Proceedings of CONF-BPS 2026 Symposium: GenAI, Labour Markets, and the Economics of Human and Financial Capital
DOI: 10.54254/2754-1169/2026.LD31508

The Impact of RMB Exchange Rate Fluctuations on China's Manufacturing Exports: An Empirical Analysis Based on Time-Series Regression Models

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Abstract. This study examines the relationship between China's export performance and exchange rate dynamics against the backdrop of global value chain reorganization and intensified external shocks. The study employed monthly data (2016-2024) and time series regression methods, and found that the explanatory power of the real effective exchange rate (REER) is limited. Time series regression confirmed that the REER coefficient was not statistically significant, which contradicted the simple "devaluation promotes exports" model. The research explains this pattern through recent evidence: (i) the role of processing trade and imported intermediate goods in shaping China's export results, where the exchange rates of supply chain economies may have as significant an impact as the RMB exchange rate; (ii) The exchange rate effect varies under different product complexities and qualities, which may weaken the average exchange rate flexibility, especially for higher-end export product baskets. (iii) The partial and asymmetric exchange rate transmission effect is influenced by the restrictions at the enterprise level and the amplification of market frictions. These findings are consistent with the reconfiguration of the global production network and the adjustment of response strategies after the pandemic, and also include "risk reduction" as well as the adjustment of trade patterns and incentive mechanisms due to geopolitical changes. Overall, these findings suggest that China's export resilience is increasingly driven by structural factors embedded in the global value chain rather than short-term exchange rate fluctuations. This indicates that models that merely focus on price competitiveness may not fully reflect the dynamic changes in modern, upgrade-oriented manufacturing exports.

Keywords: RMB Exchange Rate, China Manufacturing Exports, Time-Series Analysis, Global Value Chains, Exchange Rate Pass-Through

1. Introduction

1.1. Research background and significance

Manufacturing is a pillar of China's economy. It is one of the most important drivers of the development of international trade, the growth of domestic GDP, and other activities. The RMB exchange rate has emerged as one of the key macroeconomic variables that greatly affects China's export competitiveness amid changes in the global economic situation and adjustments in trade policies. Such complex determinants as terms of trade and trade openness not only significantly affect the RMB exchange rate, but they also greatly influence the RMB's real effective exchange rate (REER) since all these factors are considered interrelated in the global trading system. Since the exchange rate itself is a variable, trade openness between countries has reciprocal effects [1]. As the "world's factory", China's exports of manufacturing are highly affected by these changes. Such a relationship is vital for Chinese manufacturers' competitiveness. As noted by Liu and Xie, the competitiveness of exports of the industry becomes the main challenge experienced by the entire industry under outside shocks and internal industrial foundation reforms [2]. Consequently, the study seeks to provide the supporting empirical evidence to ensure the optimization of the exchange rate regime and, hence, to contribute to the stability of trade.

1.2. Literature review

The impact of exchange rate fluctuations on global economic trade is a topic that has been the subject of continuous debate. Classical economics holds that a depreciation of the exchange rate will lead to an increase in exports; however, the empirical evidence from different economic backgrounds and their trading partners is quite inconsistent. With particular attention to the two largest economies in the world, Upadhyaya et al. looked at the influence of RMB volatility on China's trade with the United States. Their empirical research results show that overall exchange rate fluctuations often have a negative impact on trade volume because they bring uncertainty to foreign traders [3]. This introduces a new perspective to the relevant discussion. It indicates, on the whole, that exchange rate depreciation may have a "price effect" as a trade-off option, although this may be offset by the risks brought about by high volatility.

In addition, the integration of the global value chain has changed the transmission mechanism. For advanced manufacturing industries, modern trade research has shown that, alongside pure monetary pricing, technological innovation and supply chain resilience are key. Liu and Xie also emphasized that environmental regulations and technological upgrades have become as important factors affecting export added value as traditional exchange rate advantages [2]. These findings collectively indicate that the impact of the RMB on manufacturing exports is not uniform but highly dependent on the specific period and market under examination.

