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Forex of India since 1991: A Study Based on Mann-Kendall Time Series Trends

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Keywords:
New Economic Policy 1991, Foreign Exchange Reserve of India, Gross National Product.

ABSTRACT

India's has become the fourth largest country in terms of foreign exchange reserves. The Foreign Exchange Reserves (FX Reserves) of India refer to the total foreign currency assets held by the Reserve Bank of India (RBI). It includes Special Drawing Rights (SDRs), Physical Gold and Foreign Currency Assets. Foreign exchange reserve play a crucial role in stabilizing the Indian economy, particularly with regard to foreign trade and the payment system. This study examines a dataset covering a period of 31 years from 1991 to 2022. The objective of the study is to analyze the long-term trends in foreign exchange reserves in order to gain insight into the dynamics of the Indian economy and to explore their association with GDP growth. The Mann-Kendall test is used to analyze trends in time series data and regression to analysis its impact on the growth of GDP of India. The result of the Mann Kendall test that the computed p-value is lower than the significance level 0.05 at 95% of confident level, the null hypothesis is rejected. Hence, the foreign exchange reserve of India increases further and has positive trend. But in respect of GDP it has no impact on the growth of GDP of India since the p-value is greater than the significance level of 0.05 at 95% of confident level. Therefore, the Government of India needs to adopt new initiatives, policies, and strategies to further strengthen its foreign exchange reserves. Strengthening reserves will enhance macroeconomic stability and improve resilience to external shocks in the global economy

Kata Kunci:
Kebijakan Ekonomi Baru 1991, Cadangan Devisa India, Produk Nasional Bruto.

ABSTRAK

Pasar Forex India sejak 1991: Sebuah Studi Berdasarkan Tren Deret Waktu Mann-Kendall. *India telah menjadi negara dengan cadangan devisa terbesar keempat di dunia. Cadangan Devisa (FX Reserves) India mengacu pada total aset mata uang asing yang dimiliki oleh Bank Sentral India (RBI). Ini termasuk Hak Penarikan Khusus (SDR), emas fisik, dan aset mata uang asing. Studi ini menggunakan kumpulan data selama 31 tahun dari tahun 1991 hingga 2022. Tujuan penelitian ini adalah untuk menganalisis tren jangka panjang guna mendapatkan wawasan tentang dinamika perekonomian India dan mengeksplorasi hubungannya dengan pertumbuhan PDB. Uji Mann-Kendall digunakan untuk menganalisis tren dalam data deret waktu dan regresi untuk menganalisis dampaknya terhadap pertumbuhan PDB India. Studi ini mengungkapkan melalui uji Mann-Kendall bahwa nilai p yang dihitung lebih rendah dari tingkat signifikansi 0,05 pada tingkat kepercayaan 95%, sehingga hipotesis nol ditolak. Oleh karena itu, cadangan devisa India meningkat lebih lanjut dan memiliki tren positif. Namun, dalam hal PDB, tidak ada dampak pada pertumbuhan PDB India karena nilai p lebih besar dari tingkat signifikansi 0,05 pada tingkat kepercayaan 95%. Dengan demikian, Pemerintah India harus mengambil inisiatif, kebijakan, dan strategi baru untuk memperkuat cadangan devisanya. Hal ini akan meningkatkan stabilitas makroekonomi, dan meningkatkan ketahanan terhadap guncangan eksternal dalam ekonomi global.*

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INTRODUCTION

India's foreign exchange reserves are the fourth largest in the world as of 2023, standing at around US$598.89 billion, whereas China holds the first position, followed by Japan and Switzerland. The Foreign Exchange Reserves (FX reserves) of India refer to the total foreign currency assets held by the Reserve Bank of India (RBI). Forex facilitates international trade by enabling the exchange of currencies. A positive trade balance, where exports exceed imports, leads to increased demand for the country's currency, strengthening it against others. A stable and liquid forex market attracts foreign investors. By investing in foreign currencies or currency-denominated assets, individuals and institutions can spread risk and potentially achieve higher returns. The influx of foreign capital contributes to economic growth, technological advancement, and job creation. The RBI uses forex reserves to stabilize the value of the domestic currency and regulate the economy. Forex also plays a crucial role in the tourism sector. A weaker domestic currency makes a country's tourist destinations more affordable for foreign visitors, increasing tourism revenue. This revenue contributes to GDP growth, creates jobs in the hospitality industry, and stimulates related sectors such as transportation, entertainment, and retail. Overall, forex markets serve as a vital component of the global economy, facilitating international trade, investment, and economic growth, while allowing countries to manage their monetary policies effectively

Empirical research on the Indian Forex market has explored various dynamics such as volatility behavior, spillover effects, determinants of exchange rate movements, and market regularity. However. several gaps remain. For instance, Rajamani, Suganya, and Solomon (2024) examined volatility and spillover mechanisms across major INR exchange rates using ARCH/GARCH techniques, highlighting market interdependence but noting limited understanding of short- vs. long-term drivers (Rajamani et al., 2024). Datta (2023) employed entropy measures to demonstrate that forex return regularity increases during financial crises, suggesting that traditional models may understate structural shifts during periods of stress (Datta, 2023). A wavelet-based investigation of multiscale dynamics revealed persistence and long memory in INR exchange rates; nevertheless, forecasting improvements and asymmetric effects warrant deeper investigation (Multiscale Foreign Exchange Dynamics, 2025).

Volatility behavior and spillover research have further confirmed conditional volatility patterns and cross-rate influences; however, macroeconomic interactions and policy impacts remain less explored (Volatility Behaviour and Spillover Effect, 2025). Prior studies have also examined macroeconomic determinants of exchange rate fluctuations using regression analyses of interest rate differentials, trade deficits, and capital flows, yet often omitted high-frequency data and structural break analysis (Shah, 2024). Forecasting studies employing ARIMA and VAR models indicated that lag effects dominate macroeconomic variables but did not integrate nonlinear dynamics or machine learning techniques (Forecasting Exchange Rate Volatility, 2023). Other research has attempted to forecast volatility using GARCH models for the INR against multiple currencies; however, market efficiency and predictive robustness remain open questions (Forecasting the Volatility of Indian Forex, 2024). Empirical work linking exchange rate and equity market volatility has shown interdependence between INR–USD returns and the BSE Sensex, suggesting financial market integration effects that deserve further causal investigation (INR-USD and Sensex Volatility, 2022).

