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Exchange Rate Dynamics and Volatility of the Nepali Rupee (1998-2020): Forecasts, Financial Risks, and Policy Implications

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ABSTRACT

The research examines Nepali Rupee (NPR) to US Dollar (USD) exchange rate patterns from 1998 to 2020, while creating predictions for 2021-2024 to assess financial risks and inform policymakers. Monthly average data (n = 271) were obtained from the Nepal Rastra Bank's portal and analyzed using R studio. The study examined volatility measures, including percent and marginal changes, and performed three time-series diagnostic tests. The ETS (M, Ad, N) model was used for short-term predictions, with results showing accuracy for predictions (RMSE = 1.24; MAE = 0.88; MAPE ≈ 1.03%). The analysis reveals that the NPR experiences ongoing long-term depreciation with regular brief market fluctuations. The ETS model provides accurate short-term predictions, but its predictive bands expand when forecasting into the future, indicating increasing market unpredictability. The study also examines the impact of exchange rate fluctuations on import-dependent firms, exporters, and foreign currency projects. The research recommends risk management strategies for businesses, including natural hedging and forward contracts. It also suggests two macroeconomic strategies: reserve management and derivatives market expansion. The study demonstrates that univariate models, like ETS, fail to detect structural changes after 2020, notably due to COVID-19 and worldwide inflation. It recommends using ARIMAX, GARCH, and machine learning models for better forecasting. The study emphasizes the need for additional tests to verify model accuracy through out-of-sample data evaluation.

1. INTRODUCTION

The exchange rate is a critical macro-economic factor for countries involved in foreign relations through trade, investments, and economic policies (Gajurel, 2022). For smaller countries like Nepal, fluctuations in the exchange rate have significant implications for imports, exports, and overall economic stability. The value

of the Nepalese Rupee (NPR) against the United States Dollar (USD) varies significantly due to factors such as political instability, inflation, global disruptions, and domestic policies (Neupane & Paudel, 2025). Understanding these fluctuations is essential for businesses, governments, and researchers who need accurate information for making informed decisions about investments and other economic activities (Adhikari et al., 2025). This research aims to analyze the trends of the NPR/USD exchange rate from 1998 to 2020, forecast trends for 2021-2024 using time series models like moving averages, decomposition techniques, and exponential smoothing, and quantify exchange rate risks. The study will also explore ways to mitigate risks associated with volatile exchange rates, providing recommendations for businesses, governments, and researchers.

Despite the growing importance of analyzing and forecasting exchange rate variability, accurate predictions remain challenging, especially in emerging economies like Nepal. Political turmoil, external events, inflation, and trade imbalances contribute to the complexity of forecasting currency rates. Conventional methods such as ARIMA are often ineffective in emerging economies, where non-linearities, breaks, or strong seasonality exist (Neupane & Paudel, 2025). This issue is compounded in Nepal due to the lack of long-term data and the frequent occurrence of irregular events, such as political instability, natural disasters, and remittance variability (Gajurel, 2022). Moreover, there is a gap in academic research in Nepal that links exchange rate forecasting to financial decision-making, particularly in the context of investments. The specific objectives of this research are to: (a) analyze the long-term trends and volatility of the NPR/USD exchange rate from 1998 to 2020, (b) forecast exchange rate values for 2021-2024 using moving averages, classical decomposition, and exponential smoothing (ETS) models, (c) assess the financial implications of exchange rate fluctuations and associated risks for businesses and foreign-currency-exposed investments, and (d) propose practical financial hedging strategies and policy measures to manage exchange rate risk in Nepal. The research questions address (a) long-term trends and volatility, (b) the use of time series models for forecasting, (c) financial risks associated with fluctuations, and (d) hedging strategies to mitigate exchange rate risks. The study hypothesizes that the Nepalese Rupee (NPR) has experienced significant long-term depreciation against the US Dollar (USD) from 1998 to 2020, and this trend will continue into the period 2021-2024.

The volatility of the NPR/USD exchange rate presents challenges for businesses, investors, and policymakers in Nepal, as fluctuating values complicate trade, investments, and economic planning. Political instability, inflation, global events, and domestic policies contribute to these fluctuations (Gajurel, 2022). The absence of effective forecasting models complicates financial decision-making, which this study aims to address by using Exponential Smoothing (ETS) models to forecast trends and analyze exchange rate volatility. The study will explore how non-linearities and irregular events, such as political unrest and natural disasters, complicate forecasting exchange rate behavior in Nepal. By assessing the financial risks associated with exchange rate fluctuations, this research aims to provide practical recommendations for businesses and policymakers on how to mitigate risks and take advantage of exchange rate trends. The findings from this research will help improve financial decision-making in Nepal by offering strategies to manage the impact of volatile exchange rates.

