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IMPORT DEMAND FOR INTERMEDIATE GOODS IN MEXICO: 1993-2018

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Tittle: Import Demand for Intermediate Goods in Mexico: 1993-2018

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Abstract: In this paper, we study the import of intermediate goods (MIG) for México, these imports represent 80% of total imports, and they are close related to exports and production for domestic demand. We first try to estimate a VEC model using MIG, exports, domestic demand, and real exchange rates but we find impossible to estimate directly due to problems of endogeneity between MIG, exports and domestic demand. We construct instrumental variables for exports and domestic demand. But then we face multicollinearity problems between the instrumental variables. Therefore, we estimate two separate VECs one for MIG for exports and another for MIG for domestic demand. We find minimal possibilities to increase local content for exports, but we find hope in the production for domestic demand.

Keywords: VEC, Imports, Intermediate goods, Mexico
Subject classification codes: F02, F14, F15.

1. Introduction

Given the adverse influence that may have excessive imports, on economic growth, especially in the developing countries such as Mexico, it is essential to correctly quantify the elasticity of demand for imports and the propensity to import. According to Santos-Paulino (2002), to identify the main variables that affect the behaviour of imports can help economic policymakers to design and evaluate the sustainability of an economic strategy. The estimation of demand for imports provides important policy addresses, such as the sensitivity of import demand to changes in income and relative prices.

Import management is a crucial issue for developing countries in their quest for economic growth, and in this regard, Mexico is not an exception. México exports a value equivalent to 30% of GDP, and Imports even more significant value, which produces an endemic current account deficit. More than 80% of total Mexican exports go to the USA and slightly over 80% of exports are manufactured products. Nevertheless, the impact of exports on the rest of the economy is minimal. This happens because the import content of exports is very high. México has been growing for the last 38 years at an unacceptable rate. Between 1980-2018, the average growth rate of GDP per capita was 0.9%, and the weight of manufacturing in total GDP went from 18% in 1980 to 16.5% in 2018.

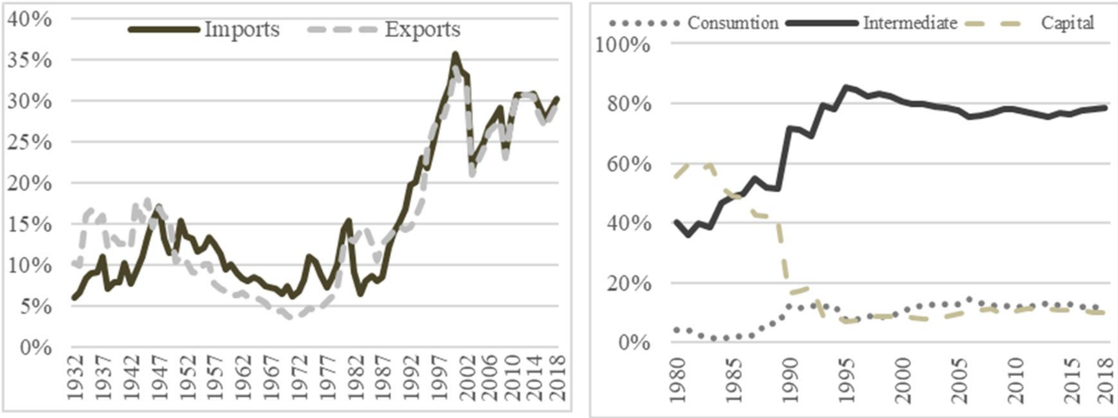
Industrialization seeks two objectives, increase growth and achieve commercial surpluses, surpluses allow neutralize interference by rating and international financial agencies and give s greater autonomy. In developing countries with a high proportion of manufacturing value added in GDP, China (30%), South Korea (27%), Thailand (26.5%), Malaysia (25%) and Singapore (20%), record trade surpluses exceeding 5% of GDP; and high rates of income growth per capita, higher than 3%, and coming up to 6% in the case of China.

In contrast, developing countries that followed neoliberal policies are de-industrializing. In Latin America, for example, countries such as Argentina and Brazil with levels of 30% in 1980, are in 2018 at levels of 13% and 10% respectively. In the case of Mexico, this figure went from 18% in 1980 to 16.5% in 2018. This deindustrialization was accompanied by large current account deficits. In 2018, in Argentina, the current account deficit was 5% of GDP, Brazil's 0.5% and in Mexico of 1.7%. These two trends are rigging a slow growth of per capita income. During the period 1980-2018, average annual growth for Argentina, Brazil and Mexico rates were 0.8%, 0.7%, and 0.9% respectively.

Mexico’s economic integration with the global markets has strengthened, especially in the last four decades, and Mexico’s openness ratio (percentage of imports and exports in GDP) rose to its peak of 70% in 2000 compared with 11% in 1970. In 2018 this figure was reduced to 60% (See Figure 1 Panel A). During this period imports of capital goods were reduced from 60% of total imports in 1983 to 10% in 2018 (see Figure 1, Panel B). At the same time, intermediate goods in total imports increased from 40% to nearly 80% in 2018.

Figure 1: Mexican Foreign Trade

A: Trade Balance as a % of GDP B: Composition of imports



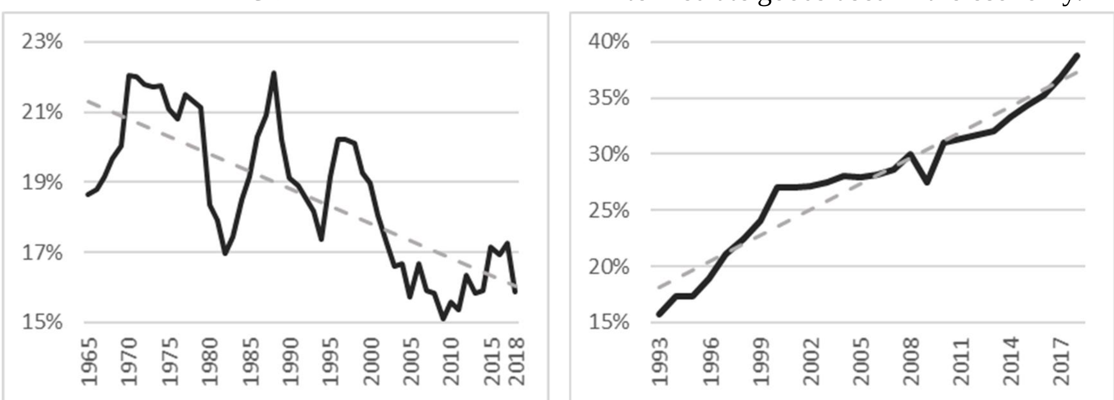
Source: *BIE, Estadísticas Históricas de México of INEGI*

