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PAPER

Trade balance shock and its importance on Gross National Saving Rate and Exchange Rate: A VAR analysis using time series national data for Japan

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Abstract This research focuses on investigating the dynamic network among trade balance (TB), the Gross national saving rate (GNSR), and the exchange rate (ER) in Japan. The study used time series data from 1981 to 2019. The research conducts a vector auto-regression (VAR) to investigate the dynamic relationship in the series. The first step started with a unit root test to check the stationarity. The data series is stationary at first difference.

Further, we employed Johansen co-integrated analysis, Granger causality, an impulse variance analysis followed by variance decomposition. The result shows the unidirectional Granger causal relationship between TB and ER. Its own shock explains that TB's contribution is 73% and GNSR & ER contributes 25.67 and 0.67 to TB, respectively. The GNSR variance decomposition describes 95.12 variations by its own innovative shock, and ER shows a 52% change in the variable from its own shock. This study establishes that trade balance is significant to exchange rate growth in Japan. This research is original work, and it will contribute the knowledge about the trade balance, gross national saving rate, and exchange rate behaviour & effect to each other.

Keywords: Trade balance, exchange rate, saving rate, VAR model.

JEL Classification: F14, F31, E21.

1. Introduction

The economy of Japan portrays several aspects to comprehend about the success story of East Asia from an economic viewpoint. One can find out a lot many things from the Japanese experience. According to an author (Li, 2017) in his book entitled *'The Japanese Economy: Success and Challenges'* suggested a right direction to uplift the Japanese economy for economic revitalisation and make Japan a crucial industrialised performer worldwide. (Ono, 2017) investigated the effectiveness of progressive monetary policy in Japan considering people's price anticipations.

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(Nemoto and Goto, 2005) examined 47 prefectures during 1981-2000 for analysing the change in the productivity of the Japanese economy. (Ko and Murase, 2013) explored the involvement of technology and non-technology shocks in the fluctuations in impulsiveness of output and growth in labour during the post-war Japanese economy. Being a moderate-sized nation, Japan has full industrial capacity, the chase of unacceptable economic strategies, and the "lost decades" assumptions have prevented the growth level significantly since the initial stage of the 1990s (Li, 2017). (Aminian et al., 2012) revelled regarding the exchange rate depreciation and noted that it is significantly parallel to an export subsidy and an import tax and analysed that the US government's burden could theoretically contribute towards inflation of the Japanese yen.

(Eichengreen and Hatase, 2007) Analysed the influence of Japan's withdrawal from its currency peg in 1971 and proposed that the worldwide circumstances were satisfactory as well as opinions about the importance of consuming fiscal policy to support internal demand as the escalation in the real ER slow down the evolution of net exports as well as investment.

(Suzuki, 1996) examined factors that delayed economic revitalisation and contemplated some of the corrective procedures employed, remarkably fundamental restructuring. The paper investigates the dynamic network among trade balance, gross national saving rate, and exchange rate in Japan using time series data from 1981 to 2019. Vector auto-regression analysis (VAR) is employed in the series to investigate the dynamic relationship. The first step started with a unit root test to check the stationarity. The data series is stationary at first difference. Further, we employed Johansen co-integrated analysis, Granger causality, impulse variance analysis followed by variance decomposition.

2. Literature Review

Various research has been published on the trade balance, the gross national saving rate, and the exchange rate of different countries. The researchers focused on the impact of variables mentioned above on countries' economy. The current paper discussed the dynamic system among the variables. Hence, we reviewed numerous articles that provided us with a glimpse of these variables.

In the post environment catastrophe, the exchange rate (ER) and the exchange rate (ER) scheme's preference hold the main platform for developing territories. (Klein and Shambaugh, 2010; Rose, 2011; Ghosh et al.,2015). (Habib et al., 2017) investigated 5-year mean data for a group of around one hundred and fifty territories in the post-Bretton Woods period and analysed the influence of changes in the real exchange rate on economic growth.

(Chen and Liu, 2018) evaluated the effect of government spending shocks on China's real exchange rate and found that for real exchange rate appreciation, both government consumption shocks and government investment shocks will help increase economic growth. However, it is not similar to the empirical evidence from few developed nations still with forecasting the conventional Mundell Fleming Model. (Du and Wei, 2015) showed that the opposition for marriage partners could modify the steadiness of RER, i.e., Real Exchange Rate by way of altering savings and supply of labour. One of the papers of (Yin and Ma, 2018) demonstrated a prospective influence on the causality among the two markets from the financial crisis as well as the casual rapport among oil and the reciprocal exchange rates against the US dollar through a novel Bayesian, graph-based approach.