Studies on selected macroeconomic factors influencing INR/USD volatility (e.g., FIIs, WPI, and reserves) point to rich interactions that require more comprehensive models capable of capturing global shock transmission (Usha & Thimmaiah, 2024). Finally, studies on currency risk management practices in Indian firms have shown a reliance on forward contracts and a limited use of other derivatives, indicating a need for further research on firm-

level hedging behavior and policy effectiveness in a regime where policy frameworks and market microstructure evolve rapidly (Basanna & Vittala, 2019). Together, these studies illustrate a strong foundation for understanding Indian forex market dynamics but also highlight the need for further research on nonlinear forecasting methods, high-frequency data, macrofinancial linkages, crisis behavior, policy impacts, and firm-level hedging strategies to support more effective market analysis, risk management, and policy design. Hence, this study assumes significance in highlighting the underlying strength of the Indian economy and elucidating its growth dynamics

Foreign Exchange Reserve

The Reserve Bank of India (RBI) Act, 1934, gives the RBI the authority to act as the custodian of foreign exchange reserves and to manage these reserves with defined objectives. Foreign exchange reserves, also known as forex reserves or international reserves, refer to a stockpile of assets held by a central bank in foreign currencies. These assets can include (Vanlalramsanga & Ramesh Golait, 2012)

Special Drawing Rights (SDRs): These are international reserve assets created by the International Monetary Fund (IMF) that can be exchanged for other foreign currencies. Gold: Gold is an essential asset for storing value. It serves as a hedge and boosts confidence in a country's economic stability, particularly during periods of financial uncertainty. The Reserve Bank of India (RBI) holds physical gold to support the value of its currency. Additionally, gold's tangibility allows countries to diversify their overall investment portfolios.

Foreign Currency Assets: These are deposits held in foreign banks, denominated in foreign currencies as well as bonds issued by foreign governments or corporations, denominated in foreign currencies.

The RBI needs to maintain exchange rate stability by buying or selling its own currency in the foreign exchange market. Hence, foreign exchange reserves support exchange rate stability. Governments and companies sometimes need to make payments in foreign currencies, and foreign exchange reserves are used to meet these obligations. This provides liquidity to the domestic financial system in times of crisis. Large foreign exchange reserves can be seen as a sign of a country's economic strength and stability, which can attract foreign investment. The composition of foreign exchange reserves varies from country to country. However, the US dollar is the most commonly held reserve currency, followed by the euro, the Japanese yen, and the Chinese yuan. Foreign exchange reserves play a critical role in maintaining the economic stability of a country. The analysis of India's forex reserves helps to determine whether the country has sufficient buffers to withstand external currency crises. Research has shown that foreign exchange reserves affect trade and investment flows, trade competitiveness, foreign direct investment (FDI), and portfolio investment. Maintaining adequate reserves is crucial to ensure that the country meets its debt repayment obligations without resorting to crisis measures. Therefore, India's position in the global financial system and its ability to participate in international financial markets need to be examined. This study provides valuable insights into the country's economic health, policy effectiveness, and resilience to external shocks. This information is useful for policymakers and market participants in making informed decisions. Given the survey of the literature and the scope of the study, the objective established for this research is:

1. To explore the nature of the trend of Foreign Exchange Reserve of India.
2. To identify the impact of Foreign Exchange Reserve on GDP Growth Rate of India.

Given the survey of literature, the scope and the objectives, the hypotheses established for the purpose of the study are as follows:

1. There is no existing trend in the Foreign Exchange Reserve of India
2. Foreign Exchange Reserve has no impact on GDP Growth Rate of India.

LITERATURE REVIEW

The study is an updated version of many studies conducted on the growth and trend of foreign exchange reserves in India but differs in terms of analysis and presentation. Foreign exchange reserves are a critical component of a nation's economic stability and are often subject to extensive research to understand their growth, trends, and impacts on various economic indicators. This literature review systematically examines studies conducted on the growth and trend of foreign exchange reserves in India, as well as related analyses and their impacts on the economy.

The present study draws on the foundational insights provided by Rajanbabu's (2019) exploration of the growth of foreign exchange reserves in India from 1960-61 to 2017-18, and the study by Abid and Jhawar (2017), which explored the growth of forex from 2001 to 2016, contributing to an understanding of long-term reserve accumulation trends and adopting the Mann Kendall time series trend analysis. The study by Charansingh (2006) identifies the factors driving the growth of India's foreign exchange reserves, which is valuable for understanding the current study. Prabheesh et al. (2007) analyzed the demand for foreign exchange reserves in India, providing insights into the factors influencing reserve accumulation.

Mishraa et al. (2007) and Khullar and Sethi (2011) investigated volatility spillovers between stock and foreign exchange markets, contributing to an understanding of market interdependencies. Ray (2012) examined the impact of foreign exchange reserves on the stock market, a topic further explored by Jayachandran (2013) through an analysis of the correlation between exchange rates, trade, and GDP, providing insights into the broader economic implications of exchange rate movements. Arunachalam (2010) conducted a comparative study of foreign exchange reserves in India and China, revealing similarities and differences in reserve management strategies. The methodology of the present study considers Arunachalam's work. Priyadarshi and Narayanan (2011) focused on the determinants of foreign exchange reserves in India, which are taken into consideration in the present study.

Gokhale and Raju (2013) studied the correlation between exchange rates and foreign exchange reserves, offering insights into the dynamics between these key economic variables. Bhullar and Dhameja (2016) explored the long-run equilibrium between exchange rates and foreign exchange reserves, enriching the understanding of exchange rate determination. Rakesh et al. (2016) investigated the impact of currency fluctuations on the Indian stock market, highlighting the vulnerability of the stock market to exchange rate movements. Rekha and Mary (2017) studied foreign exchange rate volatility in the Nifty index, providing insights into the impact of exchange rate fluctuations on stock market performance. Poongothai and Kalaipriya (2017) analyzed the composition of foreign exchange reserves in India, offering insights into reserve management strategies. Damani and Vora (2018) explored the factors affecting the exchange rate in India, enriching the understanding of exchange rate determination mechanisms.

