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COMPARATIVE STATISTICAL MODELLING OF EXCHANGE RATE DYNAMICS ACROSS DEVELOPED, EMERGING, AND FRONTIER ECONOMIES

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Abstract:

This study examines exchange-rate dynamics across developed, emerging-market, and frontier economies using a comparative statistical framework based on a large longitudinal dataset of currency observations. The analysis evaluates distributional characteristics, cross-group differences, temporal trends, and the overall association between calendar year and log-transformed exchange-rate levels. Because the raw exchange-rate series exhibited substantial skewness and kurtosis, a natural logarithmic transformation was applied before further analysis. Descriptive statistics, robust one-way ANOVA procedures, Games–Howell post-hoc comparisons, Kruskal–Walli's testing with Bonferroni-adjusted pairwise comparisons, annual trend analysis, and simple linear regression were employed. The results revealed clear and persistent differences among the three economy classifications, with frontier economies displaying the highest mean log-transformed exchange-rate levels, followed by emerging-market and developed economies. Robust parametric and non-parametric procedures consistently confirmed statistically significant group differences. Temporal analysis showed comparatively stable patterns in developed economies, while emerging market and frontier economies exhibited stronger upward movements over time. Although calendar year significantly predicted log-transformed exchange-rate levels, its explanatory power was limited. Overall, the findings indicate that economy classification is more strongly associated with exchange-rate heterogeneity than time alone, highlighting the importance of structural and developmental differences in comparative exchange-rate analysis.

Keywords: *Exchange rates; developed economies; emerging markets; frontier economies; comparative statistics*

1. Introduction:

The impact of exchange rates on the competitiveness of trade, the relative prices, the cross-border movement of capital, inflation transmission and external adjustment are all important factors that make exchange rates an integral part of international macroeconomics. Exchange rate changes can impact the cost of imports, the profit from exports, foreign currency obligations and the overall resource allocation between tradable and non-tradable sectors. The impact is not only on the short-term price movements as exchange-rate action may also affect investment choices, production organization, and the long-term development trajectory. Therefore, it is important to study exchange-rate dynamics, both in the context of macroeconomic policy and in comparative economic analysis (Itskhoki, 2021).

The association between exchange rates and economic development is especially relevant in instances of dissimilarities in financial depth and institutional capacity, openness and composition of the economy. Extended exchange-rate misalignment can lead to fiscal or industrial competitiveness and export performance issues, and sharp currency shifts can cause uncertainty to firms, investors and policy-makers. Such impacts can be particularly strong in developing and emerging economies where productive structures are typically more vulnerable to external price impacts and foreign currency fluctuations. Hence, the study of exchange-rate behaviour should not only focus on it as a monetary issue but also as one related to other development aspects (Demir & Razmi, 2022).

The choice of exchange rate regime is one important reason for cross-country differences. There are significant differences in the extent to which exchange rates are free to move in response to market forces across countries. Economies have more or less flexible arrangements; some countries have system managed floats, some countries have reserve intervention or more strictly managed systems. These differences may have the impact on exchange rates both in terms of the intensity and time pattern. Importantly, the formal description of regimes does not always reflect the facts of the markets well, which can lead to a difference between the official description of the regime and the actual characteristics of the exchange rate (Dąbrowski et al., 2020). A further indication of the actual extent of exchange-rate flexibility between economies can then be gained from the nature of the reserve movements and the nature of the interventions.

It is particularly significant for the emerging and developing economies in which the central bank may step in the foreign exchange market even in the case of a formally declared floating rate. The reason for such intervention could be various concern about inflation, financial stability, trade competitiveness or foreign currency liabilities. This means that the observed rate movements could be driven by the interplay of market forces, policy actions, and institutional limitations, rather than being just floating. Country-level analysis shows that an exchange rate may be formally managed, but still reflect significant degrees of exchange rate management (Bouabidi, 2022).

In addition, there are significant differences in exchange-rate responses between countries, which are partly due to external economic conditions. Factors such as commodity prices, movements in the terms of trade, the global interest rate, international capital flows, and regional financial conditions may all have an impact on currency values. The effect of these influences may be especially strong in emerging and frontier economies where the export structure is more concentrated, and where financial markets are more vulnerable to external shocks. The effects of exchange-rate dynamics on the economy can differ substantially from one country to another, particularly as commodity prices fluctuate, which can have a strong effect on the exchange rate in those economies that are more reliant on primary exports (Yépez & Dzikpe, 2022). Exchange-rate fluctuations in emerging economies can also be caused by global and regional shocks and stresses, and not just domestic forces, thereby highlighting the need to undertake comparative analysis of changes in exchange rates within wider economy groups (Ahmed & Huo, 2020).

Another consideration for the differences between developed, emerging and frontier economies is the potential for exchange-rate misalignment. Misalignment takes the form of an observation of exchange rates that is not in line with the underlying economic fundamentals and can impact competitiveness, external balances and resource allocation. The fact that there are differences in exchange-rate regimes does not rule out the possibility of continued deviations, and therefore the structure of the economy and institutional factors continue to play a significant role in determining the exchange-rate outcomes (Owoundi, 2021). It is important, therefore, to study exchange rates in the context of a more comprehensive framework that takes into account the economic and market structure's heterogeneities.