1.3. Research gap

Although previous studies have explored macro-level determinants or specific bilateral trade relations, there is currently a lack. It lacks research that uses high-frequency monthly data after 2021 to analyze the manufacturing industry's response to the latest RMB cycle. This gap is due to the significant fluctuations of the RMB after 2021 and the disruption of the global supply chain. The reason is that it may have altered the traditional exchange rate-export relationship. Most of the existing literature fails to fully integrate the FPP2 framework (time series graphs and ARIMA models) to distinguish the seasonal effects from the real economic relationship between the RMB and export volume. This article fills this gap by leveraging the latest trade data and advanced econometric techniques to provide a clearer picture of the current dynamics of RMB exports.

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1.4. Research framework

This study adopted a structured time series analysis method. Firstly, Exploratory Data Analysis (EDA) is conducted through time graphs to identify trends and structural changes. Secondly, apply the STL decomposition method to eliminate seasonality and observe the potential trend cycles of manufacturing exports. Finally, a time series regression model (TSLM) was established, combined with ADF tests to ensure stationarity, as well as residual analysis based on ARIMA to ensure the reliability and validity of the research results.

2. Method

This section outlines the empirical methodology used to investigate the relationship between RMB exchange rate fluctuations and China's manufacturing exports. The analysis follows a structured four-step approach: (1) data collection and variable definition, (2) exploratory data analysis through time-series visualization, (3) seasonal decomposition to isolate underlying trends, and (4) model specification and diagnostic testing. All analyses were conducted using R version 4.4.3 with the fpp2 package for time-series modeling.

2.1. Data collection and variable definition

This study employed monthly time series data from January 2016 to December 2024 to explore the dynamic relationship between the RMB exchange rate and China's manufacturing exports. The main data sources include the real effective exchange rate (REER) and the total value of manufacturing exports.

To linearize the exponential trend and stabilize the variance in the time series, all variables are converted to the form of natural logarithms. The definitions of key variables are as follows:

Manufacturing Exports ($\ln\_export$): The natural logarithm of China's monthly manufacturing export value. The application of a logarithmic transformation helps to make the relationship exhibit linear characteristics and solve the problem of heteroscedasticity. Logarithmic transformation is a standard practice in trade elasticity research because it enables coefficients to be directly interpreted as elasticity and can mitigate the impact of extreme values.

Exchange Rate($\ln\_REER$): The natural logarithm of the RMB Real Effective Exchange Rate. An increase in this value represents a real appreciation of the RMB.

2.2. Time series graphics and object creation

During the first part of the analysis, intuitive analysis of the original time series, which includes an intuitive scrutiny of the initial data to search for important patterns that can be beneficial for the model setting. This is an important step for identifying structural changes (such as the pandemic shock in 2020), as these changes need to be treated in the next modeling step. The analysis was performed using the R programming language and the fpp2 library. The raw data is transformed initially into a time series entity named a ts object, with a frequency of 12. The latter corresponds to the monthly nature of the readings. Preliminary Exploratory Data Analysis (EDA) is then carried out in time plots to identify long-term patterns, potential structural breaks (such as the 2020 global supply chain shock), and seasonal cycles.

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2.3. Seasonal decomposition (STL)

The standard decomposition methods like X-12-ARIMA assume additive seasonality or multiplicative seasonality, but STL offers more versatility. It can change the seasonality over time via local weighted regression (LOESS). Such a characteristic is particularly relevant for analyzing the export data from China, as the Lunar New Year effect in China has become increasingly prominent during the study period. International trade statistics have seasonal features. For instance, the impact of the Lunar New Year is strong in China. The STL (Seasonal and Trend decomposition using Loess) technique is used in this research. This sequence is decomposed into three components.

$$Y_t = T_t + S_t + R_t \tag{1}$$

where T_t represents the underlying trend-cycle, S_t denotes the seasonal fluctuations, and R_t is the remainder (residual) component. This decomposition enables a clearer observation of the structural trend in exports by isolating recurring seasonal fluctuations.