Chowdhury & Anuradha (2018) predicted the economic scenario in India and its impact on exchange rate fluctuations and stock market volatility, providing insights into future economic trends. Agarwal et al. (2020) analyzed the rising foreign exchange reserves of India during the Covid-19 pandemic, highlighting the role of reserves in times of economic

crisis. Arize & Malindretos (2012) investigated the impact of Foreign exchange reserves in Asia on import demand, contributing to understanding the broader regional implications of reserve accumulation. Gondaliya & Dave (2015) studied the impact of exports and imports on exchange rates in India, providing insights into the relationship between trade flows and exchange rate movements.

Reddy (2002) focused on India's foreign exchange reserves policy, status, and issues, offering a comprehensive analysis of reserve management practices. Nag and Mitra (2002) forecasted daily foreign exchange rates using genetically optimized neural networks, contributing to the development of predictive models in exchange rate forecasting. Ramachandran and Srinivasan (2007) studied asymmetric exchange rate intervention and international reserve accumulation in India, providing insights into central bank intervention strategies. Huang et al. (2004) reviewed the forecasting of foreign exchange rates using artificial neural networks, offering insights into the application of advanced computational methods in exchange rate forecasting

Pal & Mittal (2011) analyzed the impact of macroeconomic indicators on Indian capital markets, contributing to an understanding the broader macroeconomic determinants of stock market performance. Sharma & Mahendru (2010) discussed the impact of macroeconomic variables on stock prices in India, enriching the understanding of the relationship between economic fundamentals and stock market dynamics. Kumar & Puja (2012) also explored the impact of macroeconomic fundamentals on stock prices, providing insights into the factors influencing stock market movements. Vanlalramsanga & Golait. (2012) studied the Indian foreign exchange market and the equilibrium real exchange rate of the rupee, offering insights into exchange rate determination in India.

These studies collectively contribute to a comprehensive understanding of foreign exchange reserves and their impacts on various economic indicators in the context of India, enriching both academic literature and policy discussions in the field of international finance and economics and strethening the presented study.

METHODOLOGY

This study delves into a dataset that spans 31 years of foreign exchange reserves in India, from 1991 to 2022. The objective of the investigation is to analyze the long-term trends in order to gain insight into the dynamics of the Indian economy. The year 1991 was selected as the starting point for the analysis, as it marks a notable turning point in India's economic history, with the introduction of the New Economic Policy by the Government of India, aimed at revitalizing the Indian economy. The Mann-Kendall test, named after H. Mann and D. R. Kendall, is a non-parametric statistical test used to analyze trends in time series data. It is particularly useful when the data violates assumptions of normality. The Mann-Kendall test detect trends in time series data identify whether the data exhibit a monotonic trend (i.e., consistently increasing or decreasing) over time. In economics, it is used to analyze trends in economic indicators like GDP, unemployment rates, or stock prices. The Mann-Kendall test provides a robust and versatile method for detecting trends in time series data, making it a valuable tool across various fields of study and research. This test is conducted to identify the trend in the data values $\mathbf{x_i}$ of a time series which are assumed to fit in the given Model.

$$\mathbf{x_i = f(t)+\varepsilon_i}$$

Where f(t) is the continuous function of time series and the residual $\boldsymbol{\varepsilon_i}$ can be assumed to be from the same distribution with zero mean. It is therefore assumed that the variance of

distribution is constant in time series. Mann Kendall test statistic S is calculated using given equation [1]:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} sign(x_j - x_i)$$

$$\text{sgn}(x_j - x_k) = \begin{cases} +1, if(x_j - x_k) > 0 \\ 0, if(x_j - x_k) = 0 \\ -1, if(x_j - x_k) < 0 \end{cases} \quad (2)$$

Where n is the length of the sample, x_i and x_j are from i=1, 2, …, n-1 and j= i+1, …, n. If n is bigger than 8, statistic S approximates to normal distribution. The mean of S is 0 and the variance of S can be acquired as follows:

$$\sigma^2 = \frac{n(n-1)(2n+5) - \sum_{i=1}^{m} t_i(t_i-1)(2t_i+5)}{18} \quad (3)$$

So the variance is computed when n ≥ 10, then the test statistic Z is denoted by Eq.(4).

$$z = \begin{cases} (S-1)/se, & S > 0 \\ 0, & S = 0 \\ (S+1)/se, & S < 0 \end{cases}$$

If Z>0, it indicates an increasing trend, and vice versa. Given a confidence level α, the sequential data are assumed to exhibit a statistically significant trend if |Z|>Z(1-α/2), where Z(1-α/2) is the corresponding value of P=α/2 following the standard normal distribution. In this study, confidence levels of 0.05 and 0.01 were used. In addition, the magnitude of the time series trend was evaluated by using a simple non-parametric procedure developed by Sen known as Sen's slope [5]. The trend is calculated by

$$\beta = Median\left(\frac{x_j - x_i}{j - i}\right), \ j > i$$

where β is Sen's slope estimate. A positive value of β>0 indicates an upward trend in a time series. Otherwise, the data series presents a downward trend during the study period.

The growth rate is calculated to measure the change in a quantity over a specific period of time, typically expressed as a percentage. It allows analysts, economists, policymakers, and investors to assess the pace of change in various economic, financial, or other quantitative indicators.

Growth Rate= (Final Value−Initial Value/ Initial Value) ×100%

A good methodology should be clean and clear. Clean means the use of appropriate, valid, and unflawed methods of sampling and use of instruments, procedures, and analyses. Clear means the ideal method is written in a clear manner, such that another researcher could duplicate the study.