At the same time, intermediate goods in total imports increased from 40% to nearly 80% in 2018. This shift was produced as the country abandoned the government led growth strategy and enter at the globalization movement, first by lowering tariffs unilaterally and later joining in the North American Free Trade Agreement (NAFTA). The signing of NAFTA included open borders for foreign capital (FDI). México dismantled its industrial programs and specialized in the labour-intensive parts of the fragmented production process that was swiping the World. That originated a low national content in exports as well as production for local consumption, and it means that since then the increase in exports a low impact on economic growth. Some define Mexican current economic growth model as the export of imports. This explains the reduced need for capital equipment and the increased dependence on imports to produce for local consumers and exports. (See Figure 2 Panel B).

Figure 2: Declining Mexican Manufacturing Sector and Growing Dependence on Foreign Intermediate Goods.

A: Manufacturing Value Added as a % of GDP

B: Intermediate imports as a % of total intermediate goods used in the economy.



Sourcer: WDI, Word Bank and *INEGI-Sistema de Cuentas Nacionales de México*

Most of the FDI inflow in the manufacturing industry was towards the automotive sector. Foreign automotive companies carried out a high amount of good intermediate imports including engines and software according to their global supply chain strategies. The problem with FDI is that transnational corporations do not have any interest in creating a local supply chain of intermediate goods or contribute to research and development in México. They satisfied their supply needs with a foreign network of suppliers which they know and trust, and they could be imported thanks to trade agreements such as the NAFTA (USCMA), EU-Mexico Global Agreement and Economic Partnership Agreement Mexico-Japan. Alternatively, Mexico has special agreements with firms from Asian countries where Mexico do not have trade agreement through the WTO.

For the last 36 years, there has not been a serious effort from the part of the government to induce the production of Mexican components that compete with imports. Mexican manufacturing sector is dominated by transnational corporations without any significant regulation by the government. México is a prominent exporter of manufacturing goods, but as seen in Figure 2, there is a clear declining tendency of manufacturing value added as a percentage of GDP since 1985. This paradox is explained once it is recognized that Mexican exports are labour-intensive activities which include the assembling of foreign parts with little value added. 40% of Mexican intermediate demand is satisfied with imports giving little room for linkages with the rest of the country.

This paper attempts to contribute to the literature by providing demand and real exchange price elasticities of intermediate goods in México. To the best of our knowledge, there is no study in the literature estimating income and price elasticities of intermediate imports for Mexico.

The remainder of the paper is organized as follows: the next section provides brief literature for related studies. Section III presents the model specification; Section IV discusses the data set. The final section offers conclusions.

2. Literature review

In this study, we do not follow the imperfect substitute model like the one proposed by Goldstein and Khan (1985). The underlying assumption of this model is that imports are imperfect substitutes for domestic goods so that both imported and domestic goods exist in the market. In México, most of the intermediate goods are not produced internally, so there is no choice between domestic and foreign inputs.

In the broad literature on import determinants, studies analyse determinants of imports at the aggregated and disaggregated levels by using different econometric techniques. Indeed, the aggregated models can be divided into two.

Some models estimate import demand as a function of aggregate income-expenditure. Reinhart (1995) estimated equations of imports and exports to several countries in Africa, Asia, and Latin America. For Mexico, the author provides evidence that data series of imports, exports, national income, income from trading partners of Mexico and relative prices of imports and exports from the country are consistent with processes *I(1)* and which, according to the case, are evidence of cointegration. In his analysis for Mexico, Senhadji (1998) characterized imports, income and the relative price of imports as variables *I(1)*; However, unlike Reinhart (1995), He did not find evidence of Cointegration.

Cardero and Galindo (1999) estimate the equation of imports from Mexico and analyse whether this displayed structural stability over the period 1983-1995. The authors found evidence, in this period, of that the price relative of imports are characterized as a process *I(0)*, while the imports and income can be characterized as processes *I(1)*. Also, they found two cointegrating relationships in equation for imports and determined that the largest eigenvalue associated does not show structural instability.

Bahmani-Oskooee and Hegerty (2009) estimate the equations for imports and exports in Mexico between 1962-2004. In addition to the classic regressors indicated by the model of substitutes, joining two permanent dichotomous variables: one for the accession of the country to the General Agreement on the Tariffs and Trade (GATT) and another accession to NAFTA. They estimate and prove the existence of the respective cointegration among variables relate to remember method. The authors found a related cointegration of both, exports and imports. Also, they explain that permanent dichotomous variables are statistically significant and suggest the possibility of changes in the behaviour of trade flows in response to GATT and NAFTA.

Cermeño and Rivera (2016) analyse flows of international trade in Mexico during the period of NAFTA. According with imperfect substitute goods model, they estimate imports and exports equations using cointegration test with monthly data for the period

1994-2014. The authors found cointegration for each equation of trade relationship. In both cases, price elasticities and income estimated long-term are significant, and their signs are consistent with economic theory. On the other hand, Mexican imports are elastic concerning the product, which is indicative of the high dependence of the Mexican economy imported inputs.

While some other authors take aggregate import as a function of disaggregated income expenditure namely, consumption, investment and exports components (Tang (2005); Zhou and Dube (2011); Chani and Chaudhary (2012); Modeste (2011)). In these studies, the rational of disaggregating income-expenditure is explained as avoiding aggregation bias, which results from the use of a single aggregate expenditure variable in the import function, when different macro components of final expenditure produce different impacts on imports. On the other hand, disaggregated models estimate disaggregated import demand functions mostly under Broad Economic Classification (BEC) namely, capital goods, intermediate inputs and consumption goods imports (Çakmak, U., Gökçe, Çakmak, O.A. 2016.; Togan and Berument (2007), Akal (2008); Aldan, Bozok and Günay. (2012); Thaver, Ekanayake and Plante (2012); Oktay and Gözgör (2013); Xu (2002)).