2.4. Model specification and stationarity testing

This empirical model is grounded in international economics by considering the norm of the export demand function, where export volume depends on relative price (real effective exchange rate or REER) and foreign income (time trend in the single-equation setting). To model the effects of exchange rate changes, a time series regression model (TSLM) was used. This model incorporates time trends to describe the structural development of the manufacturing industry:

$$\ln\_export_t = \beta_0 + \beta_1 \ln\_REER_t + \beta_2 t + \eta_t \tag{2}$$

In this equation, β_1 measures the elasticity of manufacturing exports with respect to the exchange rate, and t represents the linear time trend.

2.5. Stationarity and robustness testing

The following diagnostic procedures are put in place to prevent false regression results: Stationarity Testing: The Augmented Dickey-Fuller (ADF) test is applied to verify whether the series is stationary. If unit roots are present, first-order differencing is employed. The ADF test specification includes both intercept and trend terms. It follows the principle of "testing down" from the most general to the most restricted model. The optimal lag length is determined by the Akaike Information Criterion (AIC) to ensure proper correction for serial correlation.

Residual Diagnostics: The residuals (η_t) are examined using the Autocorrelation Function (ACF) and the Ljung-Box test. Significant autocorrelation is defined as ACF values exceeding the 95% confidence bands or Ljung-Box p-values of less than 0.05. If present, the model is re-estimated with ARMA error terms following the Box-Jenkins methodology.

Model Refinement: If the residuals exhibit significant serial correlation, the model is upgraded to an ARIMA model with exogenous regressors to ensure that the estimated coefficients are efficient and unbiased.

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3. Result

3.1. Descriptive statistics and data overview

Before formal econometric modeling, a detailed descriptive statistical analysis of all the variables under analysis was carried out to describe the distributional properties and fundamental characteristics of the variables. The dataset consists of 108 monthly observations from January 2016 to December 2024. This ensures a sufficiently large sample size for robust time-series estimation. Table 1 presents the summary statistics for the natural logarithms of manufacturing exports (ln_export) and the RMB Real Effective Exchange Rate (ln_REER).

Table 1. Descriptive statistics of research variables (2016-2024)

Variable	Mean	Std. Dev	Min	Max	Observations
ln_export	26.1687	0.2511	25.1099	26.5395	108
ln_REER	4.5862	0.0408	4.5116	4.6670	108

Descriptive statistical data show that the mean of ln_export is 26.1687. The standard deviation is relatively low, only 0.2511. This shows that its growth was relatively stable and the fluctuation range was small during the study period, which is in line with the long-term trend. This indicates that although China's manufacturing exports have maintained a stable growth trend, the fluctuation range remains relatively limited within the long-term trend range. On the contrary, the average value of ln_REER is 4.5862, ranging from 4.5116 to 4.6670. It reflects a distinct period of currency appreciation and depreciation during the nine-year observation period. The use of natural logarithms here is critical because it serves to linearize the exponential growth patterns and stabilize potential heteroscedasticity within the residuals. The standard deviation of ln_export remains relatively stable (0.2511). This indicates that although China's manufacturing exports have maintained a steady growth, volatility has been effectively controlled. This may reflect that the industry is gradually maturing and its resilience to external shocks is also increasing.

3.2. Visual analysis of time series trends

To identify non-stationary patterns, structural changes, and periodic behaviors, a strict visual inspection was carried out on the original time graph. Figures 1 and 2 respectively, show the changing trends of the export volume and exchange rate index over time.