(Sonaglio et al., 2016) evaluated the effect of modification in the monetary and exchange rate procedures with the alignment of the aggregate exports over the functioning of the Brazilian economy. (Patureau and Poilly, 2019) found that to devalue the real exchange rate, the strength of competitive tax policy happens to be diminished. (Iwaisako and Nakata, 2017) studied that global demand shocks were highly influential in the 1990s and especially in the 2000s, and on the other hand, foreign currency exchange shocks were crucial in describing the changes that have taken place in exports during the 1980s. Furthermore, Oil market price shocks were also found to have enormous impacts on Japanese exports in the 2000s.

(Elahi et al., 2016) quoted on their paper that the exchange rate and its modification (one of the macroeconomic variables) and the price of foreign currency in domestic currency positively influence inflation, production, exports, imports, and Balance of Payments (BOP), etc.

(Chang et al., 2019) found that unfair distribution of national income in the direction of non-household and absence from the household sector is accountable for high savings in China. Pragmatic research on the effect of trade shocks on private savings eliminates the emerging markets because while using traditional economic elements, their execution is less responsive to any justification (Agenor and Aizenman, 2004).

(Chin and Sun, 2016) observed the correlation among the trade balance, saving rate, and the real exchange rate, and their results indicated that nations with a saving rate above the threshold limit of 14.8% could progress their trade balance, either by expanding the saving rate or by decreasing their currency value. (Evans, 2017) linked the country's external situation to the prospective trade flows along with its economic provisions in the dearth of speculative prospects as well as for the Ponzi scheme.

A linear ARDL model, as projected by (Oskooee et al., 2017), found that the shot-run symmetric effects in UK trade balance and 11 partners continued in long-term symmetric effects in only five cases. While shifting to a non-linear ARDL model, they found short-run asymmetric effects beside 14 partners that survived into long-run asymmetric consequences in 8 cases.

(Sasaki and Yoshida, 2018) anticipated the output that assists that Japan's trade is subjected to the fundamental transformation in income and exchange rate. Research conducted by (Jiang et al., 2019) discussed the causes behind the divergence of trade among China-EU and measured the amount of divergence that was impacted by the cost of transportation, re-exports, and their markups.

(Oskooee et al., 2017) found that the non-linear approach has more impacts than the linear method, which showed that the trade balance of Japan enhances in the long run after craving depreciation for three nations, and seven countries reacted when the non-linear approach was employed. This effect is asymmetric, and trade responds inversely to currency rise. (Ikeda, 2017) aimed to describe the discrepancy concerning trade balance among developing countries and the developed countries provided under a straightforward endowment economy model. The conclusions showed that with collateral capital in a model, the variations can be justified by a tradeable share in consumption.

3. Research Methodology

3.1 Unit Root (ADF)

The ADF test is to check the stationarity of each variable. If the t-statistic value is lower than the critical value, then the series is non-stationary at level 5% and stationary if the t-statistic value is higher than the critical value. We can mention the equation as follows:

$$\Delta y_t = \alpha y_{t-1} + x_t \delta + \varepsilon_t \quad (1)$$

Where,

$\alpha = p-1$

Null and alternative hypothesises are

H_0: $\alpha = 0$
H_1: $\alpha < 0$

Evaluating this by using the conventional t-ratio for

$t_\alpha = \hat{\alpha} / (\delta\varepsilon(\hat{\alpha}))$

Where

$\hat{\alpha} = estimate\ of\ \alpha$

$\delta\varepsilon(\hat{\alpha}) = is\ the\ standard\ coefficient\ error$

3.2 Johansen Co-integration Test

In Johansen co-integration, the number of cointegration relations is to find out after the ADF test. There are two types of statistics, TS (trace statistic) and maximum (eigenvalue statistic). The Johansen test evaluates the *Π* matrix from the unrestricted VAR and tests whether we can reject the restriction implied by the reduced rank of *Π*. In the Johansen test, the first column represents the number of cointegration relations under the null hypothesis, the next one represents the ordered eigenvalue of the *Π* matrix, and the third one is the test statistic followed by critical values and p-value.

$$\Pi = \sum_{i=1}^{p} A_i - I, \quad \Gamma_i = -\sum_{j=i+1}^{p} A_J \quad (2)$$

The assumption formed about the trend will be conditional to determine the number of cointegration relation r, and we can continue basically from r=0 to r=k-1 until and unless we fail to reject.

