ESTIMATING AGGREGATE IMPORT DEMAND FUNCTION

APPLIED ECONOMETRICS I TERM PAPER

Table of Contents

Introduction

Economic theory suggests a positive association between the growth of a country's imports volume and its real Gross Domestic Product (GDP) along with relative prices against other countries. This is evident from the likely increase in an economy's demand for imported goods and services as their disposable income increase. Therefore, as GDP increases, meaning the value of domestic production increases, the expenditure on imports also elevates. Similar effect on imports volume of a country is carried by the increase in relative prices, considering that imported goods become relatively cheaper in comparison to local goods. Increase in either the real GDP or relative prices against any other country drives the overall demand for imports higher. This conventional economic theory is supported by various literatures, however, there is a need to test the economic theory in real world situations.

In order to test whether the economic theory for imports, real GDP and relative prices holds in real life scenario, our study will analyse the extent of association between the variables through a carefully developed econometric model. Our analysis will be based on dynamically varied economies of Pakistan, Brazil and China. The study will include relevance of global economic events i.e. the 2008 global financial crisis, in order suspect the comparable impact on global economic turndowns on developing to developed countries. The paper can be used to assess the difference in impact of global events on GDP and import volume, along with lending evidence to the discussed conventional economic theory.

Literature Review

The dynamic economic relationship between economic growth and imports volume is reinforced by various researchers, thereby, subsiding a concerning impact of growing imports. Similarly, the influence of relative prices is apparent on time series analysis of macroeconomic data of economies.

According to economic theory, relative prices tends to drive the exchange rate volatility, impeding a perception of future exchange rate movements in accordance to the competitiveness of the relevant markets. In evidence, Chinese firms construed a concern for increase in trade costs and a negative impact on developed financial markets owing to the exchange rate volatility (Héricourt & Poncet, 2015). In addition to exchange rate volatility as a significant determinant of the volume of imports for an economy, the impact of trade liberalization also leads to a positively stimulating influence on GDP growth and therefore imports. Zakaria (2014) reported a greater impact on imports as compared to exports owing to liberated trade policies i.e. relaxation on import duties, signifying a statistically significant impact of the policies on price and income elasticities on imports for Pakistan (Zakaria, 2014). Moreover, Siddiqui et.al (2005) suggested a long run negative relationship between trade growth and economic growth owing to trade liberalization (Siddiqui & Iqbal, 2005).

Furthermore, the driving factor of relative prices and population growth moves the demand for imports for a good in an economy. In the paper 'China in the Next Decade: Rising Meat Demand and Growing Imports of Feed', Hansen & Gale (2014) discussed that China projected a heavy influx of feed imports owing to the increased productivity of its livestock sector along with the country's population and the estimated meat consumption, in evaluation with growing meat prices globally. Moreover, Ashraf et.al (2011) affirmed the casual relationship between economic growth and imports as domestically unavailable raw materials as well as technology and capital need to be imported for sustaining the increasing productive capacity of the economy. This is construed with regards to food production, energy processing and domestic industries of cement, steel and textiles with regards to food, technology and chemical imports primarily (Ashraf, Rehman, & Ghazali, 2011).

In addition, domestic innovation activities, competiveness and foreign economic conditions also significantly impact the imports for an economy, especially ones with a high level of population growth (Herrerias & Orts, 2011). Furthermore, economic turndowns like 9/11 attack and 2008 global financial crisis sets a negative impact on GDP, relative prices and imports of an economy. Pakistan's foreign exchange position was significantly weakened along with an unprecedented hike in international commodity, altering exchange rate volatility considerably (Usman, 2010). Over the period of 2008 global financial crisis, the financial sector of Brazilian economy suffered a huge blow along with drop in overall efficiency and participation, leading to rise in import volume (Wolters, Eduardo, & Felício, 2014). Therefore, the literature signifies the signifying impact of major economic events and thus, the inclusion of these events in our statistical analysis.

Econometric Model

The econometric model utilizes income, relative prices and exchange rate volatility as explanatory variables. In relation to the conventional economic theory discussed in the literature review, the rise in imports volume with respect to either the rise in real GDP, exchange rate volatility or relative prices. Therefore, our econometric model dictates the positive association between aggregate demand for imports and the explanatory variables.

Methodology

For analysis of aggregate import demand function, we have used an extensive 47 years of data ranging from the years **1970 to 2016** inclusive for **Pakistan, Brazil & China**. A log-log model is utilized for developing our econometric model of imports, income (real GDP) and relative pries for the respective countries. Our research paper consists of 3 different models for each country and we have used income and relative prices as explanatory variables. For an in-depth analysis, we have used both cross-sectional and time-series analysis. Time series utilizes the three countries over 1970-2016. The cross sectional analysis tests the model for 2001 and 2014 to check significance for the impact on imports before and after the 2008 global financial crisis.

Further on, we have added quadratic terms to our models to reflect the practical behavior of the variables with respect to conventional economic theory. Moreover, statistical tests i.e. Wald Test, Global F-test and Ramsay Test are used to authenticate the specification of the model as well as the extent to which the explanatory variables fit the models. For correlation diagnostics, we have used serial correlation test, in order to identify the order of autocorrelation in our data. For breakpoint test for major economic event, the 2008 global financial crisis, we have used Chow Test to check if the parameters are significant pre and post the major economic events. The data for the countries is extracted from IMF (International Monetary Fund).
www.data.imf.org

Variable Definitions

- Income: Real gross domestic product (GDP) is an inflation-adjusted measure that reflects the value of all goods and services produced by an economy in a given year
- Relative Prices: Relative prices refers to the value of a good in terms of its domestic value.
- Exchange Rate Volatility: Exchange rate volatility is the risk associated with unexpected movements in the exchange rate.