Finally, in the literature, of intermediate goods demand, there are very fewer studies, Ueda (1983) for Japan; Stirböck (2006) for Germany; Uğur (2008) and Colak, Tokpunar and Uzun (2014) for Turkey; Goldberg, et al. (2010) for India; Hye (2008) for Pakistan; Glover and King (2011) for Central America.

3 Specification

The choice of the form of the demand function is a common problem when researchers estimating models of aggregate demand of imports. The theory of international trade does not give many clues about the appropriate form of the specification or the estimation of demand equations of imports. Two of the most commonly used functional forms are linear and logarithmic.

According to Leamer and Stern (1970), it is possible to specify the equation of import demand, which relates the demanded amount of imports with income, the price of imports and the price of domestic substitutes. The equation of demand for imports in time t is as follows.

$$M_t = f(Y_t^n, P_t^f, P_t^d) \quad (1)$$

Where M_t is the quantity of imports, Y_t^n is the national nominal income, P_t^f is the price index of imports, and P_t^d is the domestic price index of domestic goods. The ordinary Marshallian demand function points out that equation 1 is homogeneous of degree zero in prices and nominal income, implying the absence of monetary illusion and allows us to express imports based on real income and relative prices. Therefore, the restricted function is expressed in function of real income and relative prices as follows:

$$M_t = g(Y_t, R_t) \quad (2)$$

Where $Y_t = Y_t^d / P_t^d$ the real national income, and $R_t = P_t^f / P_t^d$ The ratio between the prices of imports to domestic goods (expressed in the same currency). Such demand for imports implicitly restricts that the effect of the two prices on demand is the same, but with opposite sign. The linear development of aggregate demand for imports is expressed as follows.

$$M_t = \alpha_0 + \alpha_1 Y_t + \alpha_2 R_t + \varepsilon_t \quad (3)$$

Where α_0 is the term constant in the regression, α_1 is the marginal propensity to import, α_2 is the coefficient that measures the impact of relative prices to import demand, and ε_t is the random independent term. Is the independent term (ε_t), both, randomly and identically distributed (iid)? According to economic theory, it is expected that $\alpha_1 > 0$ and $\alpha_2 < 0$. However, Goldstein and Khan (1976) argued that imports represent the difference between domestic consumption and production can result in production grow faster (slower) than the consumption in response to an increase in income real. Therefore, imports may decrease (increase) as real income increases, resulting coefficient α_1 with a negative sign (positive). Using logarithms, import demand is written as follows.

$$lnM_t = \beta_0 + \beta_1 lnY_t + \beta_2 lnR_t + u_t \quad (4)$$

Where ln represents the natural logarithm and u_t is error term. According to economic theory, is expected that $\beta_1 > 0$ and $\beta_2 < 0$; Although β_1 may be negative.

In previous research, for example, Khan and Ross (1977); Boylan, Cuddy and O´Muircheartaigh (1980) and Doroodian, Koshal and Al-Muhanna (1994) it has been argued that the specification of the logarithmic form is preferable when estimated import demand functions, since these forms of estimation allows interpreting the coefficients as elasticities of the dependent variable with respect to the independent variable. This formulation is also useful because it can mitigate the problem of heteroscedasticity.

Considering that the imported intermediated goods are used to produce exports as well as to produce goods and services for the domestic market, we propose to model the Mexican demand for intermediate goods a modified version of equation (4).

$$MIG_t = \beta_0 + \beta_1 \ln X_t + \beta_2 \ln D_t + \beta_3 \ln R_t + u_t \qquad (5)$$

Where *MIG* is total import demand for intermediate goods, *X* represents total gross exports and *D* is total gross domestic demand. Since the gross value of production is total domestic demands plus gross exports ($GVP \equiv D + X$), $D = GVP - X$. And R_t and u_t are defined as before.

One of the problems in estimating equation (5) is the problem of endogeneity, gross exports include value added plus intermediate goods, and domestic demand also is formed by value-added plus intermediate goods. Moreover, intermediated goods are formed by domestic and foreign intermediate goods. Therefore $\ln X_t = f(lnMIG_t) \rightarrow lnX_t = f(u_t)$, by the same token $\ln D_t = f(lnMIG_t) \rightarrow lnD_t = f(u_t)$. Therefore, as presented, equation (5) do not comply with OLS assumptions, therefore we replace X_t and D_t with instrumental variables.[1]

For the first instrument, we propose an export demand function and domestic demand function:

$$lnX_t = a_0 + a_1 lnGDP_t^{USA} + e_t \qquad (6)$$

[1] COMENTARIO: Debe de justificar por qué las variables propuestas son buenos instrumentos. Solamente menciona los instrumentos y las condiciones. Debe de convencer que las dos condiciones se cumplen (nota al pie 1). La primera es fácil de demostrar. La segunda debe de argumentar el por qué y ser convincente. Instrumental variables are used when an explanatory variable of interest is correlated with the error term, in which case ordinary least squares give biased results. The instrument must be correlated with the endogenous explanatory variables, conditionally on the other covariates. If this correlation is strong, then the instrument is said to have a strong first stage. A weak correlation may provide misleading inferences about parameter estimates and standard errors. The instrument cannot be correlated with the error term in the explanatory equation, conditionally on the other covariates. In other words, the instrument cannot suffer from the same problem as the original predicting variable. If this condition is met, then the instrument is said to satisfy the exclusion restriction (Nichols, 2006).

$$lnD_t = b_0 + b_1 lnGDP_t^{MEX} + \varepsilon_t \quad (7)$$

Where GDP_t^{USA} and GDP_t^{MEX} are respectively the gross domestic product of USA and Mexico.