Global Evidence: Accurately predicting the rate of exchange and its volatility has been the subject of extensive research worldwide. Traditional ARIMA models and their variations, such as GARCH or Generalized Autoregressive Conditional Heteroskedasticity, have been in practical application for many years in forecasting the rate of currency exchange between various countries and determining the volatility

of these exchanges. Research by Rossi (2013) and another study by Morina et al. (2020) underlines how important it is to consider exogenous variables, such as global events, when one attempts to forecast the change in exchange rates. Hybrid models-intersecting the power of traditional econometrics with machine learning algorithms-performed decidedly better than traditional ARIMA models when applied to exchange rate change predictions, especially within a highly volatile market (Rossi, 2013; Morina, et al., 2020).

Recently, machine learning algorithms such as deep learning models (Galeshchuk & Mukherjee, 2017) and combined forecasting models (Ni, et al., 2019) have appeared as possible methods for forecasting exchange rate determination. These methods prove to be far better than conventional methods because these models address complex, non-linear relationships among the variables. Utilization of these models, specially within the context of a developing country such as Nepal, is largely unexplored.

National-Level Evidence (Nepal): At a national level, there is limited research done on the dynamics of exchange rate movements for Nepal. Various authors have analyzed the overall effects of exchange rate changes on the export side of Nepal. Joshi et al. (2023) analyzed the short-term as well as long-term effects of exchange rate variability on the performance of the export side of Nepal, thus assuming that the real exchange rate is of prime importance to Nepal's export ability on a global platform. Likewise, Adhikari (2018) analyzed the importance of changes in foreign currency rates for Nepal's trade deficit, thus concluding that a decrease in the Nepalese Rupee affects the decrease of trade deficits, but variability and appreciation affect emerging nations.

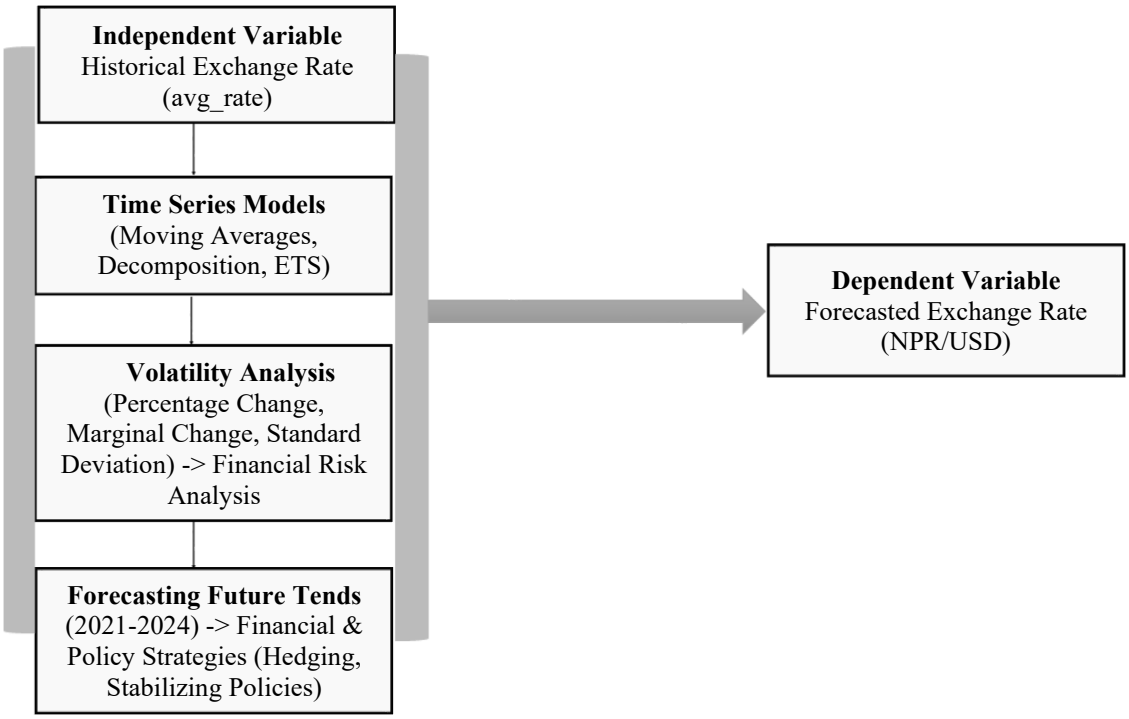
However, most of these previous studies on Nepal have dealt with macroeconomic implications, and thus a research gap exists to comprehend the impact of exchange rate changes on the profitability of projects, especially those that are heavily exposed to foreign currency. Neupane & Paudel, 2025 studied the feasibility of utilizing modern time series forecasting techniques, such as LSTM or GRU, for forecasting the value of the Nepalese foreign exchange rate. They concluded that the forecast accuracy of the foreign exchange rate was improved by LSTM, suggesting that machine learning techniques could be appropriate for this purpose.