PAKISTAN

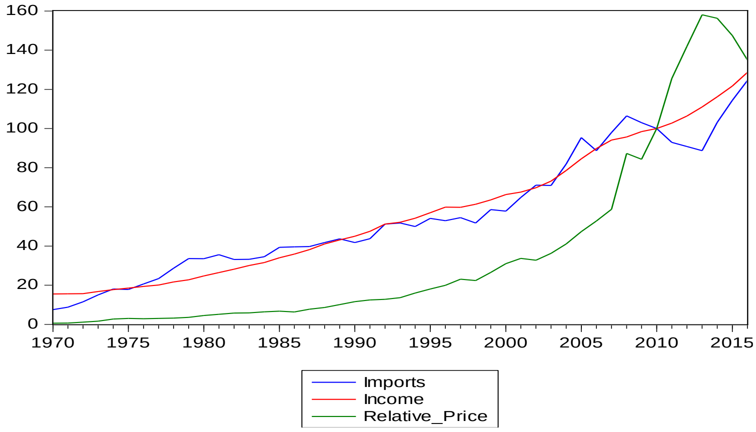


Figure 1 shows the general trend for Pakistan's imports, income, and relative prices. We can see that all three have increased over time. Income has followed a relatively linear rise, whereas, imports and relative prices have increased at an increasing rate with numerous fluctuations.

Figure 1: Time series behavior of Pakistan's imports, income, and relative prices

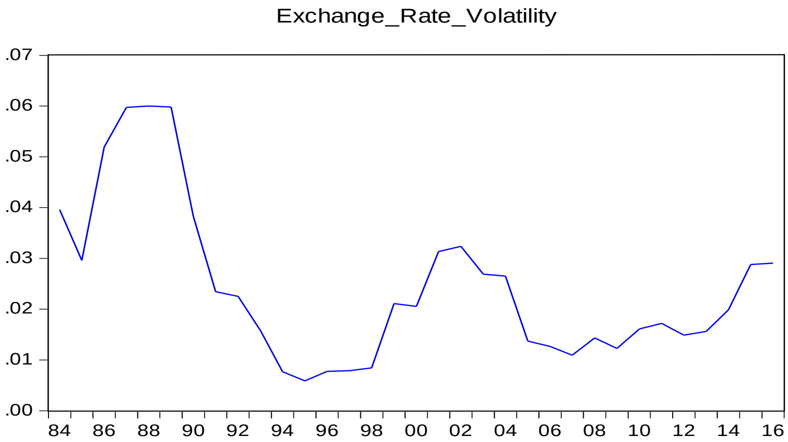


Figure 2 shows the general trend for Pakistan's exchange rate volatility. We can see that volatility increased at a sharply decreasing rate until 1995, beyond which it has been on the rise again at an increasing rate.

Figure 2: Time series behavior of Pakistan's exchange rate volatility

1) Simple Log-Log Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + e$$

Table 1: Results of the estimated model (1)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/08/21 Time: 17:39
Sample (adjusted): 1970 2016
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.970614	0.580799	3.392934	0.0015
LOG(INCOME)	0.252495	0.214041	1.179657	0.2445
LOG(RELATIVE_PRICE)	0.330255	0.092875	3.555908	0.0009

R-squared	0.938023	Mean dependent var	3.830421
Adjusted R-squared	0.935206	S.D. dependent var	0.681660
S.E. of regression	0.173514	Akaike info criterion	-0.603413
Sum squared resid	1.324715	Schwarz criterion	-0.485319
Log likelihood	17.18022	Hannan-Quinn criter.	-0.558974
F-statistic	332.9718	Durbin-Watson stat	0.267728
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: $\ln(Imports) = 1.970614 + 0.252495 \ln(Income) + 0.330255 \ln(Relative\ Prices)$

Interpretations:

β_1: Interpretation is not useful as income and relative prices can't be 0.

β_2: Keeping relative prices fixed, when Pakistan's income increases by 1%, the country's imports increase by 0.252495%.

β_3: Keeping income fixed, when Pakistan's relative prices increases by 1%, the country's imports increase by 0.330255%.

Thus, for a developing economy like Pakistan, rising income and relative prices lead to an increase in imports.

2) Quadratic Model:

$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + \beta_4 \ln(Income)^2 + \beta_5 \ln(Relative\ Prices)^2 + e$

Table 2: Results of the estimated model (2)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/08/21 Time: 17:50
Sample (adjusted): 1970 2016
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.487615	1.730168	2.593746	0.0130
LOG(INCOME)	-1.349162	1.026282	-1.314610	0.1958
LOG(RELATIVE_PRICE)	0.709153	0.093770	7.562687	0.0000
LOG(INCOME)^2	0.222321	0.148498	1.497135	0.1418
LOG(RELATIVE_PRICE)^2	-0.080179	0.021092	-3.801360	0.0005

R-squared	0.972913	Mean dependent var	3.830421
Adjusted R-squared	0.970334	S.D. dependent var	0.681660
S.E. of regression	0.117409	Akaike info criterion	-1.346023
Sum squared resid	0.578962	Schwarz criterion	-1.149199
Log likelihood	36.63154	Hannan-Quinn criter.	-1.271957
F-statistic	377.1440	Durbin-Watson stat	0.546795
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation**:**
$\ln(Imports) = 4.487615 - 1.349162 \ln(Income) + 0.709153 \ln(Relative\ Prices) + 0.222321 \ln(Income)^2 - 0.080179 \ln(Relative\ Prices)^2$
To check if quadratic terms are significant, we do Wald Test.

H_0: $\beta_4 = \beta_5 = 0$ H_1: At least one β_k in non-zero

Wald Test:

Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	27.04982	(2, 42)	0.0000
Chi-square	54.09965	2	0.0000

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.222321	0.148498
C(5)	-0.080179	0.021092

Restrictions are linear in coefficients.

Interpretation: p-value=0. This is less than 0.05, hence we reject the null hypothesis and conclude that the quadratic model is significant.
Thus, all further tests will be done on the **quadratic model**.

Ramsey RESET Test:

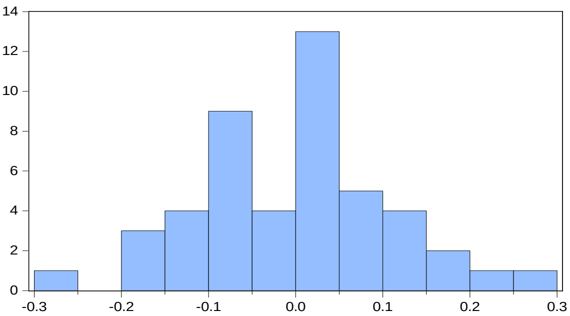
Equation: UNTITLED
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI

CE) LOG(INCOME)^2 LOG(RELATIVE_PRICE)^2
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.428709	41	0.1607
F-statistic	2.041210	(1, 41)	0.1607
Likelihood ratio	2.283541	1	0.1308

Interpretation: p-value=0.1607. This is greater than 0.05. Hence, the null hypothesis is accepted and we conclude that the model is correctly specified.

