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Research on the Impact of Population Aging on the Real Exchange Rate

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Abstract

Against the backdrop of China's demographic aging, this study seeks to investigate the relationship between population aging and the real exchange rate. First, the study selected demographic and economic data from 2000 to 2024. To account for the impact of the COVID-19 pandemic on demographic trends and economic development, data for 2020 and 2021 were excluded. Subsequently, this article employs a multivariate explanatory variable approach to construct a linear model incorporating four variables: real exchange rate, elderly population, working-age population, and GDP, and then employed ADF tests and cointegration tests to analyze the relationships among the four variables. The results indicate that an increase in the elderly population and an increase in the economic growth rate both lead to an appreciation of the RMB, while an increase in the working-age population has a depreciating effect on the RMB exchange rate. So, there is indeed a significant correlation between population age structure and the real exchange rate.

Keywords

real exchange rate, aging population, ADF test, cointegration test

1. Introduction

With the increasing frequency of international trade and China's gradual transition into an aging society, studying the impact of population aging on the real exchange rate has become particularly important.

Since the beginning of the 21st century, population aging has become a new demographic reality in China. According to the criteria established by the United Nations and the World Health Organization, China officially entered an aging society in 2000. Data in 2024 from the National Bureau of Statistics of China reveal that there were about 220 million individuals aged 65 and above, accounting for 15.6% of the total population. Compared with the figures from a decade earlier, the proportion has increased by 5.5 percentage points. Besides, the real exchange rate reflects the relative price levels between two countries and indicates the competitiveness of their goods in international markets. For example, A depreciation in the actual exchange rate helps boost exports and curb imports, thereby improving the trade balance; conversely, an appreciation may weaken export competitiveness and widen the trade deficit. Its fluctuations have a significant impact on a country's foreign trade and international economic activities. Therefore, a rigorous examination of the relationship between the two variables can offer meaningful empirical support for the formulation and calibration of future monetary policy.

This paper will employ multivariate analysis, using cointegration analysis to examine the relationship between population aging and the real exchange rate. Unlike previous studies, which primarily relied on static regression or short-term models, this paper employs cointegration analysis to effectively identify the long-term equilibrium relationship and short-term dynamic adjustment mechanisms between population aging and the real exchange rate, thereby enhancing the robustness and explanatory power of the empirical results. In addition, domestic scholars have reached differing conclusions regarding whether population aging leads to an appreciation or depreciation of the renminbi. This paper utilizes updated macroeconomic data (through 2024) and rigorous econometric methods to provide new empirical evidence on this debate, thereby helping to clarify the actual direction of the impact at this specific stage of China's development.

2. Literature Review

Cantor and Driskill [1] pioneered the empirical investigation into the relationship between population age structure and the real exchange rate. They used an overlapping generations (OLG) model to examine the relationship between changes in demographic structure and the real exchange rate. They found that demographic transitions influence the real exchange rate by altering national savings.

Braude [2] conducted an empirical analysis using data from 98 countries over 20 years. The results validated his theoretical analysis, confirming that a relationship does exist between population age structure and real exchange rates. Furthermore, these findings indicate differing patterns between developed and developing countries: In developed countries, an increase in the proportion of elderly populations leads to an appreciation of the real exchange rate, while changes in the 0-14 age group have no significant effect on the real exchange rate. Conversely, the elderly population has no discernible impact on the real exchange rate in developing countries.

This research finding links two factors that appear unrelated and verifies the relationship through empirical methods. The study has garnered widespread attention from scholars both domestically and internationally. Subsequently, more researchers have begun to focus on investigating the relationship between population age structure and real exchange rates.