Sub-National and Industry-Level Evidence: Despite this, there is a lack of sub-national and industry-specific research on exchange rate volatility. Recently, Dahal et al. (2025) analyzed the implications of exchange rate volatility for 33 industries in Nepal and found that industries that relied heavily on imports, especially those that had value chain participation, experienced a greater impact of Nepalese Rupee devaluation. This is because, even though devaluation enhances a nation's export opportunities, exchange rate volatility-inflicts injury on the import-sensitive industries, as Bahmani-Oskooee & Aftab (2017) note, especially on those of emerging economies. In other economies also, studies at the industry level have shown again that currency fluctuations affect different sectors differently: it is advantageous to export-oriented businesses while making import-dependent industries face drastically heightened costs. Auboin & Ruta (2013) Similar research in a disaggregated manner is needed in Nepal for mapping sectoral exposure to currency risk.

Theories and Conceptual Framework: This study's conceptual framework examines the historical behavior of the Nepalese rupee (NPR/USD) exchange rate from 1998 to 2020 and projects future trends for 2021-2024 using time series models, moving averages, classical decomposition, and exponential smoothing (ETS). The volatility analysis examines the financial implications of exchange rate fluctuations on firms, investors, and projects with foreign currency exposure using measures such as percentage change, marginal change, and standard deviation. In this framework, it is possible directly to link historical exchange rate data to projected

values for both short-term shocks and long-term depreciation trends. It further makes possible the suggestion of useful financial hedging strategies that could help reduce the risk from exchange rates and improve the resilience of the economy, including forward contracts, natural hedging, and currency clauses. Such strategies are complemented by policy approaches such as the accumulation of reserves, derivatives market development, export promotion, and import substitution

Figure 1: Conceptual Framework of the Study



2. METHODS

This paper investigates the Nepalese Rupee-United States Dollar exchange rate dynamics from 1998 to 2020 using a positivist approach based on quantitative research, projecting the future movements for 2021-2024. The main purposes are to investigate the financial consequences of exchange rate fluctuation, to assess the volatility of the currency, and to analyze past exchange rate history. The post-positivist paradigm will thus allow conducting objective, data-driven research on the problem and guarantee that the conclusions of this study will be supported by statistical procedures and factual evidence.

Data Collection: In this paper, the main data source will be the monthly exchange rate of the Nepalese rupee against the US dollar (NPR/USD), including buying, selling, and average values, from 1998 to 2020. The data was collected from the Nepal Rastra Bank. Only the average exchange rate series is used as a basis for all long-run trend, volatility, and forecasting analysis.

Time Series Models: The study applies the traditional time series technique of moving averages to smooth out fluctuations and bring out underlying patterns, as well as using a classical decomposition method to

separate the trend, seasonal, and irregular components in analyzing past trends and predicting future exchange rates. Estimates for 2021-2024 are produced by using exponential smoothing, with automatic model selection based on information criteria (Hyndman & Athanasopoulos, 2021). The exponential smoothing (ETS) model used in the study is formulated as: $Y_t = \alpha \cdot X_t + (1 - \alpha)(Y_{t-1} + T_{t-1})$, where Y_t = forecasted value at time t; X_t = observed value at time α = smoothing parameter (between 0 and 1); T_{t-1} = trend component at time t-1.