Time change makes the analysis of the exchange rate even more complicated. There is no guarantee that the long-term relationships between exchange rates and the key macroeconomic fundamentals are stable. During financial crises, policy changes, monetary regime changes, geopolitical shocks, trade reorientation, and greater financial integration can result in the different nature of the currency's reaction to economic forces. The idea that the relationship between real exchange rates and their determinants has evolved further underscores the importance of studying real exchange rates over time, rather than relying on a cross-sectional comparison (Cuestas et al., 2022).

Policy-wise, the management of the rate involves the following policy considerations: price stability, external competitiveness, adequacy of the reserves, growth and financial stability. The extent to which countries can absorb changes in currency varies significantly across developed, emerging, and frontier economies, resulting in these trade-offs often being different. An exchange-rate policy can therefore be incorporated into a wider development policy, especially in the case of interactions between the valuation of the currency and export competitiveness, saving behaviour and structural transformation, as in the case of Razmi (2021).

Despite the vast literature dealing with the determination and policy of exchange rates, comparative statistical tests by economic classifications are needed because the same international environment can lead to varying patterns of exchange rates in each economic classification because of economic structure and stage of development. Typically, developed economies have more developed financial markets and better institutional systems, and emerging and frontier economies may be more sensitive to external shocks, commodity dependence, and policy constraints. These structural differences

provide an excellent foundation to analyse whether there are systematic differences in exchange-rate behaviour across economy groups and whether these differences remain stable over time.

This paper looks at exchange-rate movements in developed, emerging-market and frontier economies in the light of this background and adopts a comparative statistical approach. The distributional properties of exchange rate levels, differences between groups, robustness of differences between groups under parametric and non-parametric methods, and long-term temporal patterns are analysed. It also tests the general relationship between calendar time and the log of exchange rates. The study employs descriptive statistics along with powerful mean-comparison techniques, non-parametric testing, graphical trend analysis, and regression to structure the assessment of the dynamics of the exchange rate in economies at various stages of development.

2. Methodology

2.1 Research Design and Analytical Framework

The study used a quantitative comparative longitudinal design to compare the dynamics of exchange rates among developed, emerging-market and frontier economies. Observations of exchange rates were arranged by currency-date to allow for the comparison of exchange rates over both economy classifications and the entire study period. The analytical method used was a descriptive statistics, distribution analysis, strong parametric analysis, non-parametric analysis, temporal trend analysis, and linear regression. The main dependent variable was the exchange rate in relation to USD. The economies classification was treated as a categorical grouping variable that consisted of three groups: the developed economy group, the emerging market economy group, and the frontier economy group. The temporal variable used for the trend and regression analysis was calendar year.

2.2 Data Preparation, Screening, and Variable Construction

The data set was pre-processed for duplicate entries, missing data, errors in the data formatting and invalid numerical data before analysis. The currency identifiers, country or regional classifications and economy type categories were cross-checked. For categorical variables, the nominal approach was used, and for exchange-rate and date-derived numerical variables, scale approach was applied. Character strings were converted to an SPSS-compatible date format for dates which were originally stored as character strings. The original date string was separated into its components of year, month and day, and then the date variables were recombined to form a valid numerical date variable. A variable "calendar year" was then computed from this variable to be used in temporal analysis. The economy-type classifications were numerically coded for statistical procedures, but the descriptive category terms were not changed. Identifiers for the currency pairs were also numerically coded as needed for data organisation and analysis.

2.3 Distributional Assessment and Logarithmic Transformation

The distributional characteristics of the raw exchange-rate variable were examined by means of skewness, the standard error of skewness, kurtosis, the standard error of kurtosis and a visual examination of the histogram. The use of a natural log transformation was used in this case to eliminate the high degree of variance in the magnitude of the exchange rates across currencies, and to increase comparability. The variable was transformed to:

$$\text{LN\_ER} = \ln(\text{Exchange Rate})$$

where LN_ER represents the natural logarithm of the observed exchange rate.

The same skewness and kurtosis measures were used to repeat the distributional diagnostics for the transformed variable. Another form of examination was a histogram overlaid with a normal curve to determine the shape of the transformed pooled distribution. The transformed variable was subsequently employed as the main dependent variable in subsequent comparisons and temporal analyses.

2.4 Descriptive and Robust Parametric Analysis

The developed, emerging-market, and frontier economies were analysed separately for the descriptive statistics of LN_ER. These statistics included sample size, the arithmetic mean, standard deviation, minimum and maximum. The one-way analysis of variance framework was followed to compare LN_ER based on economy, which was treated as the categorical variable. Levene's test was used to check for homogeneity of variance.

