optimization: ARMA **Residual df = 142**

AIC=-.011869 Wald chi2(2)=19.09
R^2=0.5637 Prob > chi2=0.003

Log likelihood =73.3367

	Coef.	**Z**	**P**	**95%Conf.Inter**	
Log (reer)	2.01	13	0.00	1.08	1.45
Con	4.44	10	0.00	3.58	5.30
L1. AR	0.02	1.2	0.11	0.12	0.14
L1. MA	1.04	48	0.00	1.00	1.09
Sigma	0.28	10	0.0	0.2	0.32

Table 2. Results of Robust Estimation of Expor in the ARMA Model (2006-2019)

NO. of obs= 141

Optimization: ARMA **Residual df = 139**

AIC = 1.6609 Wald chi2(2)=23.09
R-squared=0.6102 Prob> chi2=0.0015

Log likelihood =-117.585

	Coef	**Z**	**P**	**95%Conf.Interv**	
Log (reer)	1.26	4.36	0.00	1.10	2.91
Cont	4.09	7.04	0.00	2.13	3.95
L1. AR	-0.00	-0.10	0.91	-0.34	0.44
L1. MA	0.69	11.1	0.00	0.57	0.84
Sigma	0.10	17.5	0.0	0.09	0.11

Second, the heteroscedasticity test suggests that the null hypothesis is rejected (Probability>Chi=0.0015). We adopt the robust estimation in ARMA model; the results are shown in Table 2. The coefficient β is 1.266 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise exports proportion from 2006 to 2019. The β coefficient drops from 2.016 in 1994-2005 to 1.266 in 2006-2017.

Table 3. Results of Robust Estimation of Export in the Fixed Effects Model (1996-2005)

NO. of obs= 359

Group variable: firms **Number of groups =3**

R-squared:within = 0.696 corr(u_i, Xb) = 0.0004
between= 0.5290 F(1,355)= 26.55
overall = 0.062 Prob > F =0.0000
sigma_u = 2.078 F test that all u_i=0:
sigma_e =|0.5108 F(2, 355) =1980.01
rho=0.943 Prob > F = 0.0000
(fraction of variance due to) Wald chi2(1) =54.07

	Coef.	**Z**	**P**	**95%Conf.Inter**	
Log (reer)	1.95	5.1	0.00	1.21	2.70
Con	3.82	2.2	0.02	0.46	7.18

This implies that proportions of the whole exports have an average decrease with home currency appreciation and a negative change of wage ratio converting to a positive one. The results are consistent with the proposition 3 in terms of the trend of change of exports proportion.

Third, a fixed effects model is used to estimate the linkage between REER and export trade using firms-level data. The hausman test suggests that the null hypothesis is rejected (Probability> Chi2=0.041), and the value of the within R-squared is 0.696. We adopt the robust estimation in the fixed effect model; the results are shown in Table 3. The coefficient β is 1.958 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise exports proportion of firms from 1996 to 2005.

Table 4. Results of Robust Estimation of Export in the Fixed Effects Model (2006-2019)

NO. of obs= 393

Group variable: firms **Number of groups =3**

R-squared:within = 0.4992 corr(u_i, Xb) = 0.000
between= 0.6332 F(1,389)= 387.72
overall = 0.01 Prob > F =0.0000
sigma_u = 2.347 F test that all u_i=0:
sigma_e =0.196 F(2, 389) =1098.01
rho=0.996 Prob > F = 0.0000
fraction of variance due to u_i Wald chi2(1) =44.87

	Coef.	**Z**	**P**	**95%Conf.Interva**	
Log (reer)	1.77	19.9	0.00	1.59	1.94
Con	5.84	13.9	0.00	5.01	6.66

Fourth, the hausman test suggests that the null hypothesis is rejected (Probability>Chi2=0.082), and the value of the within R-squared is 0.499. We adopt

the robust estimation in the fixed effect model; the results are shown in Table 4. The coefficient β is 1.772 with 1% significance level (P=0.000).

This estimation implies that home currency appreciation tends to raise exports proportion of firms from 2006 to 2019. The β coefficient drops from 1.958 in 1996-2005 to 1.772 in 2006--2019, this implies that proportions of three export firms have an average decrease with home currency appreciation and a negative change of wage ratio converting to a positive one. The results are consistent with the proposition 3 in terms of the trend of change of exports proportion.

According to these compared results, although worker wages are going up, productivity growth rate may be lower than wage growth rate, this lead to a decline in China's export growth indirectly by the continuous appreciations of RMB. China's total factor productivity growth rate drops from around 4% before 2010 to to around 2% after 2010, according to Liu Qiao (2019).

Table 5. Results of Robust Estimation of Import in the ARMA Model (1994-2005)

NO. of obs= 144					
Optimization : ARMA			**Residual df = 142**		
AIC= -31.223			Wald chi2(2)=86.97		
R-squared=0.5637			Prob > chi2=0.0000		
Log likelihood =73.3367					
	Coef.	**Z**	**P**	**95%Conf.Interv**	
Log(reer)	1.0	2.31	0.03	0.16	1.98
Con	2.47	1.2	0.21	1.58	6.51
L1. AR	0.14	0.19	0.42	0.36	0.65
L1. MA	1.34	9.16	0.00	1.05	1.63
Sigma	0.23	7.18	0.00	0.16	0.29

Under the average change of wage ratio, the linkage between real exchange rate and import trade is further estimated using the ARMA and Panel data model.