Volatility Analysis: It calculates volatility based on the marginal or absolute change in series, the standard deviation of both series, and the identification of extreme monthly fluctuations. These measures indicate considerable short-run fluctuations and sometimes severe shocks to the long-run depreciation tendency. The findings of extreme results-that is, month-to-month variations over ±16%-and high variability are consistent with the volatility clustering that has been observed in Nepalese currency rate data. These measures enable the assessment of the volatility levels and the resultant financial risks for investments and enterprises dependent on foreign currency. Volatility is commonly expressed using the formula: Volatility = $\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$, where X_i = individual observations (monthly changes); $\bar{x}$ = mean of the observations; n = number of observations.

Forecasting Future Exchange Rates*:* ETS framework to forecast the exchange rate values for the years 2021-2024. This framework gives weight to observations. The ETS framework also accounts for the underlying trend. The ETS framework takes the form: $Y_t = \alpha \cdot X_t + (1 - \alpha)(Y_{t-1} + T_{t-1})$, where Y_t = forecasted value at time t; X_t = observed value at time α = smoothing parameter (between 0 and 1); T_{t-1} = trend component at time t-1. Set the parameters to get the forecasting accuracy. The model works best when the data shows a trend, and the seasonal effect is small. The NPR/USD series is an example where the data follows a trend, with effect and the model shows strong performance.

Financial and Policy Implications: The study examines the financial implications of the change in the exchange rate, considering import/export firms and projects in foreign currency denominations. Volatility indicators flag the risks of both gradual deterioration and sudden shocks. Hedging methods that work well include currency clauses of long-term contracts, forward contracts, and natural hedging. Increasing foreign exchange reserves, constructing basic derivatives markets, and structural adjustments to decrease dependence on imports are some of the policy choices (Dahal et al., 2025).

The Methods section provides a sound univariate approach that effectively integrates the aspects of forecasting, volatility measurement, and time series modeling to produce accurate forecasts with useful risk insights for the exchange rate environment in Nepal.

3. RESULTS

This section presents the empirical results of the study, based on the average monthly NPR/USD exchange rate from 1998 to 2020. Results are organized to meet the objectives mentioned of the study. First, the long-run trend and pattern of the exchange rate are analyzed through time series decomposition, moving averages, and descriptive analysis. Second, exchange rate volatility is calculated to determine the magnitude of fluctuation and the associated financial risk through percentage change, marginal change, and standard deviation. Third, an ETS-based forecasting model has been used to project future exchange rate movements

over the next three years from 2020. Finally, discuss how financial risk and decision-making in Nepal are influenced by these trends and projections.

Long-term trends and volatility of the Nepalese exchange rate (1998-2020): This subsection presents the empirical results of the main goal of the study, which was to examine the long-run trends and volatility of the NPR/USD exchange rate between the years 1998 and 2020. The monthly average exchange rate (avg_rate) used in the analysis is derived from 271 observations.

Table 1: Summary of Long-Term Trend and Volatility Indicators (1998-2020)

Statistical Component	Result (from R output)	Interpretation
Starting exchange rate (1998)	~63 NPR/USD	NPR was stronger in early period
Ending exchange rate (2020)	~117-118 NPR/USD	NPR weakened substantially
Linear trend slope (simple trend model)	$\beta = +2.254$ ($p < 0.001$)	Exchange rate increases ~2.25 NPR per year
R^2 of simple trend model	0.764	Time explains 76.4 percent of exchange rate movement
Intercept (simple trend model)	-4443 (not meaningful)	Indicates simple trend not ideal for forecasting
Trend slope (decomposed trend model)	0.185 per month ($p < 0.001$) -> ≈2.22 per year	Confirms steady long-term depreciation
R^2 (decomposed trend)	0.758	Trend captures majority of long-run movement
Durbin-Watson statistic	DW = 0.0038, autocorrelation = 0.994	Very strong positive autocorrelation (expected in Foreign Exchange data)
Shapiro-Wilk normality test	$W = 0.901$, $p < 0.000000000005$	Trend residuals not normally distributed
Breusch-Pagan test	$p = 0.475$	No evidence of heteroskedasticity
Mean percent change (monthly)	0.32 percent	NPR depreciates slightly on average each month
SD of percent change	4.36 percent	High monthly volatility
Mean marginal change (NPR)	0.2006 NPR	Small typical monthly movements
SD of marginal change	3.5685 NPR	High dispersion in monthly movements
Maximum monthly percent increase	16.71 percent	Sharpest single-month depreciation
Maximum monthly percent decrease	-18.16 percent	Sharpest single-month appreciation

Source: Exchange rate data (NPR/USD) sourced from the Nepal Rastra Bank (NRB) official records for the period from 1998 to 2020.