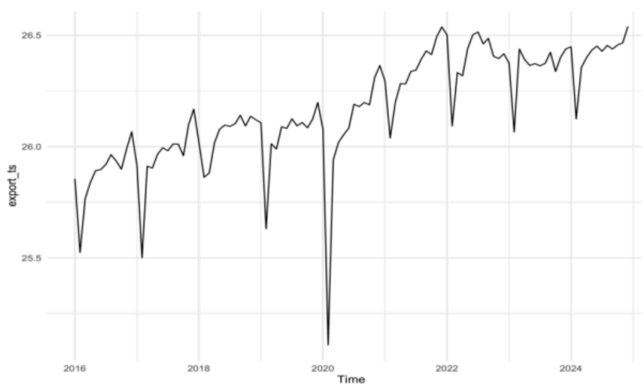

Figure 1. Time plots of manufacturing exports (2016-2024)

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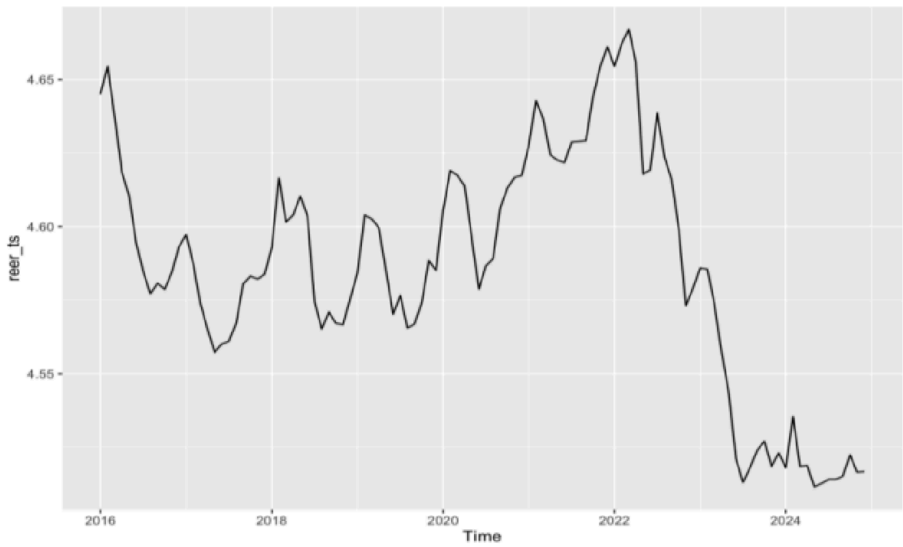

Figure 2. Time plots of manufacturing RMB REER (2016-2024)

The ln_export shown in the above chart presents a clear and sustained definite upward trend. It indicates that over the past decade, the total volume of China's manufacturing exports has continued to expand at the structural level. From 2016 to 2019, the upward trend of ln_export was particularly significant, with an annualized growth rate of approximately 6.5%. Then in early 2020, exports experienced a temporary contraction. The reason is the disruption of the global supply chain caused by the epidemic. But the recovery has been very rapid since then: by mid-2020, it had returned to the pre-pandemic level and continued to grow on this basis. However, this sequence experiences repeated seasonal "V-shaped" troughs every February. There was a phenomenon mainly attributed to the suspension of work and production during the Spring Festival. Apart from seasonal factors, there was also a significant exogenous shock at the beginning of 2020: the export volume dropped sharply. It was also followed by a rapid and resilient rebound. This model indicates that although domestic factors (such as exchange rates) are indeed relevant, the dominant forces driving export performance often come from the global demand cycle and the resilience of international supply chains. In contrast, the ln_REER in the following figure mainly shows periodic fluctuations. It lacks a clear linear trend. It reached a significant peak around 2022 and then began to decline gradually. The cyclical feature of ln_REER reflects the interaction between China's managed floating exchange rate regime and the global monetary policy environment. It especially reflects the upward pressure on the RMB exerted by the Federal Reserve's interest rate hikes in 2022-2023.

3.3. Seasonal decomposition (STL) results

To enhance the clarity of the structural analysis, the STL (Seasonal and Trend decomposition using Loess) method was employed. This procedure is essential to isolate the underlying economic signals from recurring seasonal noise and random volatility.