Jarque-Bera Normality Test: Tests if the skewness and kurtosis of residuals match a normal distribution.



Series: Residuals
Sample 1970 2016
Observations 47

Mean	1.56e-15
Median	0.011486
Maximum	0.295323
Minimum	-0.252953
Std. Dev.	0.112188
Skewness	0.190660
Kurtosis	2.944852
Jarque-Bera	0.290707
Probability	0.864717

Interpretation: JB=0.291<5.99 and p-value=0.865>0.05. Hence, the null hypothesis is accepted and we conclude that residuals follow a normal distribution.

Chow Breakpoint Test: We will break the data at 2008 to see the effects of the global financial crisis on Pakistan's imports.

Chow Breakpoint Test: 2008 (Global Financial Crisis)
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1970 - 2016

F-statistic	1.180314	Prob. F(5,37)	0.3374
Log likelihood ratio	6.955555	Prob. Chi-Square(5)	0.2240
Wald Statistic	5.901571	Prob. Chi-Square(5)	0.3159

Interpretation: p-value=0.3374>0.05. Null hypothesis is accepted. There are no breaks in the time series at 2008. Hence, financial crisis did not have a significant impact on Pakistan's imports, explained by income and relative prices.

3) Simple Log-Log Model with Volatility:

$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + \beta_4 \ln(\text{Exchange Rate Volatility}) + e$

Table 3: Results of the estimated model (3)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/09/21 Time: 19:10
Sample (adjusted): 1984 2016
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.558358	0.674995	-0.827204	0.4149
LOG(INCOME)	1.273651	0.239626	5.315158	0.0000
LOG(RELATIVE_PRICE)	-0.123619	0.089914	-1.374859	0.1797
LOG(EXCHANGE_RATE_VOLATILITY)	0.049776	0.026033	1.912054	0.0658

R-squared	0.957707	Mean dependent var	4.175275
Adjusted R-squared	0.953331	S.D. dependent var	0.379979
S.E. of regression	0.082086	Akaike info criterion	-2.048874
Sum squared resid	0.195408	Schwarz criterion	-1.867479
Log likelihood	37.80642	Hannan-Quinn criter.	-1.987840
F-statistic	218.8953	Durbin-Watson stat	0.687004
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: **ln(*Imports*) = - 0.558358 + 1.273651 ln(*Income*) - 0.123619 ln(*Relative Prices*) + 0.049776 ln(Exchange Rate Volatility)**

Interpretations:

β_1: Interpretation is not useful as income, relative prices, and exchange rate volatility can't be 0.

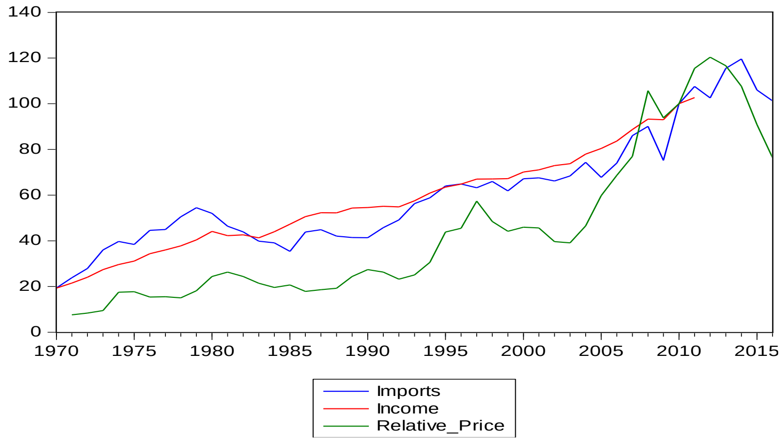
β_2: Keeping relative prices and exchange rate volatility fixed, when Pakistan's income increases by 1%, the country's imports increase by 1.273651%.

β_3: Keeping income and exchange rate volatility fixed, when Pakistan's relative prices increases by 1%, the country's imports decrease by 0.123619%.

β_4: Keeping income and relative prices fixed, when Pakistan's relative prices increases by 1%, the country's imports increase by 0.049776%.

For a developing economy like Pakistan, when exchange rate volatility is considered, we find that rising income and exchange rate volatility lead to an increase in imports. But when domestic prices rise, consumers do not shift to imports and even buy less imports.

BRAZIL



The graph shows the general trend for Brazil's imports, income, and relative prices. We can see that all three have increased over time. Income has followed a relatively linear rise, whereas, imports and relative prices have largely increased at an increasing rate.

Figure 3: Time series behavior of Brazil's imports, income, and relative prices

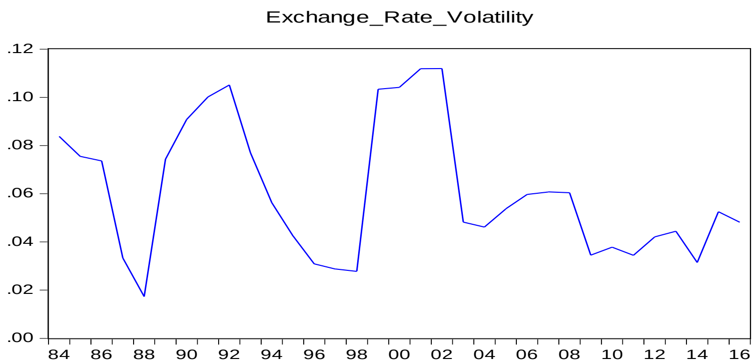


Figure 4: Time series behavior of Brazil's exchange rate volatility

The graph shows the general trend for Brazil's exchange rate volatility. We can see that volatility highly fluctuated until 2002, after which it has largely fallen but still continues to experience small fluctuations.