The empirical results show a definite long-term trend of NPR depreciating against USD between the years 1998 and 2020. In this period, the exchange rate started off at approximately 63 NPR/USD and increased gradually to approximately 117-118 NPR/USD by 2020. This near doubling of the exchange rate indicates that NPR has substantially declined during the 23 years.

A simple linear trend model, which confirms this pattern, has a statistically significant positive slope of $\beta = 2.254$ ($p < 0.001$), suggesting that the exchange rate, on average, increased by about 2.25 NPR per USD

annually. Since the R^2 value from the model is 0.764, it follows that about 76% of the volatility in the exchange rate may be due to time alone. The intercept is negative and thus has no economic meaning, but the slope is indicative of a significant depreciation trend.

Further refinement, using decomposed trend analysis-from additive decomposition-gives a slope of 0.185 NPR per month, which is approximately 2.22 NPR per year. This result supports the conclusion of a structural, long-term depreciation path and is consistent with the simple trend model. As one might expect with exchange rate data, diagnostic tests indicate that residuals are significantly autocorrelated-Durbin-Watson = 0.0038-and non-normal-Shapiro-Wilk $p < 0.00000000005$. Continuous variance implied by constant error dispersion over time is supported with the Breusch-Pagan test.

3.2 Volatility Analysis: These volatility indicators show large short-run fluctuations around the long-term depreciating trend. Also, the exchange rate has deviated far from the mean with a standard deviation of 4.362 percent and a monthly average percentage change of 0.323 percent. Similarly, the standard deviation, 3.5685 NPR, indicates that large fluctuations are only sporadic, even though the average monthly marginal change is as high as 0.2006 NPR. The most prominent exchange rate shocks that could be found in the data set are the largest monthly depreciation of +16.71% and the strongest monthly appreciation of -18.16%. These values represent periods of domestic economic hardship, worldwide financial shocks, and political turmoil. Overall, the data support the main goal of the study: between 1998 and 2020, the NPR experienced significant short-term volatility along with a consistent long-term decline versus the USD. The need for currency rate risk management for Nepal's businesses, investors, and regulators is highlighted by this combination of structural decline and infrequent major shocks.

Forecast of Future Exchange Rate Values (2021-2024): The study's second objective, which is to predict future NPR/USD exchange rate values between 2021 and 2024 using time series techniques like moving averages, decomposition-based trend projection, and exponential smoothing with ETS, is covered in this section. The ETS model produces the most accurate forecast because it manages trends and seasonal components, gives more weight to more recent observations, and takes into account the dynamic patterns found in historical data, even though the decomposition and moving average models aid in revealing long-term structure.

Table 2: ETS(M, Ad, N) Forecast of NPR/USD Average Exchange Rate (2021-2024)

Period	Point Forecast (NPR/USD)	Lo 95%	Hi 95%
Jan-21	117.874	105.0909	130.6572
Feb-21	117.5439	103.1032	131.9846
Mar-21	118.2997	102.2704	134.3291
Apr-21	118.7822	101.2305	136.334
May-21	118.594	99.5827	137.6052
Jun-21	118.6616	98.2501	139.0731
Jul-21	117.8859	96.1297	139.6421
Aug-21	117.8745	94.8253	140.9237
Sep-21	117.8362	93.542	142.1303
Oct-21	117.4334	91.9388	142.9279
Nov-21	117.3037	90.6501	143.9573
Dec-21	117.6722	89.8979	145.4466
Jan-22	117.8825	89.0229	146.7421