4. Data

Data for Mexican real gross value of production, gross domestic product, exports, and imports of intermediate goods are expressed in millions of Mexican Peso (Constant 2013 MXN$) and there were converted to dollars using the average peso-dollar exchange rate of 2013. This data was obtained from *Banco de Información Económica-INEGI* and Banco de México. The real exchange rate is the weighted average exchange rate of México with 111 countries and was obtained from Banco de México. GDP for the USA were obtained from FRED (Economic Research, Federal Reserve Bank of St. Louis). Except for real exchange rates, all variables are expressed in millions of US 2013 dollars. All series are expressed in quarterly data and covers the 1993q1 to 2018q4. We have 104 observations. Finally, al variables were seasonally adjusted using the moving average method to smooth out short-term fluctuations and highlight longer-term trends.

In order to avoid spurious regressions in the process of obtaining the instrumental variables, we run a test of the level of integration of the lnX_t, lnD_t , $lnGDP_t^{USA}$ and, $lnGDP_t^{MEX}$. The results are presented in Table 1.

Table 1. Phillips-Perron test statistic (levels)

Variable	Intercept	Trend and Intercept	None
lnX_t	-1.8347	-2.7939	4.2264
lnD_t	-1.1197	-2.4051	2.5010
$lnGDP_t^{MEX}$	-0.5552	-3.0395	3.6551
$lnGDP_t^{USA}$	-2.2543	-1.8276	6.6137

Note: the critical values of the Phillips-Perron test with intercept, trend and intercept and none to the significance levels of 1%, 5% and 10% are, respectively: -3.495021, -2.889753, -2.581890; -4.049586, -3.454032, -3.152652; -2.587607, -1.943974. -1.614676.
Source: author's estimation

Table 2. Phillips-Perron test statistic (first differences)

Variable	Intercept	Trend and Intercept	None
lnX_t	-8.6649	-8.7837	-7.6618
lnD_t	-6.5897	-6.9441	-3.6567
$lnGDP_t^{MEX}$	-10.1423	-10.0936	-9.2147
$lnGDP_t^{USA}$	-6.5897	-6.9441	-3.6567

Note: the critical values of the Phillips-Perron test with intercept, trend and intercept and none to the significance levels of 1%, 5% and 10% are, respectively: -3.495677, -2.890037, -2.582041; -4.050509, -3.454471, -3.152909; -2.587831, -1.944006, -1.614656.
Source: author's estimation

Since all variables are of the same order of integration, we estimate equation (6) and (7) to obtain instrumental variables $\widehat{lnX_t}$ and $\widehat{lnD_t}$. For the estimation of equation (6), we use a dummy variable for the period 2008Q1-2009Q4 to represent the 2008 crisis and its aftermath.

$$\widehat{lnX_t} = -9.078119 + 2.258467 lnGDP_t^{USA} - 0.163987 Crisis_{2008} \qquad (8)$$

Where $Crisis_{2008}$ is a dummy variable for the 2008-09 crisis: 2008q4, 2009q1, 2009q2 =1, R2 = 0.976829. In figure 3 panel A we represent the observed and forecast values of lnX_t.

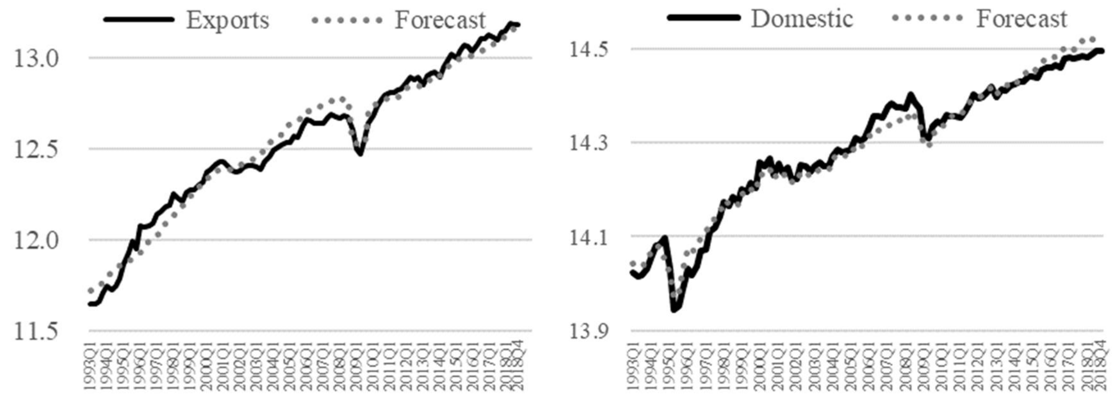
For the estimation of equation (7), we also use a dummy variable for the period 2008Q1-2009Q4 to represent the 2008 crisis and its aftermath.

$$\widehat{lnD_t} = 3.142939 + 0.801988 lnGDP_t^{MEX} - 0.034775 Crisis_{2008} \qquad (9)$$

Where $Crisis_{2008}$ is a dummy variable for the 1994-95 crisis: 1994q4, 1995q1, 1995q2, 1995q3 =1, R2 = 0.980760. In figure 3 panel B we represent the observed and forecast values of lnD_t.

Figure 3: Instrumental Variables $\widehat{lnX_t}$ and $\widehat{lnD_t}$

A: lnX_t B: lnD_t



Source: author's estimation

Since $\widehat{lnX_t}$ and $\widehat{lnD_t}$ show a high degree of collinearity as shown in table 3

Table 3. Collinearity between $\widehat{lnX_t}$ and $\widehat{lnD_t}$

Dependent Variable: $\widehat{lnX_t}$			Method: Least Squares	
Sample: 1993Q1 2018Q4			Included observations: 104	
Variable	*Coefficient*	*Std. Error*	*t-Statistic*	*Prob.*
C	-25.49039	1.029016	-24.77161	0.0000
$\widehat{lnD_t}$	2.661815	0.072017	36.96077	0.0000
R-squared: 0.930522			Adjusted R-squared: 0.929841	

Source: author's estimation

We could not estimate equation (5´) directly using instrumental variables:

$$\ln MIG_t = \beta_0 + \beta_1 \widehat{\ln X_t} + \beta_2 \widehat{\ln D_t} + \beta_3 \ln R_t + u_t \quad (5')$$

Instead, we estimate two separate equations:

$$\ln MIG_t = \beta_0 + \beta_1 \widehat{\ln X_t} + \beta_3 \ln R_t + u_t \quad (10)$$

And

$$\ln MIG_t = \beta_0 + \beta_1 \widehat{\ln D_t} + \beta_3 \ln R_t + u_t \quad (11)$$

To check that all variables are of the same order of integration, we run the Philips-Perron test an all four series.