1) Simple Log-Log Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + e$$

Table 4: Results of the estimated model (1)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/07/21 Time: 23:12
Sample (adjusted): 1971 2011
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.928439	0.326817	5.900673	0.0000
LOG(INCOME)	0.237970	0.147183	1.616836	0.1142
LOG(RELATIVE_PRICE)	0.322712	0.085186	3.788330	0.0005

R-squared	0.877294	Mean dependent var	3.976335
Adjusted R-squared	0.870835	S.D. dependent var	0.330133
S.E. of regression	0.118648	Akaike info criterion	-1.354957
Sum squared resid	0.534939	Schwarz criterion	-1.229573
Log likelihood	30.77661	Hannan-Quinn criter.	-1.309299
F-statistic	135.8411	Durbin-Watson stat	0.830467
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: $\ln(Imports) = 1.928439 + 0.237970 \ln(Income) + 0.322712 \ln(Relative\ Prices)$

Interpretations:

β_1: Interpretation is not useful as income and relative prices can't be 0.

β_2: Keeping relative prices fixed, when Brazil's income increases by 1%, the country's imports increase by 0.237970%.

β_3: Keeping income fixed, when Brazil's relative prices increases by 1%, the country's imports increase by 0.322712%.

Thus, for an emerging economy like Brazil, **rising income and relative prices lead to an increase in imports.**

2) Quadratic Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + \beta_4 \ln(Income)^2 + \beta_5 \ln(Relative\ Prices)^2 + e$$

Table 5: Results of the estimated model (2)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/07/21 Time: 23:17
Sample (adjusted): 1971 2011
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.773021	3.580401	0.774500	0.4437
LOG(INCOME)	-0.187516	2.334426	-0.080326	0.9364
LOG(RELATIVE_PRICE)	0.283767	0.633984	0.447593	0.6571
LOG(INCOME)^2	0.059939	0.304508	0.196839	0.8451

LOG(RELATIVE_PRICE)^2	0.001876	0.093728	0.020011	0.9841

R-squared	0.878233	Mean dependent var	3.976335
Adjusted R-squared	0.864704	S.D. dependent var	0.330133
S.E. of regression	0.121432	Akaike info criterion	-1.265083
Sum squared resid	0.530842	Schwarz criterion	-1.056110
Log likelihood	30.93419	Hannan-Quinn criter.	-1.188987
F-statistic	64.91176	Durbin-Watson stat	0.806301
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: **$\ln(Imports) = 2.773021 - 0.187516 \ln(Income) + 0.283767 \ln(Relative\ Prices) + 0.059939 \ln(Income)^2 + 0.001876 \ln(Relative\ Prices)^2$**

To check if quadratic terms are significant, we do Wald Test.

H_0: $\beta_4 = \beta_5 = 0$; H_1: At least one β_k in non-zero

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	0.138896	(2, 36)	0.8708
Chi-square	0.277792	2	0.8703

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	0.059939	0.304508
C(5)	0.001876	0.093728

Restrictions are linear in coefficients.

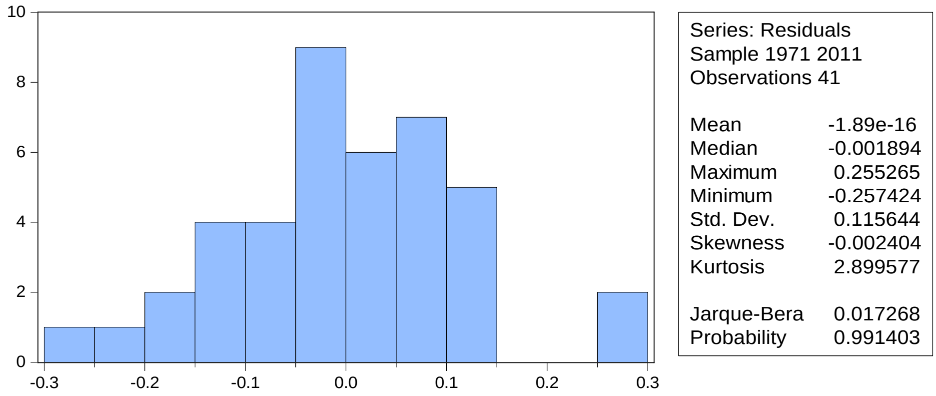
Interpretation: p-value=0.8708. This is greater than 0.05, hence we accept the null hypothesis and conclude that the quadratic model is insignificant.
Thus, all further tests will be done on the **simple log-log model**.

Ramsey RESET Test:

Equation: UNTITLED
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI
CE)
Omitted Variables: Powers of fitted values from 2 to 3

	Value	df	Probability
F-statistic	0.830581	(2, 36)	0.4440
Likelihood ratio	1.849528	2	0.3966

Interpretation: p-value=0.4440. This is greater than 0.05. Hence, the null hypothesis is accepted and we conclude that the model (simple log-log) is correctly specified.



<u>Jarque-Bera Normality Test</u>

<u>Interpretation:</u> JB=0.017<5.99 and p-value=0.991>0.05. Hence, the null hypothesis is accepted and we conclude that residuals follow a normal distribution.

<u>Chow Breakpoint Test:</u> We will break the data at 2008 to see the effects of the global financial crisis on Brazil's imports.

Chow Breakpoint Test: 2008
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1971 2011

F-statistic	0.913068	Prob. F(3,35)	0.4446
Log likelihood ratio	3.089405	Prob. Chi-Square(3)	0.3780
Wald Statistic	2.739203	Prob. Chi-Square(3)	0.4336

<u>Interpretation:</u> p-value=0.4446>0.05. Null hypothesis is accepted. There are no breaks in the time series at 2008. Hence, financial crisis did not have a significant impact on Brazil's imports, explained by income and relative prices.