Feb-22	117.5507	87.6387	147.4626
Mar-22	118.3052	87.3715	149.2389
Apr-22	118.7865	86.8595	150.7136
May-22	118.5974	85.7034	151.4914
Jun-22	118.6644	84.8281	152.5006
Jul-22	117.8881	83.1326	152.6437
Aug-22	117.8762	82.2229	153.5295
Sep-22	117.8376	81.3067	154.3685
Oct-22	117.4345	80.0449	154.8241
Nov-22	117.3046	79.0741	155.5352
Dec-22	117.6729	78.6182	156.7277
Jan-23	117.8831	78.0199	157.7463
Feb-23	117.5511	76.8944	158.2078
Mar-23	118.3055	76.8694	159.7417
Apr-23	118.7868	76.5846	160.9891
May-23	118.5977	75.642	161.5534
Jun-23	118.6646	74.9675	162.3617
Jul-23	117.8883	73.4612	162.3153
Aug-23	117.8764	72.7303	163.0224
Sep-23	117.8377	71.983	163.6924
Oct-23	117.4346	70.8812	163.9879
Nov-23	117.3047	70.0621	164.5472
Dec-23	117.673	69.7504	165.5956
Jan-24	117.8831	69.2892	166.4771
Feb-24	117.5511	68.2942	166.8081
Mar-24	118.3056	68.3937	168.2174
Apr-24	118.7869	68.2278	169.3459
May-24	118.5977	67.3988	169.7965
Jun-24	118.6646	66.8331	170.496
Jul-24	117.8883	65.4311	170.3455

Source: Exchange rate data (NPR/USD) sourced from the Nepal Rastra Bank (NRB) official records for the period from 1998 to 2020.

The future path of the Nepalese currency rate has been forecast using the ETS model, in particular, ETS(M,Ad,N) as defined by R's stlf() function. Such a model includes multiplicative errors, an additive damped trend, and no seasonal component, which is an acceptable structure given that the nature of the NPR/USD series includes a strong long-term upward trend and little or no seasonality. Smoothing parameters of the ETS model ($\alpha = 0.9999$, $\beta = 0.337$, $\phi = 0.8$) indicate that the model places substantial weight on the recent observations and has captured the upward depreciation trend of NPR. Performance metrics such as RMSE = 1.238, MAE = 0.882, and MAPE ≈ 1.03% indicate high accuracy in the forecasting model. The 48 months' forecast (2021-2024) shows that the exchange rate will be remarkably stable and hover around 117-119 NPR/USD, a figure very consistent with the recent historical values. However, its confidence intervals widen substantially over the forecast horizon, with their upper bound exceeding 170 NPR/USD well past the middle of 2024. That signals the increasing long-term uncertainty, a fact that reflects Nepal's sensitivity to external shocks, political instability, import dependence, and global financial conditions. Overall, the estimates indicate that the Nepalese rupee will continue to depreciate mildly in the short run, with increased uncertainty in the medium term. This pattern demonstrates the currency's continuing structural weakness and

emphasizes the significance of hedging techniques and governmental reforms to reduce exposure to external shocks.

Financial Implications of Exchange Rate Fluctuations Based on Volatility Analysis: This section evaluates the financial impact of exchange rate fluctuations using volatility indicators calculated from the monthly NPR/USD average exchange rate from 1998 to 2020. The monthly percentage change, marginal (absolute) change, and standard deviations are used to determine how volatile the exchange rate has been over time. These figures give light on the currency risk that Nepalese businesses, investors, and governments face.

Table 4: Volatility indicators of NPR/USD average exchange rate (1998-2020)

Volatility measure	Value (R output)	Interpretation (brief)
Mean monthly percent change	0.32 percent	On average, NPR depreciates slightly each month
Standard deviation of percent change	4.36 percent	High variability in monthly percentage movements
Mean marginal change (NPR)	0.2006 NPR	Typical level change per month is small
Standard deviation of marginal change (NPR)	3.5685 NPR	Monthly changes often deviate several NPR
Maximum monthly percent depreciation	16.71 percent	Largest one-month loss in NPR value
Maximum monthly percent appreciation	-18.16 percent	Largest one-month gain in NPR value
Number of monthly observations	271	Coverage from 1998 to 2020

Source: Exchange rate data (NPR/USD) sourced from the Nepal Rastra Bank (NRB) official records for the period from 1998 to 2020.

Table 4's results show that although the average monthly percentage change in the exchange rate is only roughly 0.32 percent, the standard deviation of 4.36 percent indicates that actual monthly movements can occasionally be significantly larger than the average. This indicates that the Nepalese rupee experiences frequent short-term volatility rather than smooth movement. Similarly, the standard deviation of 3.57 NPR shows that the exchange rate varies by several rupees in many months, even though the average marginal change of 0.20 NPR per month seems insignificant. Extreme figures, like a maximum monthly depreciation of +16.71 percent and a maximum appreciation of -18.16 percent, show that strong shocks rather than gradual adjustments can occasionally affect the exchange rate.