Possible group variances were also considered, and the following robust tests of equality of means were also specified: Welch and Brown-Forsythe. When a significant difference was found between the groups, the Games-Howell test was used since this is a valid test for unequal variances and group sizes. The comparison of developed versus emerging-market economies and developed versus frontier economies was done pairwise, as was the comparison of emerging-market versus frontier economies. The level of significance was set at 0.05.

The contribution of between-group variation to the total variation in LN_ER was estimated using the effect-size measure of eta-squared ($\eta 2$).

2.5 Non-Parametric Robustness Analysis

To compare the distribution of LN_ER across the three economy classifications, without assuming normality as required by the conventional parametric procedures, a non-parametric robustness test, the Kruskal-Wallis H test, was conducted. The test variable was set as LN_ER, and the grouping variable was economy type. Post-hoc comparisons were performed between groups where the omnibus test revealed differences between groups.

Pairwise significance values were obtained and were adjusted using the Bonferroni method to reduce the family-wise Type I error resulting from multiple comparisons. The level of significance for the whole was chosen as 0.05. A comparative boxplot was also employed to illustrate the differences in the location, spread and distribution of LN_ER by economy classification.

2.6 Annual Trend Analysis

The reconstructed numerical date variable was used to calculate the calendar year to investigate the time-series behaviour of exchange-rate levels. Descriptive statistics of LN_ER have been obtained for the whole sample at the annual level. The analysis was then repeated for each group of economies: developed, emerging-market and frontier. The average, number of observations and standard deviation were computed for each year and economy classification. Selected annual means were computed to give a summary of longer-term developments in log levels of exchange rates.

2.7 Graphical Analysis of Temporal Dynamics

Temporal patterns were visualised using a multiple-line chart. The horizontal axis shows Calendar year, and the vertical axis shows the annual mean of LN_ER. The grouping variable was economy type, and this allowed the developed, emerging-market and frontier economies to be plotted on separate lines. Graphical analysis was employed to compare the direction of change in exchange-rate levels over time for the three economy classifications. This figure was only used descriptively and was not considered as an independent inferential test.

2.8 Linear Regression and Diagnostic Assessment

A simple ordinary least-squares linear regression was conducted to estimate the overall association between calendar year and the log-transformed exchange-rate variable.

The model was specified as:

$$LN\_ER_i = \beta_0 + \beta_1 Year_i + \varepsilon_i$$

where:

LN_ER_i represents the log-transformed exchange rate for observation i;

β_0 represents the intercept;

β_1 represents the estimated change in LN_ER associated with a one-year increase in calendar time;

$Year_i$ represents calendar year; and

ε_i represents the residual error term.

Model evaluation consisted of the multiple correlation coefficient, coefficient of determination, adjusted coefficient of determination, overall F test, unstandardized regression coefficient, standard error, standardised coefficient, t statistic, p value and 95% confidence interval. Standardised predicted values and standardised residuals were stored for diagnostic purposes. The scatter diagram of standardised residuals on standardised predicted values was examined for systematic patterns, variability in the residuals and lack of normality of the residual pattern. The collinearity diagnostics were also produced during the regression process. A two-sided alpha of 0.05 was used to check for statistical significance.

3. Results

3.1 Data Screening and Distributional Characteristics

The analytical data set consisted of 131,250 valid observations with no missing values on the exchange-rate variable that was analysed. The raw exchange-rate series had large positive skewness and excess kurtosis, 3.292 and 9.781, respectively. LN_ER was thus created by taking the natural log of ER. The skewness decreased to 0.707 and the kurtosis to −0.326, thus showing a significant improvement in distributional symmetry. For the following comparative analyses, the transformed series was still multimodal (as several different currencies with different numerical levels were combined), but the transformed variable was now better suited for these analyses. Table 1 confirms that the raw series of exchange rates were greatly modified by logarithmic transformation, as indicated by the substantially reduced skewness and kurtosis.

Table 1. Distributional characteristics of the raw and log-transformed exchange-rate variables

Variable	N	Missing	Skewness	SE Skewness	Kurtosis	SE Kurtosis
Exchange Rate	131,250	0	3.292	0.007	9.781	0.014
Log Exchange Rate (LN_ER)	131,250	0	0.707	0.007	-0.326	0.014

3.2 Distribution of the Log-Transformed Exchange Rate

Visual inspection of the histogram of LN_ER showed substantially improved symmetry compared with the raw exchange-rate variable. However, several distinct peaks remained visible, indicating a multimodal pooled distribution. This pattern reflects the combination of multiple currency series with different exchange-rate levels and supports the use of robust and non-parametric procedures alongside conventional parametric analysis. As illustrated in Figure 1, the log-transformed exchange-rate distribution shows improved overall symmetry but remains distinctly multimodal, reflecting substantial heterogeneity across the pooled currency series.