In the trace test, the null hypothesis of r cointegration relations is tested in opposition to the alternative of k co-integrating relation.

Where,

k = number of endogenous variables

(For r=0, 1 …k-1).

The alternative of k co-integrating relations is defined that there is no unit root in any series. So, VAR will be stationary when the levels of all series are the same.
In the Trace statistic, the null hypothesis of r cointegration relations is formulated as:

$$\tau_{tr}\left(\frac{r}{k}\right) = -T\sum_{i=r+1}^{k}\log(1-人_i) \quad (3)$$

Where
$人_i = i^{th}$ = i[th] largest eigenvalue of the *Π* matrix in equation 2.
Further, the null hypothesis of r cointegration relations in opposition to the alternative of r+1 cointegration relations is tested by maximum eigenvalue. It is derived as follows:

$$\tau_{\max}\left(\frac{r}{r+1}\right) = -T\log(1-人_{r+1}) \quad (4)$$

For *r=0, 1…k-1*

3.3 Granger Causality

It is an important test to estimate the direction of causality among the variables. If *X* causes *Y*, it means that X can help predict *y* and adding lagged values of *X* can improve the explanation. There can be a case of two-way causation if *X* granger causes *Y* and *Y* granger causes *X*. This model allows us to predict the unidirectional, bidirectional, and no causality among the three variables such as trade balance, gross national saving rate, and exchange rate.

3.4 Vector auto-regression analysis

The vector autoregression is utilised to analyse the dynamic impact of random disturbance on the system of variables and forecast the dynamic relationships that exist among the interrelated time series. The VAR model equation is for each variable, explaining the relationship with its own lags and the lags of other variables of the system. VAR approach eludes the requirement for structural modelling by treating all the endogenous variables in the system as a function of p-lagged value.
The stationary, k-dimensional VAR (p) process as be represent as follows:

$$y_t = B_1 y_{t-1} + \cdots. + B_p y_{t-p} + Cx_t + e_t \quad (5)$$

In the VAR model process, we can write our equation for trade balance (TB), gross national saving rate (GNSR), and exchange rate (ER) as follows:

$$TB_t = \alpha_1 + \beta_{11}TB_{t-1} + \beta_{12}GNSR_{t-1} + \beta_{13}ER_{t-1} + e_{1t}$$
$$GNSR_t = \alpha_1 + \beta_{21}GNSR_{t-1} + \beta_{22}TB_{t-1} + \beta_{23}ER_{t-1} + e_{2t} \quad (6)$$
$$ER_t = \alpha_1 + \beta_{31}ER_{t-1}TB_{t-1} + \beta_{32}GNSR_{t-1}\beta_{33}TB_{t-1} + e_{3t}$$

3.5 Impulse Response Function

The IRF detects the reaction of a single-time SD shock of the innovations on CV and FV of the endogenous variables. The overtime changes in the error terms show the current and lagged effect on the endogenous variables. It is not only the direct effects of a shock to the i^{th} variables, but through the dynamic lag structure of the VAR model, it is going pass on to all of the other endogenous variables.

The i^{th} innovation $\epsilon_{i,t}$ is a shock to i endogenous variable $y_{i,t}$,

If ϵ_t are uncorrelated and interpretation of the impulse response is straightforward.

3.6 Variance Decomposition

The VD segregates the variation in an endogenous variable into the component shock to the VAR, whereas IRF detects the reaction of a one-time SD (standard deviation) shock to one endogenous variable on to the other variables in the VAR. It means the VD produces the information and relative importance of every random innovation in affecting the variables in the VAR system. In the framework of vector autoregression, a variance decomposition analysis is conducted to investigate how TB, GNSR, and ER variables affect other variables.

4. Result Analysis

4.1 Data Sources

The time-series data has been collected from the Census and Economic Information Center (CEIC data source). The time-series data collected from 1981 to 2019 country of Japan. The data series include trade balance, gross national saving rate, and the exchange rate of Japan. We collected yearly data series for the investigation.