First, the heteroscedasticity test suggests that the null hypothesis is rejected (Probability>Chi=0.000). We adopt the robust estimation in ARMA model; the results are shown in Table 5. The coefficient β is 1.073 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise the whole imports proportion from 1994 to 2005.

Second, the heteroscedasticity test suggests that the null hypothesis is rejected (Probability>Chi=0.000). We adopt the robust estimation in ARMA model; the results are shown in Table 6. The coefficient β is 1.924 with 1% significance level (P=0.000).

This estimation implies that home currency appreciation tends to raise imports proportion from 2006 to 2019.

Table 6. Results of Robust Estimation of Import in the ARMA Model (2006-2019)

NO. of obs= 141					
Optimization : ARMA			**Residual df = 139**		
AIC= -55.098			Wald chi2(2)=286.9		
R-squared=0.4688			Prob > chi2=0.0000		
Log likelihood =81.08					
	Coef.	**Z**	**P**	**95%Conf.Interv**	
Log(reer)	1.92	12.7	0.0	1.62	2.22
Con	-0.4	-0.06	0.9	-1.43	1.34
L1. AR	0.01	0.23	0.41	0.12	0.14
L1. MA	0.65	9.84	0.00	0.52	0.78
Sigma	0.13	20.2	0.00	0.12	0.14

Table 7. Results of Robust Estimation of Import in the Fixed Effects Model (1996-2005)

NO. of obs= 359					
Group variable: firms			**Number of groups =3**		
R-squared: within = 0.2924			corr(u_i, Xb) = 0.000		
between=0.0197			F(1,355)= 44.87		
overall = 0.011			Prob > F =0.0000		
sigma_u = 0.9038			F test that all u_i=0:		
sigma_e =0.6008			F(2, 355) =765.01		
rho=0.697			Prob > F = 0.0000		
(fraction of variance due to u_i)			Wald chi2(1)=7.14		
	Coef.	**Z**	**P**	**95%Conf.Interv**	
Log (reer)	1.2	2.67	0.0	0.31	2.06
Cont	7.3	3.55	0.0	3.30	11.43

Table 8. Results of Robust Estimation of Import in the Fixed Effects Model (2006-2019)

NO. of obs= 393					
Group variable: firms			**Number of groups =3**		
R-squared: within = 0.4532			corr(u_i, Xb) =0.000		
between=0.1092			F(1,389)= 54.72		
overall = 0.0132			Prob > F =0.0000		
sigma_u = 0.581			F test that all u_i=0:		
sigma_e =0.303			F(2, 389) =1199.01		
rho=0.786			Prob > F = 0.0000		
(fraction of variance due to u_i)			Wald chi2(1) =60.71		
	Coef	**Z**	**P**	**95%Conf.Interv**	
Log (reer)	1.76	12.6	0.00	1.49	2.03
Con	6.17	8.64	0.00	4.74	7.59

The β coefficient rises from 1.073 in 1994-2005 to

1.924 in 2006-2019; this implies that proportions of the whole imports have an average increase with home currency appreciation and a negative change of wage ratio converting to a positive one. The results are consistent with the proposition 6 in terms of the trend of change of exports proportion.

Third, a fixed effects model is used to estimate the linkage between REER and import trade using firms-level data. The hausman test suggests that the null hypothesis is also rejected by the Probability>Chi2=0.032, and the value of the within R-squared is 0.2924. We adopt the robust estimation in the fixed effect model; the results are shown in Table 7. The coefficient β is 1.193 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise industries' imports proportion of firms from 1996 to 2005.

Fourth, the hausman test suggests that the null hypothesis is rejected (Probability>Chi2=0.002), and the value of the within R-squared is 0.4532. We adopt the robust estimation in the fixed effect model; the results are shown in Table 8. The coefficient β is 1.765 with 1% significance level (P=0.000). This estimation implies that home currency appreciation tends to raise industries' imports proportion of firms from 2006 to 2019.

The β coefficient rises from 1.193 in 1996-2005 to 1.765 in 2006-2019; this implies that proportions of three import firms have an average increase with home currency appreciation and a negative change of wage ratio converting to a positive one. The results are consistent with the proposition 6 in terms of the trend of change of imports proportion.

According to these compared results, although RMB continues appreciation, people have preferred import products, this lead to a raise in China's import growth indirectly as worker wages are going up. Specially, the event which China took part into WTO in 2001 has promotes the growth of import and export proportions.

IV. CONCLUSION

No many studies involve the change of import-exports proportion. This motivates us to further research the relationship between export-import proportion and other variables.

In this paper, we integrate the model of Hiruyuki and Gordon Menzies to verify a new point that a change of wage ratio and real exchange rate can have effects on the proportional change of exports and imports in terms of the US and China. The dynamic relationship between real exchange rate appreciation and trade fluctuations are mainly analyzed as China currency has keep steady rise, especially after 2005.

The proportion of exports shows lowering trend with the wage ratio change from minus to plus and real exchange rate appreciation. This indicates that there is a listless performance on exports under the background of industries structure upgrading. In fact, it is maybe that this mismatch between increase of wage ratio and quality of workforce contributes to this drop in export proportion increases.

Therefore, educations of workforce should be strengthened to improve their products, especially in rural area. However, the proportion of imports shows rising trend with the wage ratio change from minus to plus and real exchange rate appreciation. It is maybe that wage raises and people pursuit the higher quality of life, this contributes to the increase in import proportion increase.

As the previous studies, we look forward to better data on wage ratio, more variables and import-export industries, to enable more precise changes of export-import proportions in future research.

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