

TESTING THE CAUSALITY AND COINTEGRATION BETWEEN EXPORTS, IMPORTS, AND EXCHANGE RATES: EVIDENCE FROM INDIA

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Abstract

The aim of this paper is to investigate the dynamic causality and cointegration between the exports, imports, and the USD exchange rate in India. The quarterly time series data from 2002:Q1 to 2018:Q3 are used. Stationarity of the variables are diagnosed using the Ng-Perron unit root test, and the long-run equilibrium relationship between the variables is tested using the Johansen's cointegration test. In addition, the direction of causality and the short and long-run relationships between the variables are investigated using the Vector Error Correction Model (VECM). The findings indicate the existence of a long-run cointegrating relationship between the exports, imports, and the USD exchange rate. In the long-run, exchange rate is positively related to the exports and negatively related to the imports. The VECM results suggest that there are unidirectional Granger causalities running from exchange rate to exports and from exchange rate to imports. In addition, there is a feedback relationship between exports and imports. The existence of cointegration suggests that the macroeconomic policies have been effective in bringing exports and imports in long-run equilibrium, and thus, India is not in violation of her international budget constraint. These findings may have important implications for decision-making by national policymakers.

Keywords: Exchange Rate, Export, Import, Granger Causality, International Budget Constraints

JEL Classification: F41, C22, C32

1. Introduction

Trade policy plays a fundamental role in determining the viability of trade transactions of a country. Restrictive policy on imports associated with depreciated exchange rate can cause a decline in import-based industrial production, while at the same time providing the incentive for promoting the export having higher domestic value-added component. An appreciated exchange rate acts as the disincentive for export causing a decline in the foreign exchange reserve level, which, in turn, decreases imports. Hence, the identification and measurement of relationships between the exports, imports, and exchange rate can be crucial in the pursuit of maintaining external balance and stability, the essential components of a sound macroeconomic structure and environment in the economy. Such a strong and stable state of the macroeconomy would work as the catalyst for attaining a higher rate of growth on a sustained basis. Further, investors, researchers, and national policymakers could better predict the associated future trends and implications by accurately identifying and understanding the relationships existing between the exports, imports, and exchange rate. Furthermore, the presence of such relationship between exports and imports indicates that a country is not in violation of its international budget constraint, because its macroeconomic policies has been effective in bringing exports and imports into long-run equilibrium [14]. Hence, the study of causality and cointegration relationship between these variables holds significant importance and attracts the attention of researchers.

There is a plethora of studies investigating the causal and cointegrating relationships between exports, imports, and exchange rate in the context of India. However, most existing studies have certain weaknesses in their adapted methodologies. For instance, the unit root tests applied in most existing studies are outdated and therefore result in incorrect conclusions.

This paper differs from the existing literature in the Indian context in several ways. First, this paper has employed the fairly recently developed Ng-Perron unit root tests which have better size and power properties than the more commonly used Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root tests. Second, this paper uses data that are more recent in the context of pertinent literature in the context of Indian research. Finally, we analyze both short and long-run causalities between the exports, imports, and the exchange rate in the context of India.

The remainder of this study proceeds as follows: Section 2 presents a review of past empirical studies. Section 3 describes a brief description and the sources of the data and the variables used in the study. The econometric methodologies used in the study, empirical results, and their interpretations are presented in section 4. The last section summarizes the paper and provides concluding remarks and policy implications.

2. Literature review

Over the past two decades, the study of the dynamic causality and long-run equilibrium relationship between the exports, imports, and the exchange rate has received increasing attention in the literature. These studies are conducted for both developed and developing countries. In this section, we provide a brief review of some of the relevant literatures conducted in various countries in the world.

[15] and [29] investigated the presence of a cointegrating relationship between exports and imports for the USA using quarterly time series data between 1967-1989 and 1967-1994 respectively and found the conflicting results. While [15] found evidence in support of a long-run relationship between the exports and imports, Stilianos and Jyh-Lin (1999) found no long-run relationship between these variables.

[3] investigated a long-run equilibrium relationship between exports and imports of Korea using cointegration test for the quarterly data from 1963 to 1991. The findings from their empirical analysis indicate the existence of a long-run equilibrium relationship between exports and imports of Korea. The authors further document that Korea is not in violation of her international budget constraint.