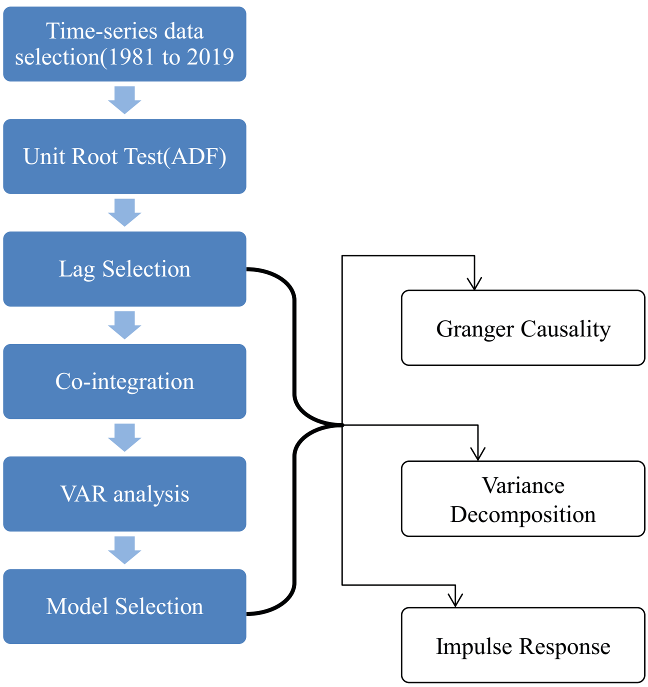

Diagram 1. Process of VAR Model analysis

4.2 Unit Root Analysis

Primarily, we check the data stationarity. ADF test applied to determine the stationarity of the time-series data. The test results are non-stationary at level and stationary at the first difference (See table 1.). After the unit root test, Johansen co-integration test is applied. Based on the Trace and Max-Eigen statistic value shown in table 2, we can say there is no cointegration among the variables. The trace statistic value is 35.33, which is lesser than the critical value of 42.91 at 5% level. In Max –Eigenvalue, the Max-Eigen Statistic is 15.00, which is lesser than the critical statistic value of 25.82. So, we get the same result of no co-integration among the variables. Co-integration results allow us to employ an unrestricted VAR model due to no co-integration among three variables trade balance, gross national saving rate, and exchange rate.

Table 1. Augmented Dickey-Fuller

	Level (5%)			**First Difference (5%)**		
	Test Statistic	**Critical Value**	**P-Value**	**Test Statistic**	**Critical Value**	**P-Value**
TB	-2.9719	-3.5366	0.1534	-5.1346	-3.5366	0.0009
GNSR	-3.2138	-3.5484	0.0987	-4.8290	-3.5403	0.0022
ER	-2.8238	-3.5366	0.1982	-5.5397	-3.5366	0.0003

4.3 Co-integration Analysis

Table 2. Unrestricted Co-integration R T (Trace)

Hypothesized No. of CE (s)	**EV**	**TS**	**0.05 CV**	**P-value**
None	0.340809	35.33435	42.91525	0.2316
At most 1	0.268686	20.33163	25.87211	0.2096
At most 2	0.222642	9.066776	12.51798	0.1763
Unrestricted Cointegration R T (Maximum EV)				
Hypothesized No. of CE (s)	**EV**	**Max-ES**	**0.05 CV**	**P-value**
None	0.340809	15.00272	25.82321	0.6342
At most 1	0.268686	11.26486	19.38704	0.4864
At most 2	0.222642	9.066776	12.51798	0.1763

4.4 Lag Selection Criteria

Table 3. Lag order Selection

Lag	LogL	LR	FPE	AIC	SC	HQ
0	- 654.8374 -	NA	1.28e+13	38.69632	38.83100	38.74225
1	- 575.9821 -	139.1564*	2.11e+11*	34.58718	35.12590*	34.77090*
2	- 566.8889 -	14.44212	2.13e+11	34.58170*	35.52445	34.90321
3	- 563.4273 -	4.886903	3.06e+11	34.90749	36.25428	35.36678
4	- 559.9816	4.256483	4.55e+11	35.23421	36.98504	35.83129

4.5 VAR analysis and interpretation

To perform the VAR analysis, first, we determine the optimum lag (see table 3) based on the result of the SC value. Lag order selection criteria are based on LR, FPR, AIC, SC, and HQ values. These values start from 0 to 4th lag and are based on the above result, which shows the lag one is statistically significant for the VAR model. So, we applied lag one in our model for the VAR analysis.