RESULT AND DISCUSSION

Foreign Exchange Reserve has played a significant role in stabilizing the Indian economy, particularly in terms of foreign trade and payment systems. The implementation of the New Economic Policy in 1991 has opened up the Indian market to foreign countries, and the policies of liberalization, globalization, and privatization have further encouraged foreign companies to invest in India. This has been made possible through the support of the Foreign Exchange Reserve, which has facilitated the entry of foreign capital into the country. As a result, the Indian economy has experienced a new surge of growth and development, as evidenced by the increase in the GDP growth rate. The study of the Foreign Exchange Reserve of India, as recorded by the Reserve Bank of India, provides valuable information for policymakers to develop new economic policies, with the goal of making the Indian economy the third largest in the world. Table 1 presents the recorded Foreign Exchange Reserve of India for reference.

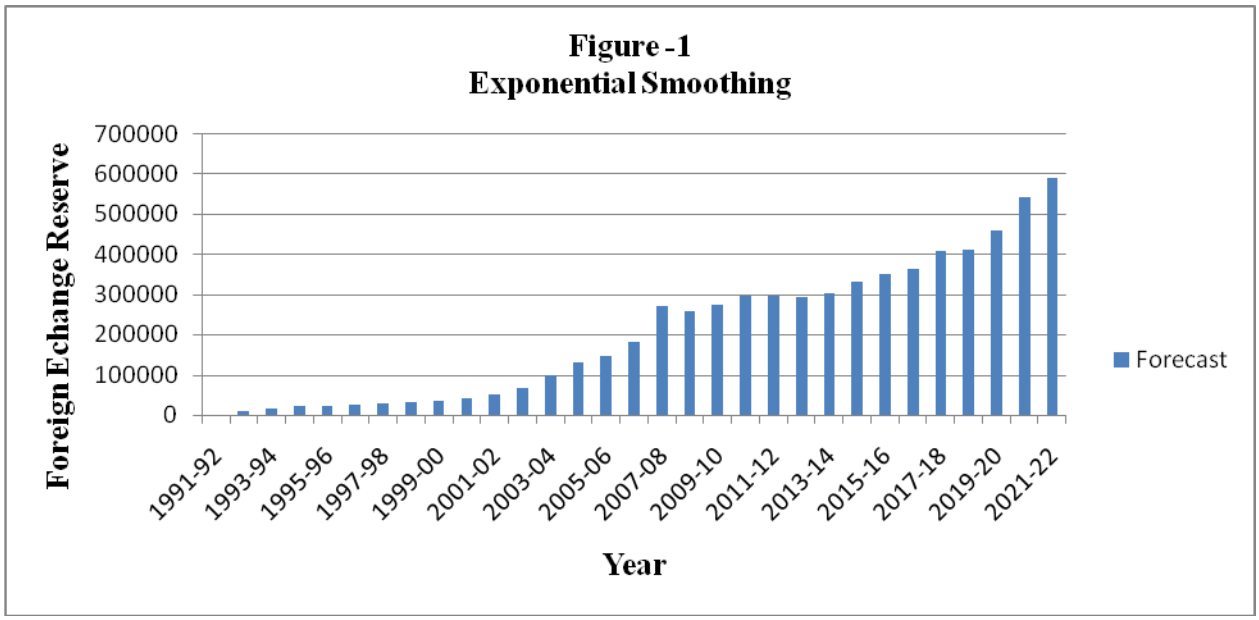
Table 1. Foreign Exchange Reserve of India in US $ Millions

End of Financial Year	SDRs	Gold	Foreign Currency Assets*	Total	Growth Rate of Forex
	US $ Millions	US $ Millions	US $ Millions	US $ Millions	
1991-92	90	3,499	5,631	9,220	
1992-93	18	3,380	6,434	9,832	6.63
1993-94	108	4,078	15,068	19,254	95.82
1994-95	7	4,370	20,809	25,186	30.80
1995-96	82	4,561	17,044	21,687	-13.89
1996-97	2	4,054	22,367	26,423	21.83
1997-98	1	3,391	25,975	29,367	11.14
1998-99	8	2,960	29,522	32,490	10.63
1999-00	4	2,974	35,058	38,036	17.06
2000-01	2	2,725	39,554	42,281	11.16
2001-02	10	3,047	51,049	54,106	27.96
2002-03	4	3,534	71,890	76,100	40.64
2003-04	2	4,198	107,448	112,959	48.43
2004-05	5	4,500	135,571	141,514	25.27
2005-06	3	5,755	145,108	151,622	7.14
2006-07	2	6,784	191,924	199,179	31.36
2007-08	18	10,039	299,230	309,723	55.49
2008-09	1	9,577	241,426	251,985	-18.64
2009-10	5,006	17,986	254,685	279,057	10.74
2010-11	4,569	22,972	274,330	304,818	9.23
2011-12	4,469	27,023	260,069	294,397	-3.41
2012-13	4,328	25,692	259,726	292,046	-0.79
2013-14	4,464	21,567	276,359	304,223	4.16
2014-15	3,985	19,038	317,324	341,638	12.29

2015-16	1,502	20,115	336,104	360,176	5.42
2016-17	1,447	19,869	346,319	369,955	2.71
2017-18	1,540	21,484	399,442	424,545	14.75
2018-19	1,457	23,071	385,357	412,871	-2.74
2019-20	1,433	30,578	442,213	477,807	15.72
2020-21	1,486	33,880	536,693	576,984	20.75
2021-22	18,891	42,551	540,724	607,309	5.25
2022-23	18,392	45,200	509,691	578,449	-4.75