[2] investigated the long-run equilibrium relationship between exports and imports in 50 countries employing cointegration approach [17], using the quarterly data for the period between 1973:Q2 and 1998:Q1. The results suggest the presence of cointegration in thirty-five of the fifty countries, and indicate that these specific thirty-five countries are not in violation of their international budget constraint.

[7] studied the existence of the long-run relationship between Malaysian exports and imports for annual data between 1959 and 2000. Using both the restricted and unrestricted cointegration techniques, the authors establish the presence of a cointegrating relationship between exports and imports of Malaysia and conclude that Malaysian is not in violation of her inter-temporal budget constraint. However, an empirical illustration in a commentary by [30] reveals that the long-run relationship between Malaysian exports and imports as established by [7] requires further investigation before it can be generalized.

[23] investigated the long-run relationship between exports and imports for two Pacific Island Countries, Fiji and Papua New Guinea (PNG). For Fiji, they used annual data for the period 1960-2000, while for PNG, they used annual data for the period 1960-1998. Using the bounds-testing approach to cointegration, the authors find that the exports and imports for Fiji and PNG are

cointegrated. They further document that Fiji satisfies the strong form of its intertemporal budget constraint, while PNG satisfies only the weak form of its intertemporal budget constraint.

[27] investigated cointegration and causality among the exchange rate, exports, and imports of Turkey. Using the cointegration test, vector error correction model, variance decomposition analysis, and impulse response function for monthly data between 1998 and 2006, the authors find the existence of a cointegrating relationship between Turkish exports and imports. In addition, they show that there exists a bidirectional relationship between exports and imports of Turkey.

[20] investigated the possibility of long-run equilibrium relationship between the logarithmic values of exports and imports for India in two currencies, Indian rupee and USD, between 1949-1950 and 2004-2005. Using annual data and employing the unit-root and cointegration approach, the authors found no cointegration between exports and imports. They further concluded that India was in violation of her international budget constraint.

[16] examine the long-run relationship between exports and imports to find out whether Bangladesh is in violation of her intertemporal budget constraint. The author used data from the year 1976 to 2006. Their empirical investigation found that there exists no long-run relationship between Bangladesh's exports and imports. This concludes that the economy of Bangladesh does violate its intertemporal budget constraint. Contrast to this, [31] studies the existence of a causal relationship between exports and imports of Bangladesh using annual data from 1976 to 2005. The author employed the unit root test, Johansen cointegration test, and error-correction mechanism, and showed the existence of a long-run equilibrium relationship between exports and imports and conclude that Bangladesh is not in violation of her international budget constraints. The study further documents the presence of a bidirectional long-term causality and a unidirectional short-term causality between exports and imports of Bangladesh.

[22] test the long-run relationship between exports and imports of Pakistan using quarterly data for the period between 1972 and 2006. They employed the unit root test and Johansen's maximum likelihood cointegration technique and found the existence of a long-run equilibrium relationship between the exports and imports of Pakistan. They further document that Pakistan is not in violation of her international budget constraint. Furthermore, using Granger causality test based on the vector error correction model, the study found the existence of a bidirectional relationship between exports and imports for Pakistan. Similarly, [5] examined the long-run relationship between exports and imports of Pakistan using an Autoregressive Distributed Lag (ARDL) cointegration method. Using annual time series data for the period between 1948-1949 and 2012-2013, the study found the existence of a long-run cointegrating relationship between the exports and imports of Pakistan. The authors further conclude that Pakistan is not in violation of her international budget constraint, as concluded by [22].

[4] empirically examined the relationship of the exchange rate with exports and imports of major South Asian and Southeast Asian countries using annual data for the period between 1979-2010. Using the ARDL approach to cointegration and vector error correction model, the authors investigated the long and short-run relationship between the variables and document the existence of a long-run relationship between exchange rate and exports in more than half of the sample countries. On the other hand, the long-run relationship between exchange rate and imports was found only in one sample country. Furthermore, no significant short-run relationship was found between the variables in the majority of the countries in the sample.

[1] examines the effect of the exchange rate on exports using monthly data from January 2001 to November 2015 for Indonesia. The study finds no evidence of a cointegrating relationship between the exports and the exchange rate.