3) Simple Log-Log Model with Volatility:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + \beta_4 \ln(\text{Exchange Rate Volatility}) + e$$

Table 6: Results of the estimated model (3)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/07/21 Time: 23:51
Sample (adjusted): 1984 2011
Included observations: 28 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.582485	0.698960	-0.833360	0.4129
LOG(INCOME)	1.053680	0.250267	4.210232	0.0003
LOG(RELATIVE_PRICE)	0.061495	0.103720	0.592900	0.5588
LOG(EXCHANGE_RATE_VOLATILITY)	-0.010043	0.032939	-0.304895	0.7631

R-squared	0.926630	Mean dependent var	4.101443
Adjusted R-squared	0.917459	S.D. dependent var	0.291503
S.E. of regression	0.083749	Akaike info criterion	-1.990424
Sum squared resid	0.168333	Schwarz criterion	-1.800109
Log likelihood	31.86594	Hannan-Quinn criter.	-1.932243
F-statistic	101.0364	Durbin-Watson stat	1.219429
Prob(F-statistic)	0.000000		

<u>Global F-Test:</u> p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: **ln(*Imports*) = - 0.582485 + 1.053680 ln(*Income*) + 0.061495 ln(*Relative Prices*) - 0.010043 ln(Exchange Rate Volatility)**

Interpretations:

β_1: Interpretation is not useful as income, relative prices, and exchange rate volatility can't be 0.

β_2: Keeping relative prices and exchange rate volatility fixed, when Brazil's income increases by 1%, the country's imports increase by 1.053680%.

β_3: Keeping income and exchange rate volatility fixed, when Brazil's relative prices increases by 1%, the country's imports increase by 0.061495%.

β_4: Keeping income and relative prices fixed, when Brazil's relative prices increases by 1%, the country's imports decrease by 0.010043%.

For an emerging economy like Brazil, when exchange rate volatility is considered, we find that rising income and relative prices lead to an increase in imports. But when exchange rate volatility rises, Brazil starts consuming less imports.

CHINA

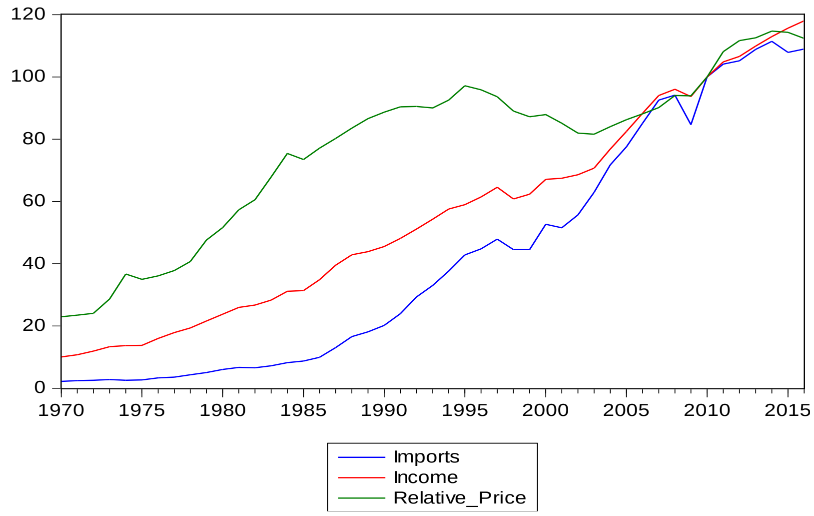
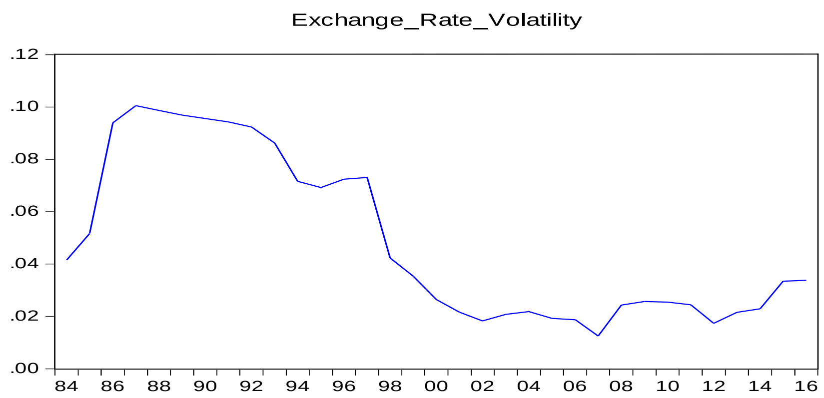


Figure 5 shows the general trend for China's imports, income, and relative prices. We can see that all three have increased over time. Income and imports have increased at an increasing rate. Relative prices were increasing at an increasing rate until 1995, after which they fell and started following a linear rise.

Figure 5: Time series behavior of China's imports, income, and relative prices



The graph shows the general trend for China's exchange rate volatility. We can see that volatility decreased at an increasing rate until 2001, after which it has been rising gradually.

Figure 6: Time series behavior of China's exchange rate volatility

1) Simple Log-Log Model:

ln(*Imports*) = β_1 + β_2 ln(*Income*) + β_3 ln(*Relative Prices*) + *e*

Table 7: Results of the estimated model (1)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/08/21 Time: 16:30
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.899698	0.262965	-7.224145	0.0000
LOG(INCOME)	2.308550	0.081639	28.27751	0.0000
LOG(RELATIVE_PRICE)	-0.886745	0.126567	-7.006104	0.0000

R-squared	0.990335	Mean dependent var	2.975094
Adjusted R-squared	0.989915	S.D. dependent var	1.405999
S.E. of regression	0.141194	Akaike info criterion	-1.018087
Sum squared resid	0.917051	Schwarz criterion	-0.902261
Log likelihood	27.94313	Hannan-Quinn criter.	-0.974143
F-statistic	2356.830	Durbin-Watson stat	0.204082
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.
Equation: $\ln(Imports) = -1.899698 + 2.308550 \ln(Income) - 0.886745 \ln(Relative\ Prices)$

Interpretations:

β_1: Interpretation is not useful as income and relative prices can't be 0.

β_2: Keeping relative prices fixed, when China's income increases by 1%, the country's imports increase by 2.308550%.

β_3: Keeping income fixed, when China's relative prices increases by 1%, the country's imports decrease by 0.886745%.

Thus, for a developed economy like China, rising income leads to an increase in imports. But when domestic prices rise, consumers do not shift to imports and even buy less imports.

Ramsey RESET Test:

Ramsey RESET Test
Equation: UNTITLED
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI
CE)
Omitted Variables: Squares of fitted values

	Value	df	Probability
t-statistic	1.083957	45	0.2842
F-statistic	1.174964	(1, 45)	0.2842
Likelihood ratio	1.262987	1	0.2611

Interpretation: p-value=0.2842. This is greater than 0.05. Hence, the null hypothesis is accepted and we conclude that the model (simple log-log) is correctly specified.