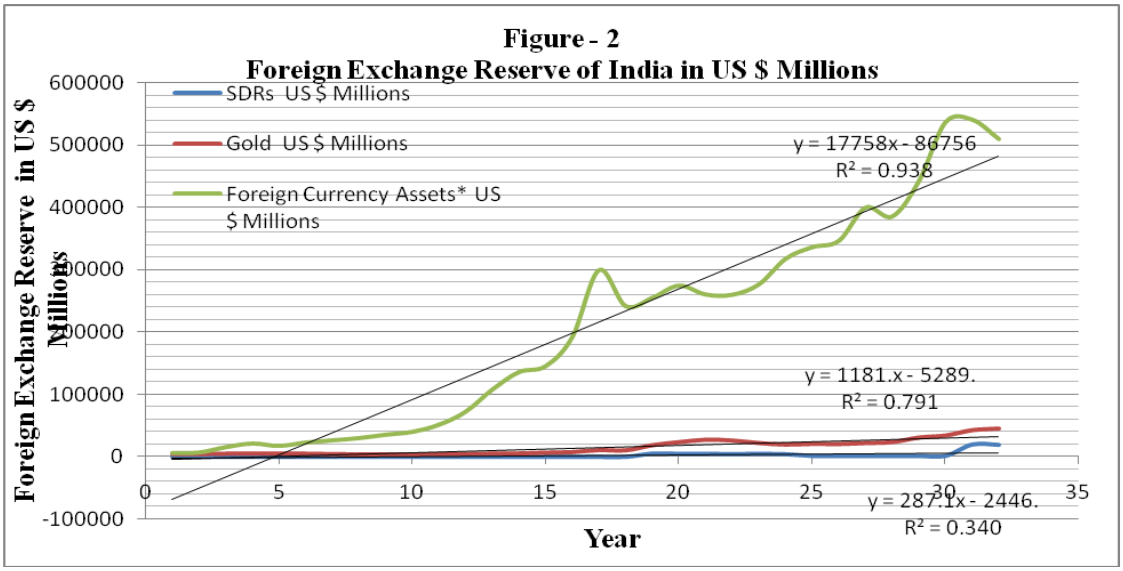
Source: Reserve Bank of India

Foreign exchange reserve is evaluated based on three components - SDRs, Gold, and Foreign Currency Assets. While SDRs contribute only a small percentage compared to the Gold reserve and Foreign Currency Assets, it has shown improvement in recent years since 2021. The Gold reserve has been fairly consistent from 1991 to 2005, but it has shown remarkable improvement since 2006. The third component, Foreign Currency Assets, has shown a consistent upward trend since 1991. Overall, India's Foreign Exchange Reserve has increased steadily since 1991, as illustrated in Figure-1.



Source: Compiled by author

Exponential smoothing is a widely used technique in forecasting and time series analysis, and Figure-1 illustrates its application to Indian's total foreign exchange reserves. This method is particularly useful for analyzing data that exhibit trends or seasonality. The exponential smoothing parameter, denotated by α, plays a crucial role in determining the weight assigned to each observation of India's foreign exchange reserve. The trend of the foreign exchange reserve of India is moving upward with more quantity, as shown by the exponential smoothing graph. It's a simple yet effective method for generating forecasts from time series data, capturing trends and seasonal patterns and offering flexibility in parameter selection. Figure 2 presents the trend in the movement of India's foreign exchange reserves, which have consistently increased over time from relatively low initial levels



Source: Compiled by author

Figure 2 demonstrates that the SRDs and Gold reserve trend, have remained almost flat and have shown only a minor increase over time, whereas the Foreign Currency Assets have shown a consistent increase, indicating a greater contribution to the Foreign Exchange Reserve of India. As a result, the Reserve Bank of India (RBI) has a larger quantity of foreign currency than SRDs and gold reserves. This suggests that the future of foreign trade in India appears promising. In order to explore the trend further, Mann-Kendall trend test is conducted and presented in the following tables.

Table 2. Descriptive Statistics for Foreign Exchange Reserve of India in US $ Millions

Variable	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
9220	31	0	31	9832.000	607309.000	231161.903	186944.761

Source: Compiled by author

The present study examines India's foreign exchange reserves over a period of 31 years, beginning in 1991. The analysis of the data reveals that the lowest level of India's foreign exchange reserves, measured in US$ million, was 9,832, while the highest reached 607,309. The mean value of the reserves was 231,161.903, with a standard deviation of 186,944.761. These data were further analyzed using the Mann–Kendall trend test to derive valuable insights into the trends and fluctuations of India's foreign exchange reserves, as presented in Table 3.

Table 3. Mann-Kendall trend test

Mann-Kendall trend test / Two-tailed test (9220):	
Kendall's tau	0.944
S	439
Var(S)	3461.667
p-value (Two-tailed)	**<0.0001**
Alpha (α)	0.05
The p-value is computed using an exact method.	

Test interpretation:	
H0: There is no trend in the series	
Ha: There is a trend in the series	
As the computed p-value is lower than the significance level alpha=0.05, one should reject the null hypothesis H0, and accept the alternative hypothesis Ha	

Source: Compiled by author

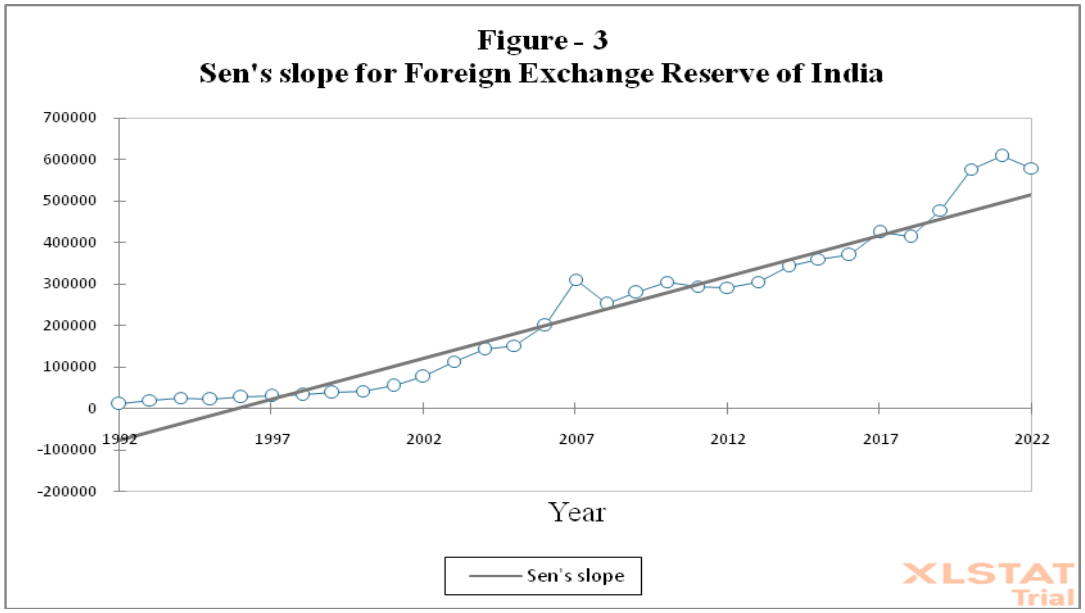
The Mann-Kendall trend test is used to determine the presence of a monotonic trend in a dataset over time. Kendall's tau measures the strength and direction of the association between two variables. In this study, Kendall's tau is 0.944, indicating a very strong positive correlation or trend in the data. The calculated score, S, is 439, evaluate the significance of the observed trend. It represents the sum of the signs of the differences between all pairs of data points. Var(S) is 3461.667 is the variance of the S statistic, measure of the variability or dispersion of the S values that would be expected if there were no trend in the data. The p-value associated with the Mann-Kendall test indicates the probability of obtaining the observed trend (or a more extreme one) if there were no actual trend in the data. A small p-value suggests strong evidence against the null hypothesis of no trend. The significance level, often denoted as α, is the threshold used to determine whether the p-value is small enough to reject the null hypothesis. Here, the p-value is less than 0.0001 (usually written as <0.0001), indicating extremely strong evidence against the null hypothesis. Hence, the results confirm a significant positive trend in India's foreign exchange reserves, which continuously support the country's foreign trade and payment systems. It is further assumed that this sustained growth trend contributes positively to the nation's GDP