Financially, the Nepalese economy faces increased exchange rate risk due to a steady long-term depreciation trend and significant short-term volatility. Import-dependent businesses may face unexpectedly high input costs if the rupee falls significantly, while exporters and remittance recipients face uncertainty about the value of their foreign currency earnings. Long-term investment projects denominated in foreign currency, such as infrastructure or energy projects, may have inaccurate cost estimates due to significant exchange rate fluctuations. These findings imply that Nepalese businesses, investors, and policymakers should explicitly include exchange rate volatility in pricing, budgeting, and financial planning, as well as consider using risk management tools such as hedging contracts or natural hedging strategies to reduce their exposure to unexpected exchange rate shocks.

Financial and policy strategies for managing exchange rate risk in Nepal: The study's empirical results show that the Nepalese rupee has experienced significant short-term volatility, sporadic dramatic shocks, and

a steady long-term decline against the US dollar. Exchange rate risk is still a major and persistent concern for businesses, investors, and governments, according to volatility measurements (high standard deviations and significant monthly percentage changes) and ETS-based estimates. Based on these conclusions, this subsection suggests useful financial strategies for businesses and policy choices for the Nepalese government and Nepal Rastra Bank (NRB) to control and reduce exchange rate risk.

Table 5: Proposed financial and policy strategies for managing exchange rate risk in Nepal

Level	Strategy	Description	Link to findings
Firm / project level	Natural hedging	Matching the currency of revenues and costs (e.g., borrowing in USD when revenues are in USD, or sourcing inputs in local currency when revenues are in NPR).	Reduces the impact of monthly volatility and extreme shocks on profit margins.
	Financial hedging with banks	Using forward contracts or swap arrangements with commercial banks to lock in future exchange rates for major imports, exports, or debt repayments.	Protects firms from large, unexpected movements (e.g., ±16-18 percent monthly changes).
	Foreign Exchange clauses in contracts	Including exchange rate adjustment clauses or pricing in a reference currency (e.g., USD) for long-term contracts.	Helps manage the risk of long-run depreciation revealed in the trend and forecast.
	Scenario analysis and stress testing	Using historical volatility (mean and standard deviation of percentage and marginal changes) to simulate worst-case exchange rate scenarios in project appraisal.	Uses empirical volatility (e.g., 4.36 percent SD) to quantify potential financial losses.
	Liquidity and reserve management	Maintaining a buffer of foreign currency reserves (e.g., USD balances) for firms heavily dependent on imports or foreign debt.	Provides protection during months with extreme depreciation.
	Currency diversification	Avoiding excessive exposure to a single foreign currency by diversifying currency baskets for borrowing, saving, or investing.	Reduces the concentration of risk associated with NPR/USD movements.
Policy / macro level	Strengthening Foreign Exchange reserves	Building and maintaining adequate foreign exchange reserves through export promotion, tourism, remittance inflows, and prudent external borrowing.	Allows NRB to smooth excessive volatility and respond to external shocks.
	Developing Foreign Exchnage derivatives markets	Gradually promoting simple currency hedging instruments (forwards, swaps) in the domestic financial system under NRB regulation.	Provides firms with tools to manage the volatility documented in the study.
	Coordinated inflation and exchange rate management	Implementing policies to control inflation (the inflation proxy in this study) and maintain macroeconomic stability.	Helps reduce depreciation pressure and moderating effect of inflation on the exchange rate.
	Clear and transparent policy communication	Providing regular guidance on exchange rate policy, intervention rules, and macroeconomic outlook.	Reduces uncertainty and improves planning for businesses facing FOREIGN EXCHANGE risk.

	Limiting unhedged Foreign Exchange borrowing	Using macroprudential regulation to discourage excessive unhedged foreign-currency debt in banks and corporates.	Lowers systemic vulnerability to sudden depreciation episodes.
	Structural reforms to boost exports and productivity	Supporting sectors that earn foreign exchange (e.g., tourism, hydropower, IT services) and reduce import dependence.	Addresses the long-run depreciation trend by improving external balance.

Source: Exchange rate data (NPR/USD) sourced from the Nepal Rastra Bank (NRB) official records for the period from 1998 to 2020.