2) Quadratic Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + \beta_4 \ln(Income)^2 + \beta_5 \ln(Relative\ Prices)^2 + e$$

Table 8: Results of the estimated model (2)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/08/21 Time: 16:34
Sample (adjusted): 1968 2016
Included observations: 49 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.508927	1.704017	4.406602	0.0001
LOG(INCOME)	5.207983	0.704702	7.390333	0.0000
LOG(RELATIVE_PRICE)	-8.024907	1.287514	-6.232872	0.0000
LOG(INCOME)^2	-0.376015	0.086262	-4.358972	0.0001
LOG(RELATIVE_PRICE)^2	0.850446	0.151223	5.623803	0.0000

R-squared	0.994381	Mean dependent var	2.975094
Adjusted R-squared	0.993870	S.D. dependent var	1.405999
S.E. of regression	0.110079	Akaike info criterion	-1.478795
Sum squared resid	0.533160	Schwarz criterion	-1.285752
Log likelihood	41.23048	Hannan-Quinn criter.	-1.405555
F-statistic	1946.701	Durbin-Watson stat	0.731815
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: $\mathbf{\ln(\mathit{Imports}) = 7.508927 + 5.207983 \ln(\mathit{Income}) - 8.024907 \ln(\mathit{Relative\ Prices}) - 0.376015 \ln(\mathit{Income})^2 + 0.850446 \ln(\mathit{Relative\ Prices})^2}$

To check if quadratic terms are significant, we do Wald Test.
H_0: $\beta_4 = \beta_5 = 0$ H_1: At least one β_k in non-zero

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	15.84062	(2, 44)	0.0000
Chi-square	31.68124	2	0.0000

Null Hypothesis: C(4)=C(5)=0
Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(4)	-0.376015	0.086262
C(5)	0.850446	0.151223

Restrictions are linear in coefficients.

Interpretation: p-value=0. This is less than 0.05, hence we reject the null hypothesis and conclude that the quadratic model is significant.

Ramsey RESET Test

Equation: UNTITLED

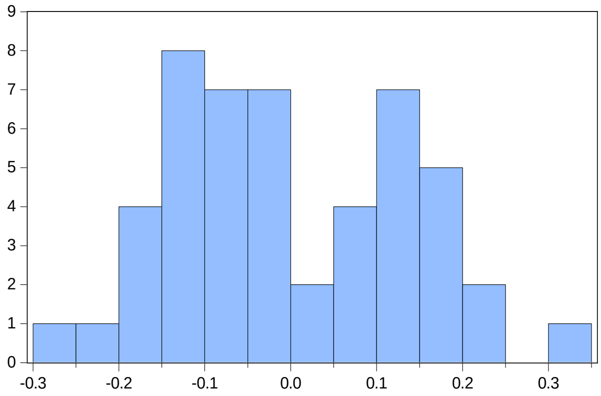
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI
CE) LOG(INCOME)^2 LOG(RELATIVE_PRICE)^2
Omitted Variables: Powers of fitted values from 2 to 3

	Value	df	Probability
F-statistic	77.06129	(2, 42)	0.0000
Likelihood ratio	75.51244	2	0.0000

Interpretation: p-value=0. This is less than 0.05. Hence, the null hypothesis is rejected and we conclude that the quadratic model is misspecified. It may have specification problems due to wrong functional form or the omission of a significant variable.

Hence, all further tests will be done on the **simple log-log model**.

Jarque-Bera Normality Test:



Series: Residuals	
Sample 1968 2016	
Observations 49	
Mean	9.49e-16
Median	-0.041985
Maximum	0.303554
Minimum	-0.268606
Std. Dev.	0.138222
Skewness	0.252197
Kurtosis	2.133928
Jarque-Bera	2.050844
Probability	0.358645

Interpretation: JB=2.051<5.99 and p-value=0.359>0.05. Hence, the null hypothesis is accepted and we conclude that residuals follow a normal distribution.

Chow Breakpoint Test: We will break the data at 2008 to see the effects of the global financial crisis on China's imports.

Chow Breakpoint Test: 2008
Null Hypothesis: No breaks at specified breakpoints
Varying regressors: All equation variables
Equation Sample: 1968 2016

F-statistic	4.639155	Prob. F(3,43)	0.0068
Log likelihood ratio	13.73970	Prob. Chi-Square(3)	0.0033
Wald Statistic	13.91746	Prob. Chi-Square(3)	0.0030

Interpretation: p-value=0.0068<0.05. Null hypothesis is rejected. There are breaks in the time series at 2008. Hence, financial crisis had a significant impact on China's imports, explained by income and relative prices.

3) Simple Log-Log Model with Volatility:

$$\ln(Imports)=\beta_1+\beta_2\ln(Income)+\beta_3\ln(Relative\ Prices)+\beta_4\ln(\text{Exchange Rate Volatility})+e$$

Table 9: Results of the estimated model (3)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/10/21 Time: 00:08
Sample (adjusted): 1984 2016
Included observations: 33 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.384186	1.617768	-0.237479	0.8140
LOG(INCOME)	2.443188	0.212216	11.51276	0.0000
LOG(RELATIVE_PRICE)	-1.272048	0.491327	-2.589006	0.0149

LOG(EXCHANGE_RATE_VOLATILITY)	0.098369	0.077724	1.265629	0.2157

R-squared	0.975344	Mean dependent var	3.814448
Adjusted R-squared	0.972793	S.D. dependent var	0.797959
S.E. of regression	0.131619	Akaike info criterion	-1.104604
Sum squared resid	0.502380	Schwarz criterion	-0.923209
Log likelihood	22.22597	Hannan-Quinn criter.	-1.043570
F-statistic	382.3959	Durbin-Watson stat	0.268715
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: **ln($Imports$) = - 0.384186 + 2.443188 ln($Income$) - 1.272048 ln($Relative\ Prices$) + 0.098369 ln(Exchange Rate Volatility)**

Interpretations:

β_1: Interpretation is not useful as income, relative prices, and exchange rate volatility can't be 0.

β_2: Keeping relative prices and exchange rate volatility fixed, when China's income increases by 1%, the country's imports increase by 2.443188%.