Table 4. Sen's slope

Sen's slope:			
	Value	Lower bound (95%)	Upper bound (95%)
Slope	19768.923	17511.933	21691.333
Intercept	-39457280.692	-43316995.000	-34926369.667

Source: Compiled by author

Table - 4 depict the β the Sen's slope estimate. Where, $\beta>0$ indicates upward trend in a time series. Here, β is grated than 0 indicates that the Foreign Exchange Reserve of India increase further. This is presented in the Figure – 3.



Source: Compiled by author

Sen's slope is a statistical method commonly used in time series analysis to estimate the rate of change of a variable over time. It measures the magnitude of change in the variable being analyzed, where a positive Sen's slope indicates an upward movement of the variable. This implies that the variable has experienced positive changes in its values over the given period. To gain further insight, the growth trends of foreign exchange reserves and GDP are compared, as presented in Table 5.

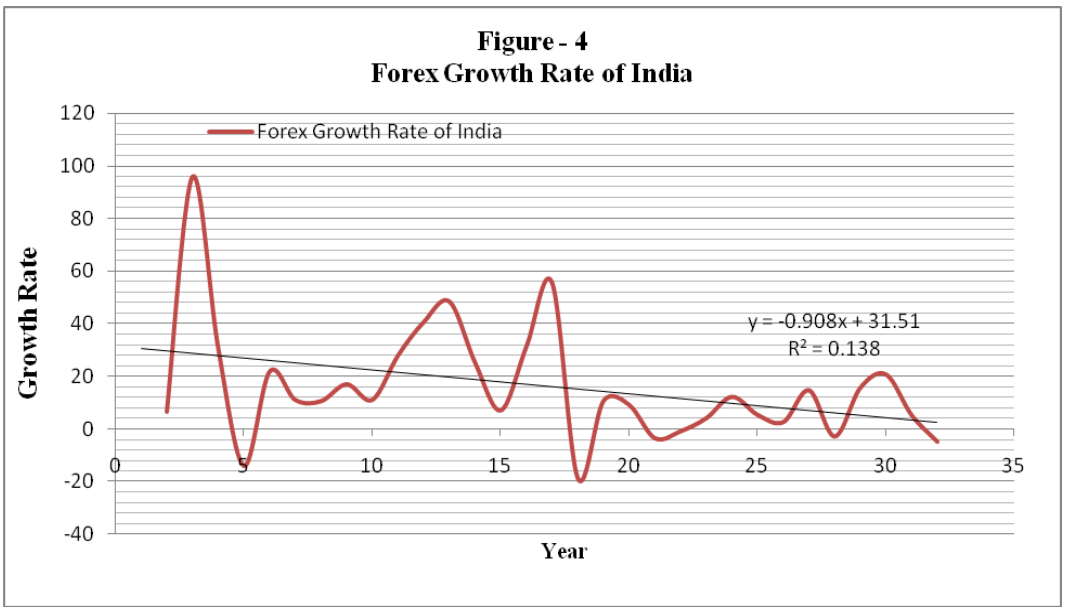
Table 5. Growth Rate of Forex and GDP of India

End of Financial Year	Forex Growth Rate of India	GDP Growth Rate of India
1991-92		1.06
1992-93	6.63	5.48
1993-94	95.82	4.75
1994-95	30.80	6.66
1995-96	-13.89	7.57
1996-97	21.83	7.55
1997-98	11.14	4.05
1998-99	10.63	6.18
1999-00	17.06	8.85
2000-01	11.16	3.84
2001-02	27.96	4.82
2002-03	40.64	3.80
2003-04	48.43	7.86
2004-05	25.27	7.92
2005-06	7.14	7.92
2006-07	31.36	8.06
2007-08	55.49	7.66
2008-09	-18.64	3.09

2009-10	10.74	7.86
2010-11	9.23	8.50
2011-12	-3.41	5.24
2012-13	-0.79	5.46
2013-14	4.16	6.39
2014-15	12.29	7.41
2015-16	5.42	8.00
2016-17	2.71	8.26
2017-18	14.75	6.80
2018-19	-2.74	6.45
2019-20	15.72	3.87
2020-21	20.75	-5.83
2021-22	5.25	9.05
2022-23	-4.75	7.24

Source: Compiled by author(Growth rate for Forex was calculated by author and GDP is obtained from World Bank national accounts data and OECD National Accounts data