Table 4. Phillips-Perron test statistic (levels)

Variable	Intercept	Trend and Intercept	None
$ln\hat{X}_t$	-1.701161	-2.070307	4.643329
$ln\hat{D}_t$	-0.530482	-2.921970	3.509370
$lnMIG_t$	-2.124900	-2.209419	3.682476
lnR_t	-2.416571	-2.441255	-2.326734

Note: the critical values of the Phillips-Perron test with intercept, trend and intercept and none to the significance levels of 1%, 5% and 10% are, respectively: -3.495021, -2.889753, -2.581890; -4.049586, -3.454032, -3.152652; -2.587607 -1.943974. -1.614676.
Source: author's estimation

Table 5. Phillips-Perron test statistic (first differences)

Variable	Intercept	Trend and Intercept	None
$ln\hat{X}_t$	-8.300857	-8.545032	-7.363969
$ln\hat{D}_t$	-8.770516	-8.720341	-8.097782
$lnMIG_t$	-10.12532	-10.51482	-9.180217
lnR_t	-9.718287	-9.671822	-9.755982

Note: the critical values of the Phillips-Perron test with intercept, trend and intercept and none to the significance levels of 1%, 5% and 10% are, respectively: -3.495677, -2.890037, -2.582041; -4.050509, -3.454471, -3.152909; -2.587831, -1.944006, -1.614656.
Source: author's estimation

5. Estimation of the VEC models

We choose the vector error correction method to estimate equation (10) and (11).

A. Estimation of equation (9)

First, we run a VAR using $lnMIG_t$, $\widehat{lnX_t}$, and lnR_t, then we find the optimal lag length using several criteria

Table 6. VAR Lag Order Selection Criteria

Endogenous variables: $lnMIG_t$, $\widehat{lnX_t}$, and lnR_t.	Exogenous variables: c
Sample: 1993Q1 2018Q4	Included observations: 96

Lag	LogL	LR	FPE	AIC	SC	HQ
0	156.6911	NA	8.17e-06	-3.2018	-3.1217	-3.1695
1	505.5438	668.6343	6.87e-09	-10.2821	-9.9616*	-10.1525*
2	515.8646	19.1363	6.69e-09	-10.3096	-9.7487	-10.0829
3	526.7295	19.4664	6.45e-09	-10.3485	-9.5471	-10.0246
4	538.9894	21.1993*	6.04e-09	-10.4164	-9.3746	-9.9953
5	548.8664	16.4616	5.96e-09*	-10.4347*	-9.1525	-9.9164
6	556.5654	12.3505	6.16e-09	-10.4076	-8.8850	-9.7921
7	559.3190	4.24508	7.08e-09	-10.2774	-8.5144	-9.5648
8	563.6369	6.38689	7.90e-09	-10.1799	-8.1765	-9.3701

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: author’s estimation

The FPE and AIC criteria suggest five lags; the SC and HQ criterion suggests using two lags. We adopt the FPE and AIC criterion. The next step is to perform the Juselius-Johansen (1990) test with five lags for $lnMIG_t$, $\widehat{lnX_t}$, and lnR_t. We use the model with no interceptor trend and five lags. Table 6 and 7 show the results of the Johansen Juselius test. The Johansen method suggests two statistics to determine the number of vectors of cointegration: the trace statistic and the test of the maximum eigenvalue. The critical values appropriate for the test are the Osterwald Lenmum (1992). The null and alternative hypotheses are tested using these statistics:

Table 7. Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	(0.05) Critical Value	Prob**
None *	34.16896	34.16896	24.27596
At most 1 *	13.16793	13.16793	12.32090
At most 2 *	5.796967	5.796967	4.129906

Trace test indicates three cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: author’s estimation

Table 8. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Max-Eigen Statistic	(0.05) Critical Value	Prob**
None *	21.00103	17.79730	0.0159
At most 1	7.370960	11.22480	0.2190
At most 2	5.796967	4.129906	0.0191

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: author’s estimation

Johansen's cointegration test reject the hypothesis of non-cointegration vector at least at the level of five percent, thus indicating the presence of a cointegration equation. The presence of at least one relation cointegration between the variables in levels justifies the use of a VEC model, that is, a model that combines the short-term properties of economic relationships with long-term data information, in the form of a level provided by the Johansen test.

$$\Delta y_t = \beta_0 + \sum_{i=1}^{N} \beta_i \Delta y_{t-i} + \sum_{i=1}^{N} \delta_{1,i} \Delta x_{1,t-i} + \cdots + \sum_{i=1}^{N} \delta_{j,i} \Delta x_{j,t-i} + \sum_{i=1}^{M} \theta_i D_i + \varphi Z_{t-1} + \mu_t \quad (12)$$

Where y is the dependent variable in the first equation of the VEC, x_i ,$i=1,..,4$ are the variables that appear as dependent on the other equations of the VEC, but as independent in the first equation, D_i are exogenous variables for all the VEC and Z_{t-1} is the residual of the cointegration equation. The error-correction term, φ, is related to the fact that the deviation of the last period of the long run equilibrium (the error), it influences the dynamics of short-term of the dependent variable. Thus, the coefficient φ measures the speed of adjustment, to which $lnMIG_t$ returns to equilibrium after a change in the independent variables.

The results of the estimation of the equation (8) appear in Table 9.[2] The RP^2 is 0.71, above 50%, so we have a good fit. We also find that the first term of error correction, φ, has the expected sign and is significant: -0.012, (0.005), [-2.513]; this implies that the model returns to its equilibrium level at a rate of 11.82% per quarter. These results confirm that there exists a long-term joint *causality* of all independent variables towards import demand for intermediate goods.