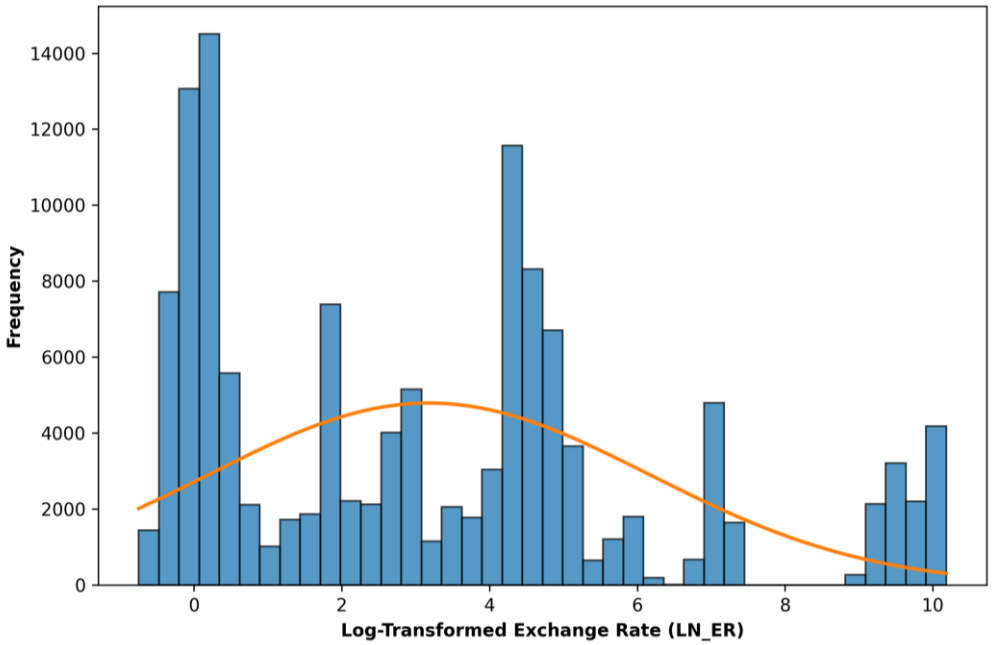

Figure 1. Histogram of the log-transformed exchange-rate variable (LN_ER) with superimposed normal curve

3.3 Descriptive Statistics Across Economy Types

Clear descriptive differences were evident across the three economy classifications. Developed economies had the lowest mean log-transformed exchange-rate level (M = 1.4774, SD = 2.6043), followed by emerging-market economies (M = 3.4338, SD = 2.5600). Frontier economies recorded the highest mean level (M = 5.8835, SD = 2.0697). Across all observations, the overall mean was 3.1817 (SD = 2.9858). The descriptive ordering was therefore consistently Frontier > Emerging > Developed. As presented in Table 2, mean LN_ER increased progressively from developed to emerging market and frontier economies.

Table 2. Descriptive statistics of log-transformed exchange rates across economy types

Economy Type	N	Mean	SD	Minimum	Maximum
Developed Economy	52,392	1.4774	2.6043	-0.75	7.36
Emerging Market Economy	50,523	3.4338	2.5600	0.13	9.74
Frontier Economy	28,335	5.8835	2.0697	4.07	10.18
Total	131,250	3.1817	2.9858	-0.75	10.18

3.4 Robust Comparison of Economy Groups

The assumption of homogeneity of variance was violated, as Levene's test based on the mean was statistically significant, Levene = 1307.874, $p < .001$. Accordingly, robust omnibus tests were emphasised. The conventional ANOVA was significant, $F(2, 131247) = 29425.413$, $p < .001$, while the Welch test also confirmed significant differences among the three economy groups, $F(2, 79080.002) = 34602.523$, $p < .001$. The Brown-Forsythe test produced a comparable result, $F(2, 126782.187) = 31594.061$, $p < .001$.

The estimated eta-squared effect size was approximately $\eta^2 = .310$, indicating that around 31.0% of the total variation in LN_ER was associated with differences among economy classifications. Games-Howell post-hoc comparisons showed that all three pairwise differences were statistically significant. Developed economies had lower LN_ER than emerging-market economies by 1.95636 units; developed economies had lower levels than frontier economies by 4.40609 units, and emerging-market economies had lower levels than frontier economies by 2.44973 units, with $p < .001$ in each comparison. Table 3 shows that robust omnibus tests and Games-Howell comparisons consistently identified significant differences among all three economy groups.

Table 3. Robust omnibus and Games-Howell comparisons of log-transformed exchange rates across economy types

Test/Comparison	Statistic / Mean Difference	df	p-value
Levene's test	1307.874	2, 131247	<.001
Conventional ANOVA	F = 29425.413	2, 131247	<.001
Welch ANOVA	F = 34602.523	2, 79080.002	<.001
Brown-Forsythe	F = 31594.061	2, 126782.187	<.001
Developed vs Emerging	-1.95636	—	<.001
Developed vs Frontier	-4.40609	—	<.001
Emerging vs Frontier	-2.44973	—	<.001

3.5 Non-Parametric Robustness Analysis

Because the transformed distribution remained multimodal, a Kruskal-Wallis test was performed as a non-parametric robustness assessment. The test was statistically significant, $H(2) = 50702.439$, $p < .001$, indicating that the distribution of LN_ER differed significantly across the three economy classifications.