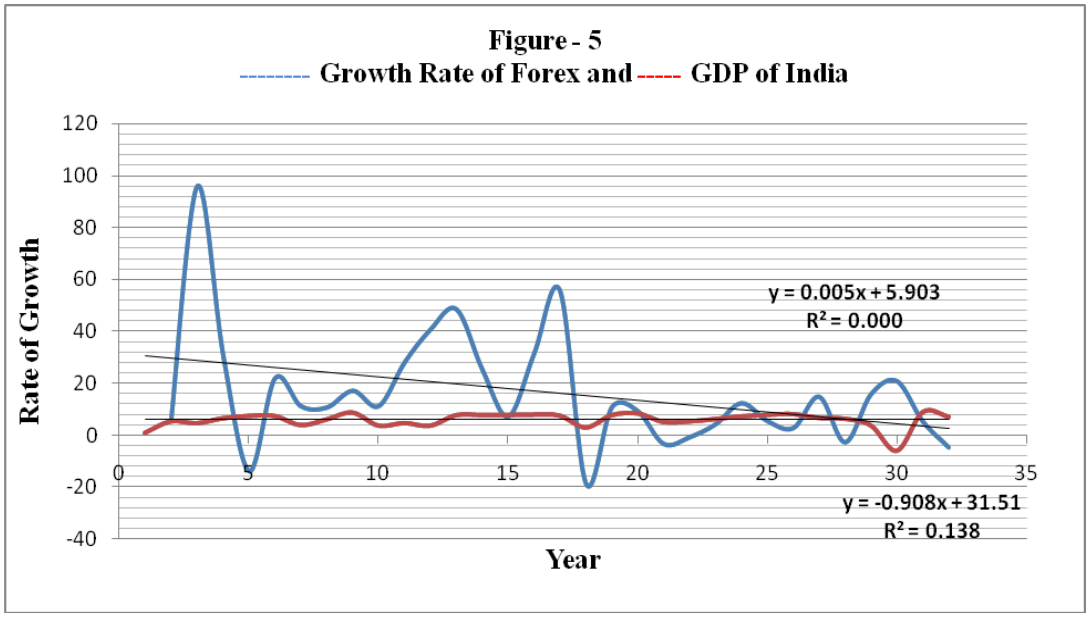
The data presented in Table 5 illustrate the growth trends of foreign exchange reserves and GDP in India. Both the datasets exhibit fluctuations. However, the growth rate of foreign exchange reserves shows a declining trend, while the GDP growth rate of India demonstrates a relatively moderate increase. These patterns are effectively illustrated in Figure 4.



Source: Compiled by author

Figure 4 depicts that India has witnessed significant growth in its foreign exchange reserves since the implementation of economic reforms in 1991. This growth was driven by increased foreign investment and trade, leading to a steady rise in foreign exchange reserves from 1991 onward. By the early 2000s, India had become one of the leading holders of foreign exchange reserves globally. The growth rate during the period from 1993 to 2004 was particularly high, fueled by robust economic growth, rising exports, foreign investment

inflows, and prudent monetary policies. However, it is important to note that the growth rate of foreign exchange reserves is not expected to remain consistently high over time. Fluctuations in global economic conditions, trade dynamics, and domestic policy decisions have negatively affected the growth rate of reserves. Recent data indicate a negative growth rate, which warrants closer examination in the context of specific time periods and economic events. Although India has experienced substantial growth in its foreign exchange reserves since the early 1990s, the growth rate has varied over time due to both domestic and global factors. Hence, the present study further examines the relationship between foreign exchange reserves and India's GDP, as illustrated in Figure 5.



Source: Compiled by author

The diagram illustrates a decline in the growth trend of Forex, while the growth trend of GDP exhibits a slow but steady increase. The growth trend of Forex is characterized by high fluctuations, whereas the growth trend of GDP moves in an upward direction. Furthermore, the growth trend of Forex turned negative in the recent year, indicating a decline in its overall growth. This result urges to explore the relationship further and presented in the following tables:

Table 6. Descriptive Statistics for the Growth Rate Forex and GDP

	Mean	Std. Deviation	N
GDP Growth Rate of India	6.1537	2.79008	31
Forex Growth Rate of India	16.0697	22.16614	31

Source: Compiled by author

Table 6 presents the mean values of the growth rate of Forex and the growth rate of GDP of India. This table depicts that the mean value of the growth rate of Forex is 16.0697, while the mean value of the growth rate of GDP of India is 6.1537. The relationship between the two variables is presented in the following table.

Table 7. Correlations between the Growth Rate Forex and GDP

		GDP Growth Rate of India	Forex Growth Rate of India
Pearson Correlation	GDP Growth Rate of India	1.000	-.053
	Forex Growth Rate of India	-.053	1.000
Sig. (1-tailed)	GDP Growth Rate of India	.	.389
	Forex Growth Rate of India	.389	.
N	GDP Growth Rate of India	31	31
	Forex Growth Rate of India	31	31

Source: Compiled by author

Based on the results, there exists a slight negative correlation between the growth rate of foreign exchange reserves and the growth rate of GDP in India. This indicates that changes in the growth rate of foreign exchange reserves do not have a significant influence on GDP growth. Therefore, it can be concluded that the growth rate of foreign exchange reserves does not exert a statistically significant impact on India's GDP growth. This relationship is further examined and discussed using the regression model presented in the following section

Table 8. Model Summary[b] for the Growth Rate Forex and GDP

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	df1	df2	Sig. F Change	
1	.053[a]	.003	-.032	2.83383	.003	.081	1	29	.778	1.974
a. Predictors: (Constant), Forex Growth Rate of India										
b. Dependent Variable: GDP Growth Rate of India										

Source: Compiled by author

Table 8 presents the values of R and R^2, which provide insights into the correlation between the variables. Specifically, the R value represents the simple correlation, which is 0.053 (the "R" Column), indicating a low level of positive correlation between the variables. On the other hand, the R^2 value (the "R Square" column) signifies the portion of the total variation in the dependent variable, Growth Rate of GDP, that can be explained by the independent variable, Growth Rate of Forex. In this case, the R value is 0.053, indicating that 5.3% of the total variation can be explained by the growth rate of Forex, which is significantly very low. However, it is noteworthy that the R^2 value is only 3%, implying that 97% of the factors other than the growth rate of Forex have an impact on the growth rate of GDP. Moreover, the significance value of 0.778 is greater than the table values of 0.05, indicating that the null hypothesis cannot be rejected. Consequently, it can be concluded that the growth rate of Forex has no impact on the growth rate of GDP. This conclusion is further supported by the ANOVA analysis, which provides deeper insights into the relationship between the variables.