Table 9. $lnMIG_t$, $\widehat{lnX_t}$, and lnR_t VEC

Method: Least Squares (Gauss-Newton / Marquardt steps)

Dependent Variable: D(LN(MIG)) Sample (adjusted): 1994Q3 2018Q4

D(LN(MIG)) = φ *($lnMIG_{t-1}$ - 1.05750921662* $\widehat{lnX_t}$+ 1.17752156205* lnR_{t-1}) + C(2)*D(LN(MIG)(-1)) + C(3)*D(LN(MIG)(-2)) + C(4)*D(LN(MIG)(-3)) + C(5)*D(LN(MIG)(-4)) + C(6)*D(LN(MIG)(-5)) + C(7)*D($\widehat{lnX}$ (-1)) + C(8)*D($\widehat{lnX}$(-2)) + C(9)*D($\widehat{lnX}$ (-3)) + C(10)*D($\widehat{lnX}$ (-4)) + C(11)*D($\widehat{lnX}$ (-5)) + C(12)*D(LNR(-1)) + C(13)*D(LNR(-2)) + C(14)*D(LNR(-3)) + C(15)*D(LNR(-4)) + C(16)*D(LNR(-5)) + C(17)*D1 + C(18)*D2 + C(19)*D3 + C(20)*D4 + C(21)*D5 + C(22)*D6 + C(23)*D7

	Coefficient	Std. Error	t-Statistic	Prob.
φ	-0.011824	0.004706	-2.512581	0.0141
C(2)	-0.242174	0.097889	-2.473978	0.0156
C(3)	-0.141647	0.095230	-1.487428	0.1411
C(4)	-0.131052	0.097115	-1.349447	0.1813
C(5)	-0.027215	0.093962	-0.289635	0.7729
C(6)	0.031875	0.084241	0.378381	0.7062

[2] To achieve normality, we use 7 dummy variables. D1:1995Q1, D2:1996Q4, D3:1997Q3, D4:2001Q3, D5:2003Q1, D6:2008Q2, D7:2008Q.

C(7)	1.003866	0.162902	6.162400	0.0000
C(8)	-0.077823	0.196392	-0.396264	0.6930
C(9)	-0.522029	0.200063	-2.609326	0.0109
C(10)	0.644836	0.204932	3.146587	0.0024
C(11)	-0.223793	0.169828	-1.317762	0.1916
C(12)	0.405480	0.067000	6.051907	0.0000
C(13)	0.002777	0.077323	0.035911	0.9714
C(14)	-0.007914	0.078892	-0.100316	0.9204
C(15)	0.074997	0.080516	0.931462	0.3546
C(16)	-0.032184	0.072301	-0.445134	0.6575
C(17)	-0.158209	0.032020	-4.940899	0.0000
C(18)	-0.057171	0.032290	-1.770528	0.0807
C(19)	0.106073	0.030780	3.446139	0.0009
C(20)	0.056547	0.030365	1.862213	0.0665
C(21)	-0.130176	0.030845	-4.220392	0.0001
C(22)	0.081377	0.032393	2.512180	0.0141
C(23)	0.073711	0.032417	2.273863	0.0258

R-squared	0.711880	Mean dependent var	0.014221
Adjusted R-squared	0.627365	S.D. dependent var	0.048340
S.E. of regression	0.029509	Akaike info criterion	-4.006364
Sum squared resid	0.065307	Schwarz criterion	-3.399688
Log-likelihood	219.3119	Hannan-Quinn criteria.	-3.760976
Durbin-Watson stat	1.893660		

Source: author's estimation

Where the cointegration equation is given by:

$$lnMIG_{t-1} = 1.05750921662\ \widehat{lnX_{t-1}}\ -1.17752156205\, lnR_{t-1} \qquad (13)$$

The residual is given by:

$$Z_{t-1} \equiv lnMIG_{t-1} - 1.05750921662\ \widehat{lnX_{t-1}} + 1.17752156205\, lnR_{t-1} \qquad (14)$$

This means that the long run elasticity of imported intermediate goods respect to a one-unit change gross exports is 1.0576 and concerning the real exchange rate is -1.1775. (The variable R is expressed as a relative revaluation of the Mexican peso).

We continue with the diagnosis of the residuals; that analysis consists of three parts: a) autocorrelation test; b) heteroscedasticity test and c) normality test. Let us start with the Breusch-Godfrey autocorrelation test with three lags. The test results appear in Table 10.

Table 10. Breusch-Godfrey Serial Correlation LM Test

Null hypothesis: No serial correlation at up to 5 lags

F-statistic	0.621157	Prob. F(5,70)	0.6841
Obs*R-squared	4.163379	Prob. Chi-Square(5)	0.5261

Source: author's estimation

Since the probability value, 68.4% is higher than the required 5%; we accept the null hypothesis; that is, our model does not have a serial correlation in the residuals at the 5% confidence level.

We continue with the heteroscedasticity test, for which we use the Breusch-Pagan-Godfrey test. The results appear in Table 11.

Table 11. Heteroskedasticity Test: Breusch-Pagan-Godfrey

Null hypothesis: Homoskedasticity

F-statistic	1.175995	Prob. F(25,72)	0.2910
Obs*R-squared	28.41411	Prob. Chi-Square(25)	0.2891
Scaled explained SS	13.93056	Prob. Chi-Square(25)	0.9629

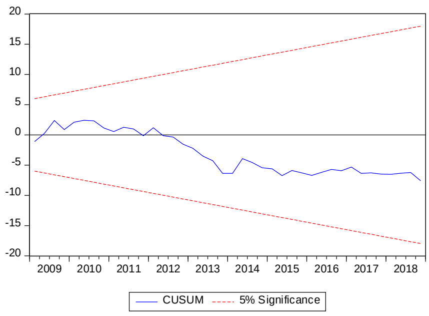
Source: author's estimation

Since the probability of Obs * R-squared is 28.9%, higher than the 5% required, we cannot reject the null hypothesis and conclude that our model does not have heteroscedasticity in the residuals.

Next, we perform the normality test of residuals, where we find a value of 0.436 for the Jarque-Bera coefficient with a probability of 0.804. This value of 80.4% is higher than the 50% required, so we cannot reject the null hypothesis and, therefore, conclude that our model presents normality in the residuals.

After verifying that our model is correctly estimated, we check if the model is stable; to do this, we use the CUSUM test. This test tells us if the CSUM line does not exceed the 5% limits, the parameters are stable. In Figure 4, we show the results for this model, and since the limits are not exceeded, we conclude that our model is stable.