Bonferroni-adjusted pairwise comparisons further showed significant differences for all group pairs. The standardised test statistic was −119.388 for Developed versus Emerging, −223.249 for Developed versus Frontier, and −121.512 for Emerging versus Frontier, with adjusted $p < .001$ for all comparisons. These results corroborated the robust parametric findings and demonstrated that the economy-group differences remained statistically significant under a non-parametric procedure. Figure 2 visually supports the significant distributional differences identified among developed, emerging-market, and frontier economies.

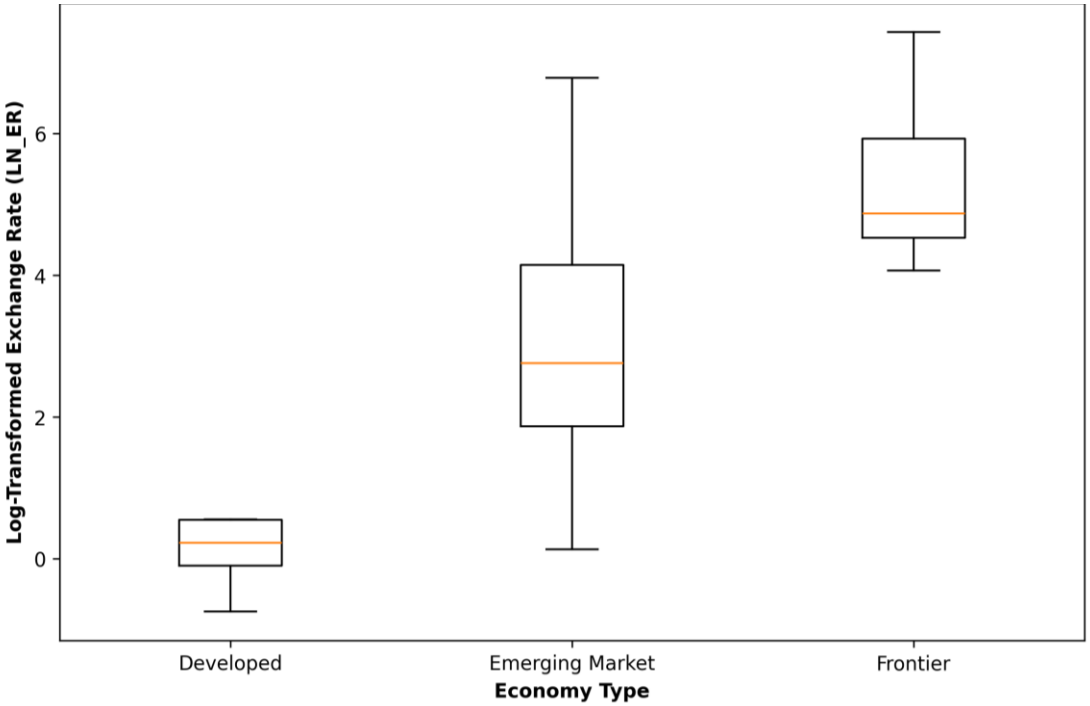

Figure 2. Comparative distribution of log-transformed exchange-rate levels across developed, emerging-market, and frontier economies

3.6 Annual Evolution of Log-Transformed Exchange Rates

Year-wise descriptive analysis indicated that the overall mean LN_ER was relatively stable during the earlier years of the observation period and increased more consistently in later years. The overall annual mean was 3.0080 in 2006, declined to 2.9053 in 2011, and subsequently increased to 3.1830 in 2015, 3.2839 in 2020, 3.3741 in 2022, 3.5393 in 2024, and 3.5726 in 2025.

Distinct temporal patterns were also evident across economy classifications. Developed economies remained comparatively stable, with the mean increasing from 1.4712 in 2006 to 1.5870 in 2025. Emerging-market economies exhibited the strongest upward movement, increasing from 2.9790 to 4.0584 over the same period. Frontier economies consistently recorded the highest levels and increased from 5.5133 in 2006 to 6.3636 in 2025. As shown in Table 4, emerging-market and frontier economies experienced stronger long-term increases in LN_ER than developed economies.

Table 4. Selected annual mean log-transformed exchange rates by economy type, 2006–2025

Year	Developed	Emerging Market	Frontier	Overall
2006	1.4712	2.9790	5.5133	3.0080
2010	1.3600	3.1969	5.6311	2.9669
2015	1.4564	3.5173	5.8078	3.1830
2020	1.5414	3.7139	6.0254	3.2839
2022	1.5946	3.7813	6.1140	3.3741
2023	1.5970	3.8543	6.2023	3.4536
2024	1.6057	3.9804	6.3371	3.5393
2025	1.5870	4.0584	6.3636	3.5726

3.7 Temporal Trend Across Economy Types

The year-by-economy trend figure showed persistent separation among the three groups throughout the study period. Frontier economies remained consistently highest, emerging markets occupied an intermediate position, and developed economies remained lowest. Developed economies exhibited a relatively flat trajectory, whereas emerging-market economies showed a pronounced upward trend, particularly from the mid-2010s onward. Frontier economies also demonstrated a gradual rise over time. Figure 3 illustrates distinct temporal trajectories across economy groups, with the strongest upward movement observed among emerging-market economies.