Table 9. ANOVA[a] for the Growth Rate Forex and GDP

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.649	1	.649	.081	.778[b]
	Residual	232.888	29	8.031		
	Total	233.537	30			
a. Dependent Variable: GDP Growth Rate of India						
b. Predictors: (Constant), Forex Growth Rate of India						

Source: Compiled by author

Based on the ANOVA results presented in Table 9, the calculated p-value exceeds the 0.05 significance level. This indicates that the growth rate of GDP, as the dependent variable, is not significantly explained by the growth rate of foreign exchange reserves, which serves as the independent variable, at the 95% confidence level. The result suggests the absence of a statistically significant relationship between the two variables. Accordingly, it is recommended that future analyses consider additional macroeconomic and structural factors influencing GDP growth, rather than relying solely on the growth rate of foreign exchange reserves.

Table 10. Coefficients[a] for the Growth Rate Forex and GDP

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	6.260	.632		9.902	.000	4.967	7.553
	Forex Growth Rate of India	-.007	.023	-.053	-.284	.778	-.054	.041
a. Dependent Variable: GDP Growth Rate of India								

Source: Compiled by author

The common regression equation is

$$Y = a + bX$$

Table10 shows the regression equation of the effects of Forex on GDP. The regression model for the study can be written as follows:

Growth Rate of GDP of India = 6.260 – 0.007 (Growth Rate o Forex)

Since the model established for the study does not fit, the null hypothesis cannot be rejected. Hence, the growth rate of Forex has no impact on the growth rate of GDP of India.

CONCLUSIONS

The Foreign Exchange Reserve has played a pivotal role in stabilizing the Indian economy, particularly in the context of foreign trade and payment systems. The implementation of the New Economic Policy in 1991 has opened up the Indian market to foreign countries, and the policies of liberalization, globalization, and privatization have further incentivized foreign companies to invest in India. It's prudent management has helped to mitigate the risks associated with external shocks, such as sudden changes in capital flows or fluctuations in exchange rates, thereby promoting macroeconomic stability and facilitating sustainable economic growth. Foreign exchange reserve is evaluated based on the three major components: SDRs, Gold, and Foreign Currency Assets. The present study finds that:

1. Special Drawing Rights (SDRs) contribute only a small proportion compared to gold reserves and foreign currency assets.
2. Gold reserves remained relatively stable during the period from 1991 to 2005 but have shown a remarkable increase since 2006.
3. Foreign currency assets have consistently increased since 1991. Overall, India's foreign exchange reserves have exhibited a steady upward trend since 1991.

4. The data reveal that the lowest level of India's foreign exchange reserves was USD 9,832 million, while the highest level reached USD 607,309 million. The mean value of the reserves was USD 231,161.903 million, with a standard deviation of USD 186,944.761 million.
5. Kendall's tau measures the strength and direction of the association between two variables. In this study, Kendall's tau value of 0.944 indicates a very strong and positive association. The calculated S statistic is 439, which evaluates the significance of the observed trend, while Var(S) equals 3,461.667, representing the variance of the S statistic and the degree of dispersion. Since the computed p-value is lower than the significance level ($\alpha = 0.05$) at the 95% confidence level, the null hypothesis (H_0) is rejected and the alternative hypothesis (H_1) is accepted.
6. Accordingly, India's foreign exchange reserves exhibit a significant increasing trend.
7. However, the growth of foreign exchange reserves does not have a statistically significant impact on the growth rate of India's GDP.

The Government of India should adopt appropriate strategies to strengthen its foreign exchange reserves. Strengthening reserves would enhance macroeconomic stability and improve resilience to external shocks in the global economy. The government should focus on promoting exports through measures such as providing financial incentives, simplifying export procedures, improving trade infrastructure, and negotiating favorable trade agreements with other countries. India should also continue its efforts to attract foreign direct investment (FDI) by improving the ease of doing business, streamlining regulatory frameworks, and offering targeted incentives to foreign investors. FDI inflows not only contribute capital but also facilitate technology transfer and the diffusion of managerial expertise, thereby supporting economic growth and the accumulation of foreign exchange reserves. Remittances from Indian expatriates working abroad represent a significant source of foreign exchange earnings. The government can encourage remittance inflows by implementing policies that reduce transaction costs, promote efficient remittance channels, and enhance financial literacy among overseas workers.Furthermore, the development of a robust and stable financial market can attract foreign investors and support the accumulation of foreign exchange reserves. In addition, diversification of foreign exchange reserves can reduce risks associated with currency volatility and market fluctuations by minimizing exposure to adverse movements in any single currency or asset class.

This study is primarily based on secondary data and is restricted to an analysis of India's foreign exchange reserves since 1991, focusing on the various components contributing to the foreign exchange reserves over a specific period. Only a limited attempt has been made to examine the relationship between foreign exchange reserves and GDP growth.

The analysis of India's foreign exchange reserves underscores the critical importance of maintaining a robust and well-managed foreign exchange position in today's interconnected global economy. As a key indicator of a nation's economic strength and resilience, foreign exchange reserves play a pivotal role in safeguarding against external shocks, ensuring liquidity for international transactions, and enhancing investor confidence. India's efforts to strengthen its foreign exchange reserves through strategic policies aimed at promoting exports, attracting foreign direct investment, encouraging remittances, strengthening financial markets, and diversifying reserve assets reflect a proactive approach toward economic stability and sustainability. However, continuous vigilance and adaptive

strategies remain essential to address the evolving dynamics of the global financial environment. By leveraging its strengths and proactively addressing emerging challenges, India can continue to reinforce its position as a dynamic and resilient participant in the global economy.

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