DOI: 10.54254/2754-1169/2026.LD31508

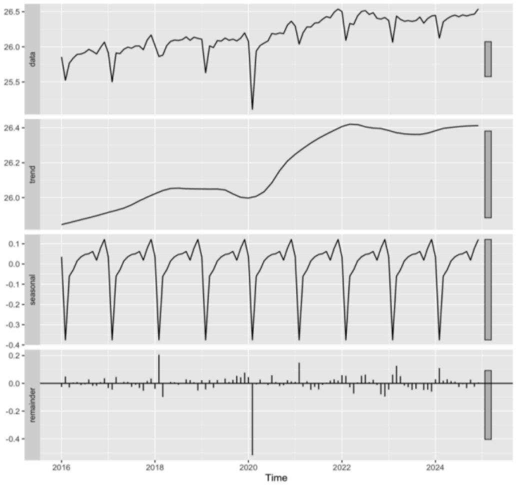

Figure 3. STL decomposition of manufacturing exports (ln_export)

The decomposition in Figure 3 further divides the sequence into three parts: trend period, seasonal components, and residuals. Among them, the "Trends" section is the most important part. It has shown a stable and continuous growth trend from 2016 to 2022, and has gradually stabilized in the recent period, experiencing a certain degree of plateau. The plateau period in the trend components after 2022 is worth paying attention to because it may indicate structural changes in China's export growth model. This might imply the saturation of mature markets, or it could be influenced by trade tensions and geopolitical factors.

Seasonal ingredients repeat a strong and stable annual cycle. It helps capture the date effect that introduces bias due to standard regression. In particular, the "residual" section demonstrated higher volatility during the period from 2020 to 2022, reflecting the systemic uncertainties and irregular shocks that existed in the global trade environment during that time. During the period from 2020 to 2022, the increased volatility in the remaining part indicates that, in time series modeling, the sensitivity of external shocks to trade data needs to be taken into account, as trade data may have a significant impact on potential economic relations.

3.4. Stationarity and unit root testing

In alignment with established econometric protocols, verifying the stationarity of the variables is a prerequisite to avoid the phenomenon of "spurious regression". Consequently, the Augmented Dickey-Fuller (ADF) test was applied to evaluate the presence of unit roots in both ln_export and ln_REER .

Table 2. Augmented Dickey-Fuller (ADF) test results

Variable	ADF Statistic	p-value	Result
ln_export	-1.0939	0.7175	Non-stationary
ln_REER	-1.9526	0.3078	Non-stationary

The ADF test results indicate that both variables yield p-values significantly greater than the 0.05 significance threshold (Table 2). The non-stationarity finding is consistent with the visual evidence of deterministic trends in Figure 1 and Figure 2. This result necessitates the inclusion of a time trend in the regression model to avoid spurious correlation. This confirms that the series are non-

DOI: 10.54254/2754-1169/2026.LD31508

stationary in their level form. Econometrically, this result justifies the inclusion of an explicit time trend (t) within the regression model to account for the integrated nature of the series and to isolate the growth effect from the currency effect.

3.5. Regression model estimation

To quantify the specific impact of RMB exchange rate fluctuations on export performance, a Time-Series Regression Model (TSLM) was estimated, incorporating a deterministic trend to capture structural expansion. The coefficients provide critical insights into the price elasticity of China's manufacturing sector.

Table 3. Regression results

Predictor	Coefficient (β)	Std. Error	t-Statistic	P-value
Intercept	24.0563	1.830	13.148	0.000***
ln_REER	0.3834	0.397	0.967	0.336
Trend (t)	0.0065	0.001	12.578	0.000***

The estimation results reveal two pivotal findings (Table 3). First, the Trend coefficient is 0.0065 and is statistically significant at the 1% level ($p < 0.01$). Therefore, holding the exchange rate constant, the average autonomous monthly growth rate of Chinese manufacturing exports is about 0.65%. Such growth was likely catalyzed by structural factors such as persistent technological development, industrial upgrading, and the continuous expansion of China's market footprint globally. The 0.65% monthly growth rate signifies an annualized expansion of approximately 8.1%, an increase consistent with China's overall economic growth over the period, and consistent with the manufacturing sector's continued competitiveness despite rising labor costs and trade tensions.