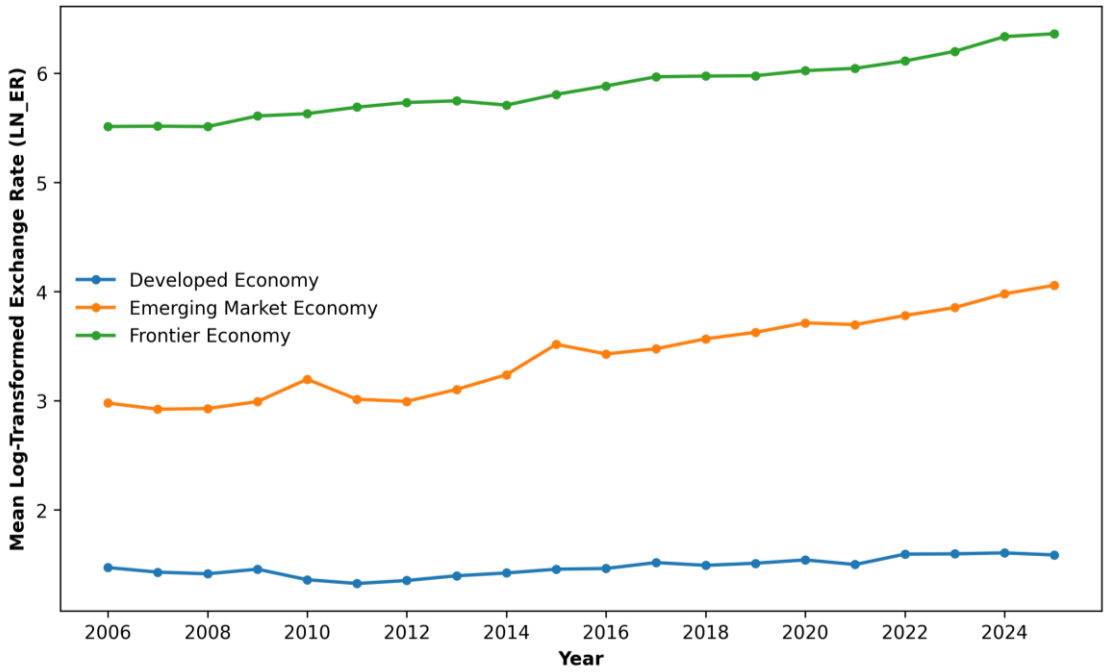

Figure 3. Annual mean log-transformed exchange-rate levels across developed, emerging-market, and frontier economies, 2006–2025

3.8 Linear Regression and Diagnostic Assessment of the Temporal Trend

A simple linear regression was conducted to evaluate the overall relationship between calendar year and LN_ER. The model was statistically significant, $F(1, 131248) = 528.809$, $p < .001$, with $R = .063$, $R^2 = .004$, and adjusted $R^2 = .004$. Year was a statistically significant positive predictor of LN_ER, $B = .034$, $SE = .001$, $\beta = .063$, $t = 22.996$, $p < .001$, with a 95% confidence interval of [.031, .037]. This indicates an estimated increase of approximately 0.034 units in LN_ER per year.

Despite its statistical significance, the model explained only 0.4% of the total variation in log-transformed exchange-rate levels, indicating that calendar year alone had limited explanatory power. Inspection of the standardised residual-versus-predicted-value plot showed visible clustering rather than a completely random residual cloud. Although no pronounced funnel-shaped pattern was evident, the structured residual pattern suggested that substantial currency- and economy-specific heterogeneity remained unexplained by the simple year-only regression model. Figure 4 shows structured residual clustering, consistent with the limited explanatory capacity of the year-only regression model.