Figure 4: Stability Test



Source: author's estimation

Finally, we study the variance decomposition of this model

Table 12. Variance decomposition[3]

Variance Decomposition of $\widehat{lnX_{t-1}}$ *:*				
Period	S.E.	$lnMIG_t$	$\widehat{lnX_t}$	lnR_t
1	0.017701	0.664833	99.33517	0.000000
2	0.029806	2.908609	91.93530	5.156095
3	0.040431	3.817004	88.46660	7.716399
4	0.047689	3.783324	89.01827	7.198406
5	0.051927	3.655488	89.73352	6.610991
6	0.055036	3.458567	90.47454	6.066894
7	0.058042	3.412070	91.07671	5.511217
8	0.061256	3.518205	91.42718	5.054620
9	0.064715	3.656093	91.58227	4.761638
10	0.068093	3.767350	91.66175	4.570903
Variance Decomposition of lnR_t				
Period	S.E.	$lnMIG_t$	$\widehat{lnX_t}$	lnR_t
1	0.040321	0.014417	24.46178	75.52381
2	0.054482	0.060128	19.67233	80.26754
3	0.062098	0.049347	17.84675	82.10390
4	0.071495	0.059058	16.91074	83.03020
5	0.078390	0.056587	16.26748	83.67593
6	0.082206	0.194764	16.33493	83.47030
7	0.085406	0.502668	16.71918	82.77815
8	0.087977	0.974251	17.15179	81.87396
9	0.089848	1.718428	17.77631	80.50526
10	0.091337	2.619270	18.34620	79.03453
Cholesky Ordering: $lnMIG_t$, $ln\hat{X}_t$, and lnR_t				

Source: author's estimation

Table 12 shows variance decomposition for the VAR $lnMIG_t$, $\widehat{lnX_t}$ moreover, lnR_t It shows the effects of impulse, innovation or shock on $\widehat{lnX_t}$ moreover, lnR_t on the rest of the variables in the VAR. Fort the case of innovation in $ln\hat{X}_t$ the most substantial effect is 4.57% in lnR_t moreover, 3.77 on $lnMIG_t$. The effect of $\widehat{lnX_t}$ on lnR_t is higher than on $lnMIG_t$. When we impose a shock on lnR_t the effects on the share on error forecast variance are minimal on $\widehat{lnX_t}$ as well as on $lnMIG_t$

B. Estimation of equation (9)

We continue with equation (9), first we run a VAR using $lnMIG_t$, $\widehat{lnD_t}$, and lnR_t, then we find the optimal lag length using several criteria.

[3] It determines how much of the forecast error variance of each variables can be explained by exogenous shocks to the other variables.

Table 13. VAR Lag Order Selection Criteria

Endogenous variables: $lnMIG_t$, $\widehat{lnD_t}$, and lnR_t.				Exogenous variables: C		
Sample: 1993Q1 2018Q4				Included observations: 96		
Lag	LogL	LR	FPE	AIC	SC	HQ
0	274.0459	NA	7.08e-07	-5.6467	-5.5666	-5.6143
1	591.3393	608.1457	1.15e-09	-12.0695	-11.7490*	-11.9400
2	607.5278	30.0162	9.91e-10	-12.2193	-11.6583	-11.9925*
3	616.1632	15.4718	1.00e-09	-12.2117	-11.4103	-11.8878
4	632.0015	27.3870	8.70e-10	-12.3542	-11.3124	-11.9331
5	644.9559	21.5907*	8.05e-10*	-12.4365*	-11.1544	-11.9183
6	651.3811	10.3070	8.54e-10	-12.3829	-10.8603	-11.7674
7	655.4610	6.2899	9.55e-10	-12.2804	-10.5174	-11.5678
8	660.9657	8.1423	1.04e-09	-12.2076	-10.2042	-11.3978

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion
Source: author’s estimation

The LR, FPE, and AIC criteria suggest five lags. We adopt that criterion and the next step is to perform the Juselius Johansen test with five lags for $lnMIG_t$, $ln\widehat{D}_t$, and lnR_t. We use the model with no interceptor trend with five lags. Table 14 and 15 show the results of the Johansen Juselius test. The Johansen method suggests two statistics to determine the number of vectors of cointegration: the trace statistic and the test of the maximum eigenvalue. The critical values appropriate for the test are the Osterwald Lenmum (1992). The null and alternative hypotheses are tested using these statistics.

Table 14: Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Trace Statistic	0.05 Critical Value	Prob**
None *	35.15881	24.27596	0.0015
At most 1 *	9.744291	12.32090	0.1302
At most 2 *	4.113860	4.129906	0.0505

Trace test indicates one cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: author’s estimation

Table 15. Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Max-Eigen Statistic	0.05 Critical Value	Prob**
None *	25.41452	17.79730	0.0030
At most 1	5.630431	11.22480	0.3936
At most 2	4.113860	4.129906	0.0505

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
Source: author’s estimation

Johansen's cointegration test suggests that the hypothesis of non-cointegration vector can be rejected at least at the level of five percent, thus indicating the presence of a cointegration equation. The presence of at least one relation of cointegration between the variables in levels justifies the use of a VEC model, that model combines the short-term properties of economic relationships with long-term data information, in the form of a level provided by the Johansen test.

The next step is to estimate a VEC and then concentrate on the first equation. The results of the estimation of the equation (9) appear in Table 16[4]. The RP^2 is 0.76, above 50%, so we have a good fit. We also find that the first term of error correction, φ, has the expected sign and is significant: -0.027, (0.005), [-5.373]; this implies that the model returns to its equilibrium level at a rate of 2.7% per quarter. These results confirm that there exists a long-term joint *causality* of all independent variables towards import demand for intermediate goods.