Strategies that directly address the empirical evidence of high exchange rate volatility and long-term depreciation found in this study are included in Table 5. Businesses can safeguard their cash flow and profit margins against unanticipated changes in the NPR/USD rate by using natural hedging, forward contracts, foreign exchange reserves, and contract clauses. Businesses can perform scenario analysis and stress testing to determine how unfavorable exchange rate movements would impact their expenses, revenues, and project viability using the actual volatility estimates from this study (such as the 4.36 percent standard deviation of monthly percentage changes and the extreme monthly shocks of +16.71% and -18.16 percent).

The results demonstrate that businesses cannot handle exchange rate risk on their own at policy level. The significant long-term depreciation trend and expanding forecast intervals emphasize how crucial it is to keep sufficient foreign exchange reserves, manage inflation, and ensure a stable macroeconomic environment. By creating basic foreign exchange derivative markets, enhancing policy transparency, and restricting unhedged foreign currency borrowing, the Nepal Rastra Bank and the Nepalese government can lessen systemic exposure to exchange rate shocks. Reducing depreciation pressure on the Nepalese rupee and enhancing the nation's resilience to external shocks require long-term, structural changes that increase exports, diversify the economy, and lessen reliance on imports.

According to the data, the Nepalese Rupee experienced considerable short-term volatility in addition to a consistent long-term decline against the US dollar between 1998 and 2020. While the ETS model predicts a slight depreciation through 2021–2024, trend analysis supports the exchange rate's continued upward trajectory. A high-risk currency position is indicated by volatility assessments that reveal regular monthly fluctuations and sporadic sharp shocks. Overall, the results show that Nepal's exchange rate dynamics are marked by significant short-term volatility and gradual structural depreciation, both of which have detrimental financial effects on companies and policymakers.

4. DISCUSSION

The result of this analysis indicated that from 1998 to 2020, the NPR has experienced continuous long-term depreciation and significant short-run volatility against the USD. The trend analysis, moving averages, and decomposition signal a consistent upward rise in the NPR/USD exchange rate, proving that the native currency weakens over time. This supports the claim that the Nepalese rupee has significantly fallen against the dollar in recent decades. The study assessed the long-term behavior, near-term evolution, and financial implications of such patterns for Nepalese decision-making. Historical patterns and volatility were examined using monthly average exchange rate data, projections were made using the ETS time series model, and

volatility metrics were translated into financial risks and management solutions. Although the ETS model provided consistent forecasts extending the historical trend into 2021-2024 (predicting rates of 117-119 NPR/USD), actual results were significantly higher (118.21 in 2021, 125.76 in 2022, 132.15 in 2023, and 133.86 in 2024). This disparity is due to using data only up to 2020, which does not account for external shocks like COVID-19, global inflation, supply-chain disruptions, the Russia-Ukraine war, and local political issues. These events dramatically increased import costs strengthened the US dollar globally, and put additional strain on Nepal's external sector. Univariate models, such as ETS, which rely solely on previous exchange rate behavior, are incapable of accommodating such unexpected shocks. The volatility analysis indicates a tough environment: even before the post-2020 shocks, the NPR/USD rate showed high standard deviation and dramatic monthly changes (±16-18%). The combination of steady structural depreciation and frequent sudden shocks causes uncertainty for importers, exporters, project managers, remittance-dependent households, and financial institutions. The findings apply directly to various stakeholders. Businesses can use the established trend and volatility for pricing, budgeting, contract design, and hedging decisions. Investors and project developers gain a better understanding of cash-flow and return concerns. Policymakers and the Nepal Rastra Bank can use evidence of long-term depreciation and significant volatility for reserve management, currency stabilization, and financial tool creation. The post-2020 forecast inaccuracy indicates directions for future research. Purely univariate models (ETS, moving averages, decomposition) have limited power when the economic environment changes quickly. Future research should explore multivariate approaches like ARIMAX (including interest rates, oil prices, reserves, and remittance inflows), GARCH-family models for time-varying volatility, and machine learning techniques (LSTM, GRU) to better capture non-linearities and structural changes. Extending the dataset beyond 2020 and assessing breakdowns would help evaluate the impact of recent global and domestic shocks. Overall, the NPR/USD exchange rate in Nepal has shown significant short-term volatility and slow structural depreciation. In an open, small, and shock-prone economy, these characteristics pose significant risks to businesses, investments, and macroeconomic stability, requiring better forecasting techniques, stronger hedging strategies, and robust legal frameworks.

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