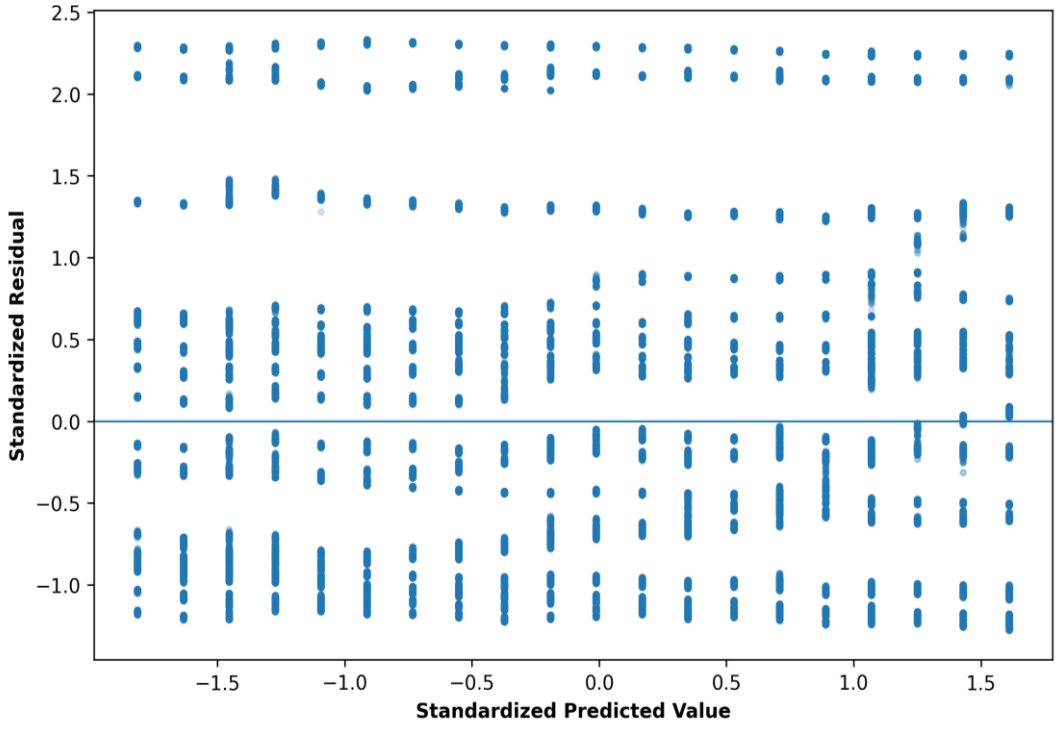

Figure 4. Standardised residuals versus standardised predicted values for the regression of LN_ER on year

4. Discussion

The present study was able to detect definite and sustained differences between the log of exchange rates in developed, emerging market and frontier economies. All the descriptive results indicated that frontier economies had the highest average value of LN_ER, the emerging-market economies had intermediate values, while the developed economies had the lowest values. This difference was not limited to descriptive analyses, but was also confirmed by strong statistical tests of the parametric and non-parametric types. The high divergence between the economy groups indicates that the exchange-rate developments are systematically linked to the other structural and developmental features of the groups, and not just to some general process of globalization.

The large differences between economy types are in line with the fact that the behaviour of the exchange rate is influenced by different macroeconomic structures, policy frameworks and levels of maturity of financial markets. However, external financial conditions, capital-flow reversals, and domestic macroeconomic imbalances can have a more pronounced effect on emerging economies, in particular. This is in line with the results that reveal significant differences in exchange rate misalignment and equilibrium exchange rates across the large emerging markets (Banerjee & Goyal, 2021). In the present results, this comparative approach is extended and the distinction is not limited to a developed–emerging one, but it is also noticeable when frontier economies are compared separately.

Possibly, the higher observed values of the exchange-rate levels of emerging and frontier economies for this transformation also indicate variation in exchange-rate regime characteristics and the way external shocks get absorbed. Disturbances can have material effects on the transmission process between advanced and emerging economies, depending on the type of the exchange rate regime (Elgahry, 2022). This is also important for the current results, since deep financial markets and robust financial institutions are common in developed economies, while the emerging and frontier economies may be subject to higher pressures for exchange rate adjustment upon facing international shocks.

These are very good results from the Welch ANOVA that demonstrated the differences between economy group remained significant even after explicitly accommodating heterogeneity of variance, as well as the results from the Games–Howell comparisons. This is of importance because exchange-rate data are often found to differ in dispersion between countries and market groups. This is in line with the findings of studies showing that both macroeconomic and structural factors in emerging markets vary significantly between countries and affect the volatility of real exchange rates (Agosin & Díaz, 2023). Comparatively large effect sizes as seen in the current analysis, additionally, indicate that economy classification reflects a significant amount of variation in exchange-rate levels.

A Kruskal–Walli's test was used for an additional robustness check and verified that the differences observed were not related to the traditional parametric assumptions. This is especially important in light of the multimodal shape of the transformed distribution of exchange rates. Moreover, exchange-rate series are prone to simultaneously facing several sources of uncertainty, and the uncertainty's impact can vary significantly across economies (Aftab, 2024). Agreement between the robust parametric and non-parametric procedures thus bolsters the confidence placed in the conclusion that the three economy groups are systematically different.

Another pattern emerged from the trend analysis that took place once a year. There were not significant long-term changes in the developed economies, but the emerging market and frontier economies displayed more noticeable increases in LN_ER. The gain was particularly strong among emerging markets. This time-lag is in line with the findings of Nguyen et al. (2024) that suggest emerging and developing economies' exchange-rate dynamics are sensitive to the composition of capital inflows and external financial conditions. This stronger EM growth trend, therefore, could be attributed to higher levels of manifestation of capital flow and macro-financial adjustment pressure on emerging economies during the study period.

The other two groups of economies generally showed a steady decline, with frontier economies showing a steady rise, but staying well above the others. This is a pattern that could correspond to less depth in foreign exchange markets, lower liquidity, higher external vulnerability and/ or less policy space to absorb shocks. Overall, the evidence from developing-country settings suggest that the impacts of exchange-rate volatility on inflation and on economic growth are potentially different and can be materially different from those in advanced economies (Olamide et al., 2022). While the current study concentrated on exchange rate levels and not on the volatility itself, the continuity of different group courses is consistent with the overall field of structural heterogeneity of developing and frontier markets.