Lag selection criteria for the study done before the VAR estimation, where we determine the optimum lag based on the results given in table 3. The results of lag selection criteria tell us that lag of one is statistically significant.

$$TB_t = -121334.4+0.683398TB_{t-1} + 4336.521GNSR_{t-1}+ 74.88208\ ER_{t-1} + e_t \quad (7)$$

$$GNSR_t =0.149646+ 4.91E\text{-}06\ TB_{t-1} + 0.993863\ GNSR_{t-1} + 0.000991\ ER_{t-1} + e_t \quad (8)$$

$$ER_t = -24.03703+ -0.000124\ TB_{t-1} + 1.704001\ GNSR_{t-1} + 0.828107\ ER_{t-1} + e_t \quad (9)$$

Table 4 represents the VAR model result, which determines that the variables are significant or not. As we can infer, the TB coefficient is significant to the ER, and others are not significant in the VAR model framework. It means that TB is significant and interactive with ER variable or is influenced by one another or TB has a significant impact on ER. Further, in the following steps, we examined the intensity and presence of interaction between the variables for which we have applied Granger causality, impulse response, and variance decomposition test analysis.

Table 4. VAR Model

TB	Coeff.	Std. Error	t-Statistic	Prob.
TB	0.683398	0.133069	5.135672	0.0000
GNSR	4336.521	2894.030	1.498437	0.1371
ER	74.88208	158.8241	0.471478	0.6383
Cons	-121334.4	68896.66	-1.761107	0.0812
GNSR	**Coeff.**	**Std. Error**	**t-Statistic**	**Prob.**
TB	-4.91E-06	4.00E-06	-1.228069	0.2223
GNSR	0.993863	0.086067	11.54757	0.0000
ER	0.000991	0.004737	0.209233	0.8347
Cons	0.149646	2.046488	0.073123	0.9419
ER	**Coeff.**	**Std. Error**	**t-Statistic**	**Prob.**
TB	-0.000124	5.74E-05	-2.160484	0.0331
GNSR	1.704001	1.247399	1.366043	0.1750
ER	0.828107	0.068457	12.09672	0.0000
Cons	-24.03703	29.69617	-0.809432	0.4202

4.6 Granger Causality Analysis

Granger causality test is conducted to determine the causality between the variables, and it's represented in table 5. The results are showing no causality among the TB, GNSR, and ER, except the unidirectional relation from ER to TB. It means ER Granger-causes TB. It is evident that the ER contributes to TB, but at the same time, TB does not contribute to the ER. It is not bidirectional causality. No causality exists from TB to GNSR, TB to ER, GNSR to TB, GNSR to ER, and ER to GNSR.

Table 5. VAR Granger Causality

	Excluded	Chi-sq	df	Prob.
TB	GNSR	2.236890	1	0.1348
TB	ER	0.185246	1	0.6669
GNSR	TB	1.508154	1	0.2194
GNSR	ER	0.043779	1	0.8343
ER	TB	4.699311	1	0.0302
ER	GNSR	1.867724	1	0.1717

4.7 Variance Decomposition Analysis

Table 6. Variance Decomposition

Period	VD of TB			VD of GNSR			VD of ER		
	TB	GNSR	ER	TB	GNSR	ER	TB	GNSR	ER
1	100.0000	0.000000	0.000000	14.08494	85.91506	0.000000	4.339237	1.114148	94.54662
2	98.96520	0.979397	0.055407	9.611132	90.37827	0.010596	11.94826	2.665062	85.38668
3	96.66060	3.179173	0.160230	6.926193	93.05028	0.023527	19.40562	3.965308	76.62907
4	93.37407	6.339454	0.286480	5.439948	94.52669	0.033366	25.67729	4.864070	69.45864
5	89.54766	10.04346	0.408875	4.708221	95.25278	0.039000	30.61833	5.404680	63.97699
6	85.62603	13.86305	0.510927	4.427198	95.53169	0.041112	34.38788	5.679088	59.93303
7	81.94331	17.47054	0.586147	4.400492	95.55864	0.040872	37.20682	5.775581	57.01760
8	78.68847	20.67604	0.635488	4.506029	95.45460	0.039368	39.27953	5.765227	54.95525
9	75.92857	23.40770	0.663733	4.670506	95.29207	0.037426	40.77625	5.700855	53.52290
10	73.65208	25.67124	0.676683	4.851628	95.11279	0.035581	41.83417	5.619308	52.54652

Table 6 represents the results of variance decomposition of the trade balance, gross national saving rate, and exchange rate. This test has examined the variance caused by a variable to itself or its variation driven by other variables or not. In the variance decomposition of TB, ER is contributing 0.67, and GNSR contributes 25.67, and more significant variation in TB is explained by its contribution by its own innovation. The GNSR variance decomposition describing the 95.12 variations by its own innovative shock, and the rest (TB=4.8 and ER=0.03) is contributing significantly less in the variation. The variance decomposition results of ER show a more significant change in the variable from its own shock. Whereas TB is contributing 41.83 and GNSR is contributing significantly less 5.61 only.