β_3: Keeping income and exchange rate volatility fixed, when China's relative prices increases by 1%, the country's imports decrease by 1.272048%.

β_4: Keeping income and relative prices fixed, when China's relative prices increases by 1%, the country's imports increase by 0.098369%.

For a developed economy like China, when exchange rate volatility is considered, we find that rising income and exchange rate volatility lead to an increase in imports. But when domestic prices rise, consumers do not shift to imports and even buy less imports. So adding the volatility variable did not have any impact on the signs of income's and relative prices' coefficients.

We also find that even with volatility, the model still shows specification error through RESET Test.

Cross-Sectional Analysis

Have tested data for countries around the world before the global financial crisis (2001) and after the global financial crises (2014), which took place in 2008.

2001, Pre Global Financial Crisis

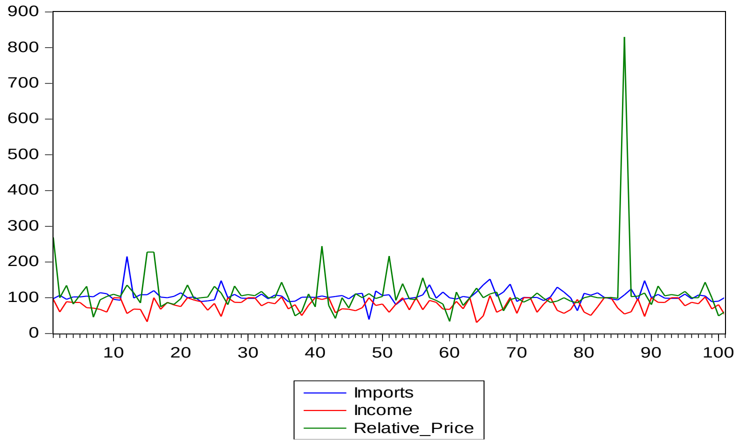


Figure 7: Cross-sectional behavior of world imports, income, and relative prices

The graph shows the cross-sectional view of world imports, income, and relative prices pre financial crisis. All 3 variables had relatively similar levels across countries, with a few having higher relative prices than others.

1) Simple Log-Log Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + e$$

Table 10: Results of the estimated model (1)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/10/21 Time: 01:55
Sample: 1 101
Included observations: 101

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	5.355490	0.351332	15.24339	0.0000
LOG(INCOME)	-0.214202	0.065015	-3.294632	0.0014
LOG(RELATIVE_PRICE)	0.046828	0.042978	1.089567	0.2786

R-squared	0.111513	Mean dependent var	4.642797
Adjusted R-squared	0.093381	S.D. dependent var	0.172076
S.E. of regression	0.163845	Akaike info criterion	-0.750537
Sum squared resid	2.630832	Schwarz criterion	-0.672860
Log likelihood	40.90213	Hannan-Quinn criter.	-0.719091
F-statistic	6.149945	Durbin-Watson stat	2.193891
Prob(F-statistic)	0.003047		

Global F-Test: p-value=0.003. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.

Equation: $\mathbf{\ln(\mathit{Imports}) = 5.355490 - 0.214202 \ln(\mathit{Income}) + 0.046828 \ln(\mathit{Relative\ Prices})}$

Interpretations:

$\boldsymbol{\beta}_1$: Interpretation is not useful as income and relative prices can't be 0.

$\boldsymbol{\beta}_2$: Keeping relative prices fixed, when income increases by 1%, imports decrease by 0.214202% across countries.

$\boldsymbol{\beta}_3$: Keeping income fixed, when relative prices increases by 1%, imports increase by 0.046828% across countries.

Thus, rising relative prices lead to an increase in imports. But when income of the rises, countries start buying less imports.

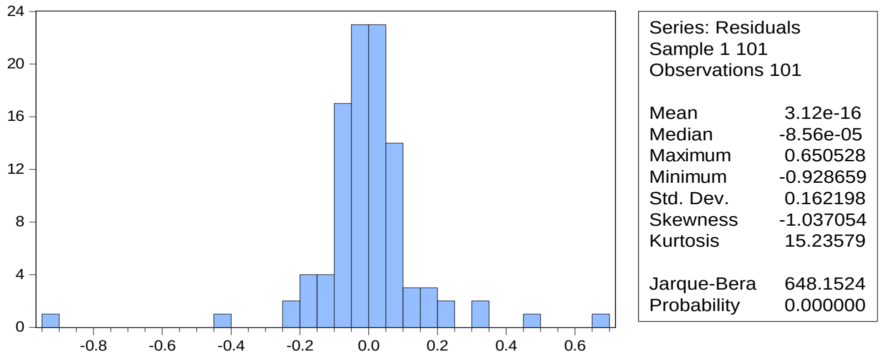
Ramsey RESET Test:

Equation: UNTITLED
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI
CE)
Omitted Variables: Powers of fitted values from 2 to 3

	Value	df	Probability
F-statistic	2.509876	(2, 96)	0.0866
Likelihood ratio	5.147754	2	0.0762

Interpretation: p-value=0.0866. This is greater than 0.05. Hence, the null hypothesis is accepted and we conclude that the model is correctly specified.
The quadratic model was giving **perfect collinearity issue** with RESET Test.

Jarque-Bera Normality Test:



Interpretation: JB=648.15>5.99 and p-value=0<0.05. Hence, the null hypothesis is rejected and we conclude that residuals do not follow a normal distribution.

So the results of the regression analysis may not be accurate as normality assumption has not been met.

2014, Post Global Financial Crisis

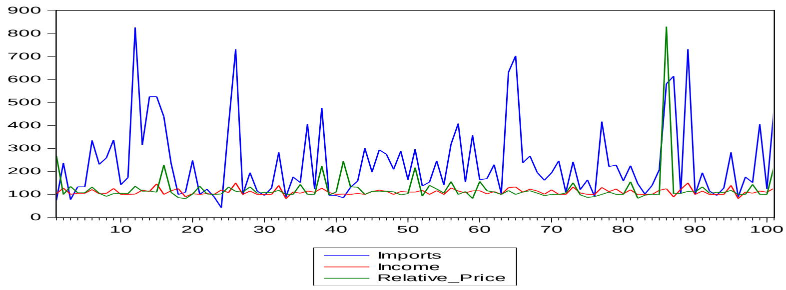


Figure 8: Cross-sectional behavior of world imports, income, and relative prices

Figure 8 shows the cross-sectional view of world imports, income, and relative prices post financial crisis. We can see that relative prices and income remain at fairly similar levels, but imports are now highly fluctuating across countries.