Andersson and Osterholm [3] conducted a relatively systematic study on this issue. They first analyzed the Swedish case in 2005, employing empirical research using 42 years of data to substantiate Braude's [2] argument that population age structure significantly impacts real exchange rates. Following the publication of these findings, they expanded their analysis to 25 countries in 2006. Employing panel regression methods, their subsequent empirical analysis yielded consistent results: both the working-age population and the elderly population exert a significant influence on real exchange rates. Rose et al. [4] used panel data covering 88 countries and spanning the period from the 1970s to the early 2000s. He found a robust and significant positive relationship between a country's fertility rate and its real effective exchange rate: for every one-child decrease in the fertility rate, the country's real effective exchange rate depreciated by approximately 0.15%.Analyzing the Impact of Population Aging in the Netherlands on Exchange Rates, Ewijk and Volkerink [5] argued that older people consume more local services (non-trade goods), such as medical and nursing care, that imports cannot meet. If the rise in demand is accompanied by rigid supply, it will directly raise the price of non-tradable goods, which in turn will increase the overall price level and the real exchange rate.

In recent years, academic articles examining the relationship between population age structure and the exchange rate have also begun to emerge domestically. Domestic scholars Yang Changjiang and Huangfu Bingchao [6] conducted research on this issue, they employ the Balassa-Samuelson effect and factor endowment theory as their analytical framework, linking the impact of population age structure on both demand and supply sides to the real exchange rate of the Renminbi. Their findings indicate that the relative increase in China's working-age population has driven the appreciation of the Renminbi exchange rate. Chi [7] argued that the impact of population aging on the real exchange rate is nonlinear, exhibiting an "inverted U" shape. Zhou [8] found that an increase in the proportion of the elderly population in a country leads to an appreciation of that country's real exchange rate. In addition, Sheng Bin and Chen Jingyu [9] constructed a two-sector century overlap model of a small economy, theoretically analyzed the long-term impact of population age structure changes on the real exchange rate, and argued that the effect of the change of old age burden coefficient on the real exchange rate was affected by the relative capital intensity of the tradable sector. The positive impact of the increase in the elderly burden coefficient on the real exchange rate needs to be premised on the higher capital intensity of the tradable sector. However, Liu [10] also found that the rise in elderly population cause the decline in the real exchange rate. To find the reason of the relationship between population structure and real exchange rate, Si [11] claimed that Population aging affects international capital inflows and outflows by altering a country's investment and savings patterns, and international capital flows influence the real exchange rate of the RMB; moreover, the short-term impact of population aging on the real exchange rate is greater when transmitted through international capital channels.

3. Methods

3.1 Data Source and Processing

This paper draws on data from the China Statistical Yearbook to present China's demographic structure from 2000 to 2024, covering children (ages 0–14), the working-age population (ages 15–64), the elderly (aged 65 and over). In addition, this paper obtained the real exchange rate index (with 2010 as the base year, set at 100) and China's annual GDP from the BIS for the period from 2000 to 2024. Furthermore, to account for the disruption caused by the COVID-19 pandemic in 2020 and 2021 to population censuses and its impact on the Chinese economy, this paper excluded population and economic data for those two years.

3.2 Method Introduction

This study employs a multiple-explanatory-variable approach, incorporating not only population age structure but also the critical explanatory variable of the economic growth rate. This is primarily because the relationship between population age structure and real exchange rate appears somewhat unrelated. Therefore, we introduce an intermediate explanatory variable—gross domestic product—which is closely linked to both factors, thereby establishing the relationship between them.

In this paper, the real effective exchange rate index is denoted by R, the children population by C, the working-age population by L, the elderly population by E, and gross domestic product (GDP) by G. The dependent variable in this paper is the real effective exchange rate (REER) of the RMB. Since C + L + E = 1, the three variables have a perfectly linear relationship. To avoid this phenomenon, this paper only selects labor and the elderly population as explanatory variables, along with GDP as an additional explanatory variable. Based on this, the following model is constructed:

$$lnR = c + \alpha lnL + \beta lnE + \gamma lnG + \varepsilon \quad (1)$$

The real effective exchange rate index typically fluctuates around 100, while the working-age and elderly populations are on the order of hundreds of millions (in persons), and nominal GDP has already reached tens of trillions (in yuan). Directly incorporating these raw variables into a regression model—given their vastly different units and orders of magnitude—can not only cause numerical instability during estimation but also render regression coefficients difficult to interpret due to scale disparities, potentially obscuring genuine economic relationships. Taking logarithms of all variables mitigates these issues by preserving information about relative changes while substantially reducing scale differences among variables, thereby facilitating model convergence and enhancing the stability and reliability of parameter estimates.