3. Variables and the data

This study is based on the quarterly time series data over the period between 2002:Q1 and 2018:Q3 from India. They were gathered from the database of the Federal Reserve Bank of St. Louis. The data set consists of the variables, “Exports,” “Imports,” and “USD Exchange Rate.” The Exchange rate is the amount of Indian rupees per unit of USD. Exports and imports are in current prices. The time series data are expressed in natural logarithms prior to the empirical analysis. Econometric and statistical software packages EViews and R are used for arranging the data and conducting the empirical analyses.

4. Methodology and Empirical Results

The econometric methodologies adopted in this paper consist of Ng-Perron unit root test, Johansen's multivariate cointegration test, and Granger causality test based on Vector Error Correction Model (VECM). These methodologies are briefly discussed as follows.

4.1 Ng-Perron Unit Root Test

Since the time series data are usually non-stationary and thus invalidate most of the standard empirical results, it becomes customary to check unit root of these series before carrying out econometric analysis. For this reason, we first establish the level of integration of the series using the Ng-Perron unit root test. [24] note that the widely used Augmented Dickey-Fuller (ADF) test suffers from low power, especially when the moving-average polynomial of the first differenced series has a large negative root [32]. As a remedy to this issue, [24] proposed the Ng-Perron test, which has better power and size properties, so its results are more reliable when applied to small data sets [13]. For this test, the null hypothesis is that the variable is non-stationary (has a unit root). This test comprises of four test statistics, (MZ_{α} , MZ_T , MSB, MPT). However, in applied research, the first two test statistics, MZ_{α} and MZ_T are usually reported more often for interpretation of the results ([8], [10], [26]).

Table No. 1. Ng-Perron Unit Root Test Results

Variables	Levels		First Differences	
	MZ_{α}	MZ_T	MZ_{α}	MZ_T
EX	0.7392	0.9726	-29.9958*	-3.8562*
IM	0.6811	0.7995	-31.3234*	-3.9531*
ER	0.4989	0.2704	-32.2883*	-3.9603*
Critical value	-8.100	-1.980	-8.100	-1.980

Notes: (*) denotes statistical significance at 0.05 level of significance. Lag lengths in the Ng-Perron tests were selected using the spectral GLS-detrended based on Schwarz Information Criterion (SIC); EX, IM, and ER denote the natural logarithmic values of the the exports, imports, and the USD exchange rate, respectively.

The Ng-Perron unit root test was conducted for each of the time series variables in their natural logarithmic scales. We conducted this test in EViews and the results for these two statistics at levels and their first differences are reported in Table 1. The results suggest that all the three time series variables are non-stationary in their levels. However, the first differences of all these time series variables are stationary at 0.05 level of significance. This indicates that all the time series variables used in the study are integrated of order 1, or $I(1)$. Having established that all variables are integrated of the same order, we proceed with the Johansen cointegration tests, which allow us to test for long run relationship between the exports, imports, and the exchange rate. If the

evidence of a cointegrating relationship is found between the exports, imports, and the exchange rate, then vector error correction model (VECM) will be estimated and related test of causality will be carried out.

4.2 The Johansen’s Multivariate Cointegration Test

After determining the stationarity of each of the time series data, we proceeded to determine the lag length of the vector autoregressive system. The Akaike Information Criterion and the Likelihood Ratio Test identified a lag length of 5. Using this lag length, we employed Johansen’s cointegration test [17] in order to test for the long-run equilibrium relationship between the exports, imports, and exchange rate. We conducted the Johansen’s cointegration test with all the variables in their natural logarithmic scales and considered both λ -trace and λ -max statistics options in EViews.

The results for both the λ -trace and λ -max statistics are reported in Table 2. The results indicate that the λ -trace statistic identified one cointegrating relationship among the exports, imports, and exchange rate, while the λ -max statistic identified no cointegrating relationship among the variables at $\alpha = 0.05$ level of significance. According to [18] and [28], since the trace statistic takes into account all of the smallest eigenvalues, it possesses more power than the maximum eigenvalue statistic. Furthermore, according to [6], the λ -trace statistic is more robust than the λ -max statistic. In addition, [17] also emphasize the use of the λ -trace statistic when the conflict occurs between the results of these two statistics. Thus, we stick with the result of λ -trace statistic, and conclude that there is one cointegrating relationship between exports, imports, and exchange rate. In other words, there exists a long run equilibrium relationship between the exports, imports, and exchange rate in India. This shows that India is not in violation of her international budget constraint.