4.8 Impulse Response Analysis

To analyse the shock of one variable to the response of another variable, we employed impulse response functions analysis. We will examine the relationship between TB, GNSR, and ER. Figure 1 showing the result of the impulse response function of three variables. We can see the standard deviation shocks and the responses of other variables. The following ten-year results indicate one standard deviation shock (innovation) to the trade balance leads to an increase in the exchange rate, but the spread is negative, and it is statistically significant. It means that there is a negative impact. At the same time, the gross national saving rate response to trade balance is declining over a period.

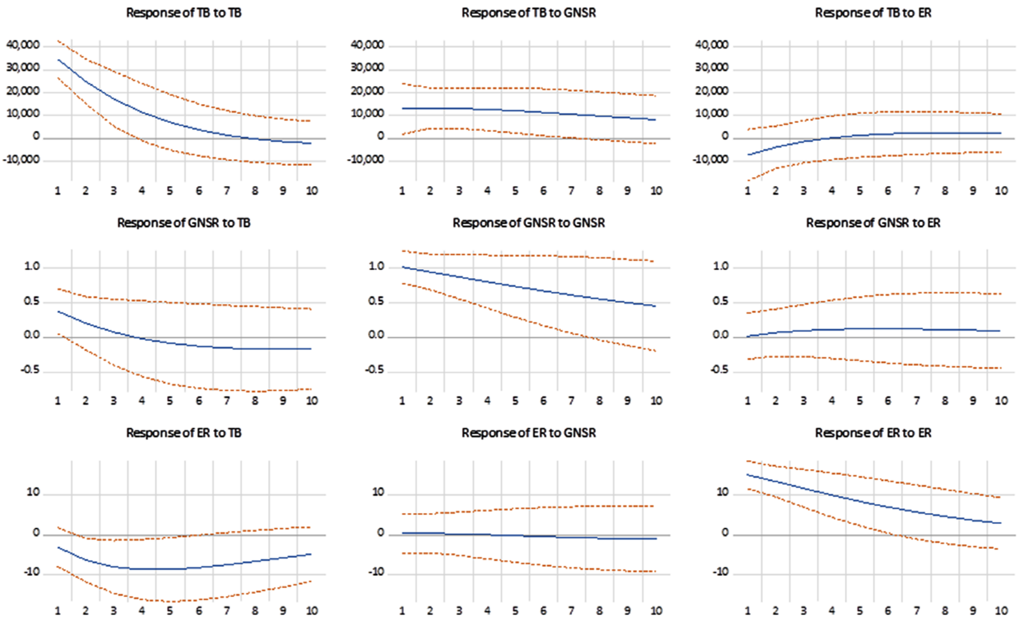

Figure 1. Impulse Response Graphs

5. Conclusion

This research article investigated the linkage between the trade balance, gross national saving rate, and exchange rate. We have used Japan data from 1981 to 2019 of 39

years. We have employed Augmented Dickey-Fuller based on the unit root test, the Johansen Co-integration test, Granger causality, impulse response function, variance decomposition under the VAR model framework to obtain the interpretation of the results and to investigate the relationship among the variables. ADF test indicates the stationarity at first difference followed by co-integration where we found no co-integration among the variables. Further used unrestricted VAR model indicates the unidirectional Granger causal relationship from exchange rate to trade balance.
In comparison, there is no causality from trade balance to gross national saving rate, gross national saving rate to exchange rate. It means that ER granger causes TB. The exchange rate is only the variable significant in the grange causality model. The result of variance decomposition reveals that TB is the vital variable in terms of explaining the ER. The rest of the figures show that the significant changes are happening from the variables' own innovation shock. Impulse variance analysis results are showing some significant empirical findings. One negative standard deviation shock of trade balance tends to increase permanently in exchange rate given period.

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