Subsequently, this paper employs ADF test to assess the stationarity of the explanatory variables and uses cointegration analysis to investigate whether there is a long-run equilibrium relationship among the four variables and attempts to derive the cointegration equation for them.

4. Results and Discussion

4.1 ADF Test

To avoid the phenomenon of spurious regression caused by data instability. Before conducting cointegration analysis, it is necessary to perform a unit root test (ADF test) on the time series to determine their stationarity.

As shown in Table 1, the ADF test statistics for lnL, lnE, and lnG are all greater than the critical value at the 5% confidence level. This indicates that the time series are non-stationary and contain unit roots. After applying first-order differencing, the ADF test statistics for DlnL, DlnE, and DlnG are all less than the critical value of the 5% confidence interval. This indicates that none of the series contain unit roots, and the time series are stationary. Furthermore, they are first-order stationary series. At this point, cointegration tests can be conducted. Therefore, this paper decides to perform cointegration tests on the relationships among the four variables.

Table 1: The outcome of the ADF test

Variable	t	p	5% critical value	conclusion
lnL	-3.263	0.073	-3.731	Non-stationary
DlnL	-5.649	0.000	-3.757	Stationary
lnE	-2.307	0.170	-2.998	Non-stationary
DlnE	-6.582	0.000	-3.005	Stationary
lnG	-3.128	0.100	-3.865	Non-stationary
DlnG	-3.958	0.010	-3.731	Stationary
lnR	-1.904	0.330	-3.013	Non-stationary
DlnR	-4.876	0.000	-3.031	stationary

4.2 Cointegration Test

Table 2: Johansen cointegration test results

Null Hypothesis	Eigenvalue	Max-Eigen	5% critical value
None	0.891	35.488	27.586
At most one	0.694	18.963	21.131
At most two	0.528	12.021	14.264
At most three	0.395	8.033	3.841

This study examines the cointegration relationships among multiple variables using the Johansen test. As shown in Table 2, the maximum eigenvalue estimate indicates that the null hypothesis of no cointegration is rejected, while the null hypothesis of at most one cointegration relationship is accepted; that is, it can be concluded that there is a cointegration relationship among lnR, lnL, lnE, and lnG.

4.3 Cointegration Equation

Table 2 shows that, at a 5% confidence level, the null hypothesis that a cointegration relationship exists is rejected, indicating that there is at least one cointegration relationship among lnR, lnL, lnE, and lnG. Once the existence of a cointegration relationship among the four variables is established, the specific cointegration equation can be derived using the principles of Johansen's maximum likelihood estimation.

Table 3: Johansen normalization restriction imposed

Variable	Coefficient	Std. err.	z	p>|z|
lnR	1.000000			
lnL	-0.137879	0.059948	-2.30	0.021
lnE	0.852155	0.327752	2.60	0.009
lnG	0.760327	0.380164	2.00	0.045
Cons.	2.6376			

As shown in Table 3, the standard errors of the derived equations are relatively small compared to the coefficients, indicating that the model fits the data well.Therefore, the cointegration equation is:

$$lnR = -0.137879lnL + 0.852155lnE + 0.760327lnG + 2.6376 \tag{2}$$

4.4 Discussion

This paper argues that the impact of population aging on the real exchange rate is not immediately apparent but is transmitted indirectly through a series of interrelated macroeconomic mechanisms. On the one hand, the elderly population typically exhibits a higher marginal propensity to consume, and their consumption structure is significantly skewed toward non-tradable sectors such as healthcare, elderly care services, and domestic services; As the proportion of the elderly population continues to rise, the expansion of demand for non-tradable goods pushes up their relative prices against a backdrop of limited supply elasticity. This, in turn, raises the overall price level through the Balassa-Samuelson effects since prices of tradable goods are relatively rigid due to constraints from international markets, this structural price shift ultimately leads to an appreciation of the real exchange rate. At the same time, based on the life-cycle hypothesis, since the working-age population is the primary source of savings, a decline in its proportion implies a downward trend in the national savings rate. This reduces the capital surplus available for foreign investment, leading to a narrowing of the current account surplus or even a shift to a deficit; In an open economy framework, such a shift in the savings-investment pattern not only weakens depreciation pressures on the domestic currency but may also trigger its appreciation due to cross-border capital inflows or asset portfolio rebalancing, further pushing up the real exchange rate. Furthermore, the continued decline in the working-age population also raises labor costs, posing a significant cost shock particularly to labor-intensive export sectors and undermining their international price competitiveness. Under these circumstances, firms often reallocate capital and labor to the non-tradable goods sector to maintain profit margins, thereby exacerbating supply-demand tensions in that sector. This interacts with the price mechanisms to create a synergistic effect, collectively reinforcing the upward trend in the real exchange rate.

4.5 Limitations

Although this study reveals a significant long-run equilibrium relationship between population aging and the real exchange rate of the RMB, it still has certain limitations. First, the annual data used in this study spans approximately 24 years (2000–2024). In time-series analysis, this relatively limited sample size may affect the precision of estimates for cointegration relationships and dynamic adjustment coefficients. Particularly against the backdrop of multiple structural shocks—such as the global financial crisis, exchange rate system reforms, and the COVID-19 pandemic, which the robustness of the conclusions should be treated with caution. Second, the use of national aggregate data makes it difficult to capture the heterogeneous effects arising from differences in industrial structure, openness, and population mobility across the eastern, central, and western regions. Furthermore, the model has not yet incorporated potential mediating variables such as capital account openness and technological progress. Future research could extend the sample period (e.g., by utilizing quarterly data), adopt a panel framework, or construct a SVAR model to more accurately identify transmission mechanisms. As policies such as delayed retirement and the silver economy are further implemented, the pathways through which demographic structure influences the exchange rate may also evolve dynamically, warranting continued monitoring.

5. Conclusion

The results indicate that there is indeed a long-term equilibrium relationship between the population age structure and the real effective exchange rate of the RMB. An increase in the elderly population and an increase in the economic growth rate both lead to an appreciation of the RMB, while an increase in the working-age population has a depreciating effect on the RMB exchange rate. These findings confirm previous analyses of the relationship between population age structure and exchange rates. They demonstrate that there is an inseparable link between the RMB exchange rate and population age structure. Under the backdrop of deepening population aging, the real effective exchange rate of the Chinese yuan faces persistent endogenous appreciation pressure, which may undermine the export competitiveness of China's labor-intensive products and exacerbate external imbalance risks. To address this challenge, forward-looking policy adjustments are suggested at the systemic level: it is imperative to accelerate the structural transformation and upgrading of industries by promoting a shift in manufacturing toward technology-intensive and capital-intensive paradigms, thereby mitigating the cost disadvantages arising from a shrinking labor supply and real exchange rate appreciation; concurrently, a multi-pillar pension security system should be further refined to anchor consumption expectations among the elderly population, as such institutional reinforcement can prevent pronounced price volatility induced by surging demand for non-tradable services—particularly in healthcare and elderly care—and thus avoid excessive upward pressure on the real exchange rate via the Balassa–Samuelson effect; furthermore, central banks are advised to explicitly integrate demographic structural variables into their monetary policy frameworks and establish a dynamic monitoring and early-warning mechanism linking demographic trends with exchange rate dynamics, which would significantly enhance the foresight, responsiveness, and precision of macroeconomic policy formulation.

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Conflicts of Interest

The authors declare no conflict of interest.

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