The three economy categories were also clearly differentiated in the temporal line graph, and in particular starting in the mid-2010s. This implies that there were no common global conditions that generated similar responses in exchange rates. Uncertainty shocks have historically had differential impacts on emerging market economies as compared to advanced economies, driven by variations in external exposure and domestic resilience of the economies (Glebocki & Saha, 2024). It is the relative stability of the developed economies that is consistent with that interpretation, with the emergent and frontier economies showing stronger gains, as the present results show.

The regression analysis also revealed that there was a positive correlation between calendar year and LN_ER, although the contribution of the year to the model was quite small. It is important to keep in mind that this is a difference between statistical significance and explanatory power. The large sample size allowed the small coefficient of determination (R2) to be obtained, indicating that a minority of the variance was explained by time, per se. This result corroborates the fact that other endogenous and exogenous factors, other than a deterministic time trend, affect the exchange-rate movements (Aysun, 2024).

Further, the explanatory power of the year is low, which substantiates the notion that exchange rate behaviour is related to financial openness, sovereign risk, capital flows, trade structure and policy conditions. The significance of country-specific balance-sheet conditions (Bernoth & Herwartz, 2021) is suggested by the relationship between exchange-rate movements and foreign currency exposure, as well as the sovereign risk. Likewise, the impact of openness on outcomes

of effective real and nominal exchange rates may differ across emerging and developing economies, suggesting that the structural integration with global markets is important in explaining the outcomes of exchange rates (Glebocki Keefe, 2022).

This interpretation was confirmed by the remaining diagnostic plot. The significant clustering of the standardised residuals around the linear model showed that the model was too simple to account for the considerable currency and economy classification specific variation. This aligns with the main findings of the existing literature on exchange rates, which highlights the importance of both domestic and foreign influences on the exchange rates of smaller and more open economies (Aysun, 2024). The conclusion that the temporal trend is to be understood as a descriptive trend and not as a complete explanatory model is thus reinforced by the diagnostic pattern.

The results also have implications for trade and competitiveness. A persistent differential in the exchange-rate levels among economy groups can affect export pricing, international competitiveness and the reorientation of the manufacturing sectors to external conditions. However, empirical evidence across sectors in emerging economies reveals that impact of real exchange rates on manufacturing exports can be different according to the product complexity and industrial structure of the sectors (Goda et al., 2024). The larger the swings in exchange rates were for emerging and frontier economies, the more likely they were to have an impact on export activity and structural change.

The results are also in line with the notion that the exchange rate in emerging markets could either act as a shock absorber or as a source of further instability depending on the type of shock and the domestic policy setting (Manopimoke et al., 2024). The continuing difference in the way in which the developed, emerging and frontier economies have responded to the exchange rate in this study lends support to the proposition that the structural position of each economy in the international financial system is an important determinant of exchange-rate response.

These differences are likely to be exacerbated by external crises. The COVID-19 era is one such example that shows that foreign-exchange markets can have large volatility spillovers during periods of global disruption (Kushwah & Negi, 2024). The present analysis was not specifically designed to separate out the effects of the crisis, but, as the study period is long, there is also a time dimension that incorporates periods of heightened global uncertainty that may have given rise to stronger temporal movements of the more externally vulnerable economy groups.

Last, recent studies on the connectedness of emerging-market exchange rates have shown that exchange-rate fluctuations are increasingly intertwined across markets, instead of being purely domestic (Silva & Divino, 2026). This corroborates the more general meaning of the present observations: exchange-rate movements depend on the interplay of the properties of the individual economy, its level of development, the world economy and cross-market relations. Overall, the results indicate that economy classification offers a useful additional frame of reference for explaining long-run differences in exchange rates, and that calendar time explains little of the differences.

5. Conclusion

The current study represents a comparative statistical evaluation of exchange-rate developments in developed, emerging-market and frontier economies over a long period of time. The results show significant and stable differences in the log exchange-rate levels between the three economy classifications. The average values across frontier economies were always the highest, followed by the emerging-market economies, and then the developed economies were relatively lower. These differences were backed up by well-established parametric procedures and corroborated by non-parametric analysis, so that the separation of the groups observed was not confined to one of the statistical assumptions. A temporal analysis also identified unique long-term trajectories. The exchange-rate evolution was relatively stable in developed economies, while it was more pronounced in the upward direction in emerging-market and frontier economies, especially in emerging markets. The regression model accounted for a very small amount of the total variation in the exchange rates, so the difference in exchange rates is not just a function of time. The study overall demonstrates that the dynamics of exchange rates are systematic around economic development and market structure. The results corroborate the relevance of economy classification as a comparative approach for assessing long-run currency dynamics and highlight the importance of considering exchange-rate movements in the context of larger structural, institutional and macroeconomic factors.

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