Table No. 2. Johansen Cointegration Test Results (Trace and maximum eigen value)

Null Hypotheses	λ -Trace statistic	5% critical value	p-value	λ -Max statistic	5% critical value	p-value
$r = 0$	32.2022	29.7971	0.0259*	18.1181	21.1316	0.1255
$r \leq 1$	14.0842	15.4947	0.0807	11.4506	14.2646	0.1330
$r \leq 2$	2.6335	3.8415	0.1046	2.6335	3.8415	0.1046

Notes: (*) denotes statistical significance at 0.05 level of significance; r = hypothesized number of cointegrating equations; the cointegration model is based on the vector autoregression model (VAR) with 5 lags as identified by the Akaike Information Criterion (AIC) and the likelihood ratio test (LRT). The critical values for λ -trace and λ -max statistics are calculated by EViews (10).

Our finding of a long run equilibrium relationship between the exports, imports, and exchange rate is consistent with the findings of [19] and [22] for Pakistan. However, our finding is contrary to the finding of [20] for India, who found that that there was no evidence of a cointegration between exports and imports and that India was in violation of her international budget constraint.

Table No. 3. Cointegration Equation normalized with respect to Exchange Rate

Exchange Rate	Export	Import	C
1.0000	-3.5232 (0.6251) [-5.6361]	10.4300 (0.5600) [5.1660]	2.8931

Note: The figures in () and [] represent the standard error and t -statistics respectively.

After normalizing the coefficient of exchange rate to one, the restricted long-run equilibrium relationship between the exchange rate, exports, and imports can be written, using Table 3, as follows.

$$EXCHANGE = -2.8931 + 3.5232 EXPORT^{**} - 10.4300 IMPORT^{**} \quad (1)$$

The equation (1) suggests that the coefficient of Exports is positive and statistically significant. This suggests that for one unit increase (decrease) in exports, the exchange rate increases (decreases) by 3.5232 units. On the other hand, the coefficient of imports is negative, but statistically significant. This suggests that one unit increase in imports is associated with 10.4300 units decrease (increase) in the exchange rate. The finding of positive relationship between exchange rate and exports is consistent with that of [22] for Pakistan. However, this finding is contrary to the findings of [19] for Pakistan and [25] at lag 1 for Nigeria. The finding of negative relationship between exchange rate and imports is consistent with the finding of [25] at lag 1 for Nigeria. However, this finding is again contrary to the findings of [22] and [19] for Pakistan. Thus, we see mixed results on the relation between exports, imports, and exchange rate.

4.3 Granger Causality and Vector Error Correction Model (VECM)

After determining the existence of one cointegrating relationship between the exports, imports, and exchange rate, we proceeded to estimate the vector error correction model (VECM). The VECM includes lags of the dependent variables, in addition to its own lags [9]. Because it can capture the short-run dynamics between time series, as well as their long-run equilibrium relationship, VECM not only indicates the direction of causality amongst the variables, but also allows us to distinguish between short-and long-run Granger causality [21]. To test the long-run Granger causality, we examined the statistical significance of the t-test for the lagged error correction terms. However, to test the short-run Granger causality, we use the Wald chi-squared test to examine the joint significance of the coefficients of the differenced explanatory variables. To the best of our knowledge, previous Indian studies have not examined both short and long-run Granger causality relationships between the exchange rate, exports, and the imports using the most recent data.

Table No. 4. Granger Causality Results from Vector error correction model (VECM)

Dependent Variable	χ^2 -statistic			<i>t</i> -statistics for error correction term
	ΔIM	ΔEX	ΔER	
ΔIM	-	11.5037*	16.1013**	-1.8651*
ΔEX	16.6791**	-	32.7422**	2.7333**
ΔER	6.1583	8.9245	-	0.2115

Notes: ΔIM , ΔEX , and ΔER denote the first differences of the logarithmic values of the import, export, and exchange rate respectively, (**) and (*) respectively denote the rejection of the null hypothesis at the 1% and 10% level of significance. Number of lags was selected as identified by using the AIC and the LRT criteria.