1) Simple Log-Log Model:

$$\ln(Imports) = \beta_1 + \beta_2 \ln(Income) + \beta_3 \ln(Relative\ Prices) + e$$

Table 11: Results of the estimated model (1)

Dependent Variable: LOG(IMPORTS)
Method: Least Squares
Date: 01/10/21 Time: 02:19
Sample: 1 101
Included observations: 101

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-9.550612	2.087625	-4.574869	0.0000
LOG(INCOME)	2.893002	0.439117	6.588229	0.0000
LOG(RELATIVE_PRICE)	0.258679	0.169422	1.526835	0.1300

R-squared	0.339988	Mean dependent var	5.277533
Adjusted R-squared	0.326518	S.D. dependent var	0.611120
S.E. of regression	0.501522	Akaike info criterion	1.486913
Sum squared resid	24.64935	Schwarz criterion	1.564590
Log likelihood	-72.08910	Hannan-Quinn criter.	1.518359
F-statistic	25.24102	Durbin-Watson stat	1.980353
Prob(F-statistic)	0.000000		

Global F-Test: p-value=0.003. This is less than 0.05, hence we reject the null hypothesis (all variables are insignificant) and conclude that at least one variable in the model is significant.
Equation: $\ln(Imports) = -9.550612 + 2.893002 \ln(Income) + 0.258679 \ln(Relative\ Prices)$

Interpretations:
β_1: Interpretation is not useful as income and relative prices can't be 0.
β_2: Keeping relative prices fixed, when income increases by 1%, imports increase by 2.893002% across countries.

β_3: Keeping income fixed, when relative prices increases by 1%, imports increase by 0.258679% across countries.
Thus, when both income and relative prices rise, countries buy more imports.

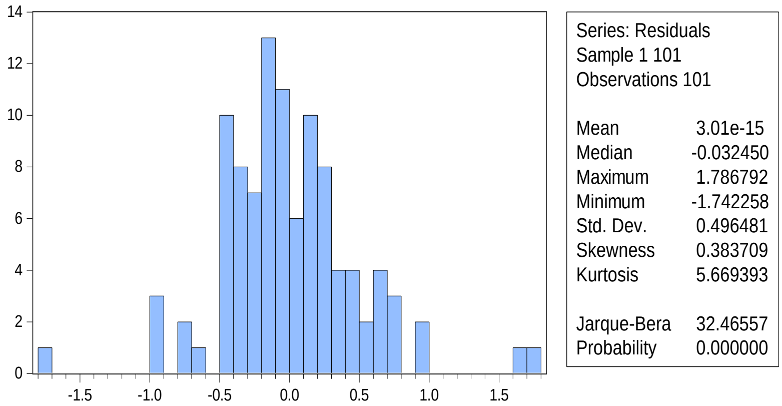
Ramsey RESET Test:

Ramsey RESET Test
Equation: UNTITLED
Specification: LOG(IMPORTS) C LOG(INCOME) LOG(RELATIVE_PRI
CE)
Omitted Variables: Powers of fitted values from 2 to 3

	Value	df	Probability
F-statistic	1.647801	(2, 96)	0.1979
Likelihood ratio	3.409062	2	0.1819

Interpretation: p-value=0.1979. This is greater than 0.05. Hence, the null hypothesis is accepted and we conclude that the model is **correctly specified**.
The Wald Test revealed the quadratic model of being **insignificant** as the hypothesis that the coefficients of quadratic values were zero was accepted.

Jarque-Bera Normality Test:



Interpretation: JB=32.466>5.99 and p-value=0<0.05. Hence, the null hypothesis is rejected and we conclude that residuals do not follow a normal distribution.

So the results of the regression analysis may not be accurate as normality assumption has not been met.

Results show that after the global financial crisis in 2008, the negative affect of income was removed, and both rising incomes and relative prices led to an increase in imports across countries.

Conclusion

From our analysis, we can statistically evaluated whether the economic theory holds true for the 3 countries. Originally, Pakistan and Brazil showed positive effect of both income and prices on imports but China showed a positive effect for income only. However, when volatility is also considered, both volatility and income increase imports if relative prices shifts. For Brazil, volatility affects import demand negatively, however, the effects of income and price remained unchanged. For China, volatility affects positively but effect of other variables remains unchanged. Hence, the findings suggested that both Pakistan and China do not increase their imports as domestic prices elevate, rather their populations tend to reduce their imports. A significant similarity lies in reducing import expenditure as relative prices inflate for both developing and developed economies.

Considering the three economies (Pakistan, Brazil & China), it can be generalized that from developing to developed economies, the factors influencing import expenditure are altered as the economy develops. Hence, the impact of relative prices is subsided by other factors for highly developed economies. Thereby, lending the similarity in reduced impact on imports owing to rising domestic prices. For developed economies, other factors may include the significant proportion of imported goods being luxuries that can be avoided as domestic prices rise and purchasing power of locals' falls. Whereas, for Pakistan, the heavy dependence on imports of necessities holds the econometric model true. Moreover, it is observed that exchange rate volatility affected developing and emerging economies more than developed economies owing to the revered effect of relative prices on developed countries.

Furthermore, with regards to major economic turndowns i.e. 2008 global financial crisis, we can observe that prior to the event, only increase in relative prices led to rise in an economy's expenditure on imports while rising carried a negative impact on imports. However, post financial crisis statistics illustrated a turndown of the negative effect of income as increase in both variables accentuated a rise in imports. The findings reciprocate a significant influence of the 2008 financial crisis on developed economies like China, whereas, it did not impact less stable economies like Pakistan and Brazil much significantly.

Findings of our research lends further scope of exploration of various factors influencing the economic relationship of imports with real GDP and relative prices for structurally varying economies. Further research can be done to foresee the impact of the dynamics of an economy over its aggregate demand of imports along with the differentiating impact of major economic events.

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