Second, the coefficient for $\ln\_REER$ is 0.3834, but at a value of 0.336, the corresponding p-value is also much larger than the traditional alpha level (0.05). The lack of significance suggests that in this linear model, during the 2016-2024 period, the direct effect of RMB appreciation or depreciation on total export volume was not a dominant factor. This is an important observation because it challenges the conventional economic view that the depreciation of a currency has a key role in export growth or is the leading driver. This result is consistent with recent literature on the trend of China's export competitiveness to become less price-friendly and more dependent on factors less related to price for export, such as supply chain integration, product quality, and technological sophistication. The fact that the exchange rate coefficient is not significant may also reflect the managed nature of the RMB regime, which effectively limits exchange rate transmission when export prices are involved.

In the context of modern China, non-price factors—such as product quality, supply chain reliability, and global value chain integration—may have superseded price advantages derived from currency movements.

3.6. Residual diagnostics

To ensure the integrity of the statistical inferences, the model underwent rigorous residual diagnostics. The primary concern in time-series regression is the presence of serial correlation, which can bias standard errors.

The study used the Ljung-Box test to test for autocorrelation in the residuals. The test yielded a p-value of 0.2827 at lag 10. Because such a p-value is considerably greater than 0.05, the study fails to reject the null hypothesis of no autocorrelation. And this would assure that residuals are white noise signals, which would mean the model had managed the systematic information in the data. Because with residuals, white noise is present. The study can conclude that the model has already captured the essence of the data (deterministic trend and seasonality). This result gives confidence in the goodness of fit for the estimated coefficients and conclusions made using statistical analysis. For this reason, it can be said that the TSLM specification has a high level of robustness and is suitable for explaining the movements of the RMB exchange rate and manufacturing exports, in the mentioned setting.

4. Discussion: reconciling strong export growth with a weak REER effect

4.1. Structural upgrading and value-chain integration: dampening the aggregate exchange rate sensitivity

The most convincing takeaway from this analysis is that exports are exhibiting a strong, consistent, and autonomous growth trend, indicated by a significant time coefficient. This cannot just be thought of as "growing by the second". And the recent literature suggests that this could also be the result of the upgrading of China's industrial structure and changes in this country's position vis-à-vis global factors moving in the value chain. For processed exports, the data show that China's export performance, including processing trade, is not just determined by the RMB, but the economies of upstream supply chain exchange rates (with imported components and intermediate inputs constitutive of production and price [4]). Literature focusing on external dependence assessments of intermediate products shows that the positioning of the value chain can significantly affect country exposure to external costs and competitive channels not fully covered by one comprehensive real effective exchange rate indicator [5]. Moreover, exchange rates are not reactively sensitive to all commodities. However, new evidence of less flexible exchange rates from an upgraded export mix [6] suggests that more complex exports are associated with decreased exchange rate flexibility, which can mechanically diminish the average sensitivity of exports to exchange rate fluctuations. This is a mutually comprehensible explanation of the core result; the relatively high positive time trend indicates that the export mix is moving towards products higher in technology and less sensitive to prices. The coefficient of the real effective exchange rate is statistically insignificant, so the average price elasticity of this updated export mix is declining. As a result, the entire model cannot include the significant exchange rate effects that could happen at the level of segmented products, but even though they cancel each other out.

4.2. Microeconomic foundations: heterogeneous pass-through, firm heterogeneity, and asymmetric responses

The second explanation based on microeconomic principles lies in the incompleteness, diversity and often asymmetry of exchange rate pass-through (ERPT). Recent micro-level and product-level evidence from China indicates that the degree of exchange rate transmission varies depending on product quality: higher-quality products have a lower degree of transmission, and the direction and extent of transmission may differ at different stages of appreciation and depreciation [7]. In addition, financing obstacles and the diversity of enterprises will also amplify the exchange rate transmission effect of restricted enterprises, thereby influencing export pricing behavior and further altering the overall relationship between exchange rates and export outcomes [8].