The results of vector error correction model are reported in Table 4. The results there indicate that the *t*-statistics for the error correction terms corresponding to the target variables ΔIM , ΔEX , and ΔER are -1.8651, 2.7333, and 0.2115 respectively. Since the *t*-statistic corresponding to the target variable, ΔIM is statistically significant at 10% level of significance, we conclude that there are long-run Granger causalities from both ΔEX and ΔER to ΔIM . Similarly, the *t*-statistic corresponding to the target variable, ΔEX is statistically significant at 1% level of significance, we conclude that there are long-run Granger causalities from ΔIM and ΔER to ΔEX . However, there

are no long-run Granger causalities from ΔIM and ΔEX to ΔER because the t -statistic corresponding to the target variable ΔER is not statistically significant for a conventional level of significance. The χ^2 -statistic corresponding to the the causality from ΔEX to ΔIM is statistically significant at 10% level of significance, while the χ^2 -statistic corresponding to the causalities from ΔIM to ΔEX , from ΔER to ΔIM , and from ΔER to ΔEX are statistically significant at 1% level of significance. These results suggest that there are short-run Granger causalities from ΔIM to ΔEX , from ΔER to ΔIM , and from ΔER to ΔEX . These results are summarized quantitatively in Table 4 and qualitatively in Table 5.

The finding of feedback relationship between exports and imports is consistent with the findings of [22] and [27] who have found the similar results for Pakistan and Turkey respectively. Similarly, the finding of unidirectional causality from exchange rate to exports is consistent with the finding of [22]. However, the finding of unidirectional causality from exchange rate to imports is contrary to the finding of [22].

Table No. 5. Causality Results based on Vector Error Correction Model

Causality		Short-Run	Long-Run	Direction of Causality
From	To			
EX	IM	Yes*	Yes*	Feedback
IM	EX	Yes**	Yes**	
ER	IM	Yes**	Yes*	Unidirectional
IM	ER	No	No	
ER	EX	Yes**	Yes**	Unidirectional
EX	ER	No	No	

Notes: (**) and (*) respectively denote the rejection of the null hypothesis at the 1% and 10% level of significance; number of lags in the VECM was determined using the Akaike Information Criterion (AIC) and likelihood ratio test (LRT). ΔEX , ΔIM , and ΔER denote the first differences of the natural logarithmic values of the exports, imports, and exchange rate respectively.

5. Conclusions and discussions

The identification and measurement of relationships between the exports, imports, and exchange rate would be crucial in the pursuit of maintaining external balance and stability, the essential component of the sound macroeconomic structure and environment in the economy. This paper investigated the dynamic causality and cointegration between the exports, imports, and the USD exchange rate in India. The econometric methodologies adopted include the Ng-Perron unit root tests, Johansen's multivariate cointegration test, and the Granger causality test in the VECM framework. We used the quarterly data for the period from 2002:Q1 to 2018: Q3. To the best of our knowledge, no previous study has investigated the dynamic causality between the exports, imports, and the USD exchange rate using the most recent data from India.

The results from the Ng-Perron unit root test suggested that each of the time series variables were non-stationary at their levels. However, they were stationary at their first differences. Then, we conducted the Johansen's cointegration test to examine the existence of cointegrating relationship between exports, imports, and exchange rate. Johansen's cointegration test revealed that there was one cointegrating relationship between these variables. It was further observed that, in the long-run, the exchange rate is positively related to the exports and negatively related to the imports. The finding from the Granger causality based on the VECM indicate that there are two unidirectional Granger causalities, which are running from exchange rate to imports and from exchange rate to exports. In addition, there is a feedback relationship between exports and imports.

The finding of the presence of cointegration suggests that India's macroeconomic policies have been effective in bringing exports and imports in long-run equilibrium. It further indicates that India's balance-of-payments crisis was indeed sustainable, and thus, she is not in violation of her

international budget constraint. Furthermore, as seen in [11] and [12], the finding of feedback relationship between exports and imports is of topmost importance for economic development of a country. As [27] state, export increases the capacity to import and real imports have usually an important positive impact on industrial and non-industrial real gross domestic product. As such, our findings may have important implications for decision making by national policymakers.

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