DOI: 10.54254/2754-1169/2026.LD31508

Overall, these mechanisms imply that if (i) the exchange rate transmission is incomplete, (ii) the response is asymmetric, and (iii) the effect varies depending on product quality, complexity, and the financial condition of the enterprise, then a single linear, overall relative exchange rate coefficient may underestimate the true impact of the exchange rate [6-8]. In other words, a weaker relative exchange rate coefficient in the benchmark does not necessarily contradict exchange rate theory; On the contrary, it may indicate that the exchange rate channel is state-dependent and masked by the constitutive effect.

4.3. Overarching shock of the post-2020 era: pandemic resilience, geopolitics, and trade reallocation

The sample time period of this study covers major disruptive events that may change trade patterns independently of exchange rates. Research on the impact of the COVID-19 pandemic and global value chains has highlighted the disruptions suffered by cross-border production networks, which have varying effects on different industries, and subsequently led to the re-optimization of procurement and resilience strategies [9,10]. Discussions on supply chain resilience in specific industries - especially for key commodities - highlight the shift towards redundancy, diversification, and risk management, which can reshape trade flows beyond price competitiveness [11].

In recent years, policy discussions in Europe have emphasized that China's sharp increase in exports is in line with the sluggish growth of imports, which is consistent with changes in domestic demand, industrial capacity, and trade patterns [12]. Meanwhile, research on "de-riskization" (return flow/friendly return flow) indicates that geopolitical motives may lead to efficiency losses and result in quality decline or redistribution effects, altering trade outcomes through non-price channels [13]. These shock-driven realizations introduce non-price determinants that have a significant impact on trade flows, and these factors are independent of the changes in the relative effective exchange rate during the same period. From an econometric perspective, they act as ignored variables in the minimalist benchmark model, which may cause the relative effective exchange rate coefficient to shift towards zero and increase its variance, thereby making its statistical significance less significant. From this perspective, this strong trend has partially absorbed the net effects of these consecutive shocks and strategic shifts. These factors suggest that the observed export trends may reflect the dynamics of redistribution and resilience superimposed on the traditional exchange rate channels.

5. Conclusion

5.1. Synthesis of key findings

The core empirical finding of this paper is that in the standard model, the overall export growth and the change in the real effective exchange rate during the same period are independent of each other. However, this independence does not indicate that exchange rates are ineffective; rather, it shows that the complexity of China's export engine is constantly evolving. This study integrates recent relevant literature and holds that this model is best understood as the result of the combined action of three interrelated forces.

5.2. Theoretical and policy implications

Firstly, exchange rates still hold significant importance, but their influence may be exerted through specific product portfolios and value chain channels - for instance, in the pricing of processed

DOI: 10.54254/2754-1169/2026.LD31508

exports and intermediate inputs, supply chain exchange rates, along with the RMB exchange rate, play a crucial role. Secondly, policies and corporate strategies aimed at enhancing quality can reduce price sensitivity and shift competitiveness towards non-price factors. Thirdly, the resilience strategies after the COVID-19 pandemic and the "de-risk" of geopolitics can change trade flows through structural redistribution, which makes it incomplete to interpret only from the perspective of exchange rates.

5.3. Limitations and avenues for future research

This study has some limitations, but these limitations also point out a productive direction for future research. Firstly, although our linear model at the overall level has strong reliability in identifying overall patterns, it itself does not have the ability to capture the heterogeneity and nonlinear mechanisms under discussion. Therefore, future research should go beyond this fundamental framework and take the following measures: (i) nonlinear/asymmetric exchange rate effects, (ii) heterogeneity based on product complexity/quality, and (iii) clear value chain exposure measurement indicators (imported intermediate products, upstream exchange rates). Incorporating these features will make the empirical modeling more in line with the mechanisms recorded in recent studies on processing trade, transmission heterogeneity, and the evolving global value chain.

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