Table 16. Results of the $lnMIG_t$, $\widehat{lnD_t}$, and lnR_t VEC

Method: Least Squares (Gauss-Newton / Marquardt steps)

Dependent Variable: $lnMIG_t$ Sample (adjusted): 1994Q3 2018Q4

D(LN(MIG)) = φ *($lnMIG_{t-1}$- 0.892470804378* $\widehat{lnD_{t-1}}$ + 3.59377448724* lnR_{t-1}) + C(2)*D(LN(MIG)(-1)) + C(3)*D(LN(MIG)(-2)) + C(4)*D(LN(MIG)(-3)) + C(5)*D(LN(MIG)(-4)) + C(6)*D(LN(MIG)(-5)) + C(7)*D($\widehat{lnD_t}$ (-1)) + C(8)*D($\widehat{lnD_t}$ (-2)) + C(9)*D($\widehat{lnD_t}$ (-3)) + C(10)*D($\widehat{lnD_t}$ (-4)) + C(11)*D($\widehat{lnD_t}$ (-5)) + C(12)*D(LNR(-1)) + C(13)*D(LNR(-2)) + C(14)*D(LNR(-3)) + C(15)*D(LNR(-4)) + C(16)*D(LNR(-5)) + C(17)*D1 + C(18)*D2 + C(19)*D3 + C(20)*D4 + C(21)*D5 + C(22)*D6

	Coefficient	Std. Error	t-Statistic	Prob.
φ	-0.027136	0.005050	-5.373270	0.0000
C(2)	-0.109683	0.090326	-1.214292	0.2284
C(3)	-0.137347	0.094158	-1.458683	0.1488
C(4)	-0.179137	0.090732	-1.974359	0.0520
C(5)	-0.130712	0.088866	-1.470887	0.1455
C(6)	-0.064312	0.086796	-0.740953	0.4610
C(7)	0.235778	0.325068	0.725318	0.4705
C(8)	0.653333	0.302588	2.159148	0.0340
C(9)	0.929720	0.285658	3.254666	0.0017
C(10)	-0.210499	0.302381	-0.696140	0.4885
C(11)	0.303008	0.306639	0.988160	0.3262
C(12)	0.164646	0.051602	3.190712	0.0021
C(13)	0.156175	0.059074	2.643733	0.0100
C(14)	0.049750	0.055627	0.894362	0.3740
C(15)	-0.165659	0.058313	-2.840833	0.0058
C(16)	0.152577	0.055080	2.770123	0.0070
C(17)	-0.151173	0.028549	-5.295134	0.0000
C(18)	0.102873	0.029532	3.483423	0.0008
C(19)	0.149339	0.028779	5.189181	0.0000
C(20)	-0.151331	0.019763	-7.657275	0.0000
C(21)	0.142775	0.032780	4.355554	0.0000
C(22)	0.078468	0.028742	2.730096	0.0079

[4] To achieve normality, we use 6 dummy variables: D1:1995Q1, D2:2000Q1, D3:2002Q2, D4:2003Q1, D5:2008Q4 and 2009Q1, D6:2009Q3.

R-squared	0.760681	Mean dependent var	0.014221
Adjusted R-squared	0.694553	S.D. dependent var	0.048340
S.E. of regression	0.026716	Akaike info criterion	-4.212350
Sum squared resid	0.054245	Schwarz criterion	-3.632051
Log-likelihood	228.4051	Hannan-Quinn criteria.	-3.977631
Durbin-Watson stat	1.956861		

Source: author's estimation

Where the cointegration equation is given by:

$$lnMIG_{t-1} = 0.892470804378\, \widehat{lnD_{t-1}} - 3.59377448724\, lnR_{t-1} \qquad (15)$$

The residual is given by:

$$Z_{t-1} \equiv lnMIG_{t-1} - 0.892470804378\, \widehat{lnD_{t-1}} + 3.59377448724\, lnR_{t-1} \qquad (16)$$

This means that the long run elasticity of imported intermediate goods respect to a one-unit change gross domestic demand is 0.892 and concerning the real exchange rate is -3.594. (The variable R is expressed as a relative revaluation of the Mexican peso).

We continue with the diagnosis of the residuals; that analysis consists of three parts: a) autocorrelation test; b) heteroscedasticity test and c) normality test. Let us start with the Breusch-Godfrey autocorrelation test with three lags. The test results appear in Table 17.

Table 17. Breusch-Godfrey Serial Correlation LM Test

Null hypothesis: No serial correlation at up to 5 lags

F-statistic	1.386327	Prob. F(5,71)	0.2398
Obs*R-squared	8.716617	Prob. Chi-Square(5)	0.1209

Source: author's estimation

Since the probability value, 23.98% is higher than the required 5%; we accept the null hypothesis; that is, our model does not have a serial correlation in the residuals at the 5% confidence level.

We continue with the heteroscedasticity test, for which we use the Breusch-Pagan-Godfrey test. The results appear in Table 18.

Table 18. Heteroskedasticity Test: Breusch-Pagan-Godfrey

Null hypothesis: Homoskedasticity

F-statistic	1.344235	Prob. F(24,73)	0.1682
Obs*R-squared	30.03602	Prob. Chi-Square(24)	0.1836
Scaled explained SS	14.13882	Prob. Chi-Square(24)	0.9435

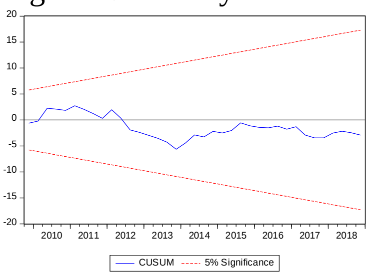
Source: author's estimation

Since the probability of Obs * R-squared, 18.4%, is higher than the 5% required, we cannot reject the null hypothesis and conclude that our model does not have heteroscedasticity in the residuals.

Next, we perform the normality test of residuals, where we find a value of 1.089 for the Jarque-Bera coefficient with a probability of 0.580. This value of 58.02% is higher than the 50% required, so we cannot reject the null hypothesis and, therefore, conclude that model presents normality in the residuals.

After verifying that our model is correctly estimated, we check if the model is stable; to do this, we use the CUSUM test. This test tells us if the CSUM line does not exceed the 5% limits, the parameters are stable. In Figure 5, we show the results for this model, and since the limits are not exceeded, we conclude that our model is stable.

Figure 5. Stability Test



Source: author's estimation

Finally, we study the variance decomposition of this model.

Table 19. Variance decomposition

Variance Decomposition of $\widehat{lnD_t}$:				
Period	S.E.	$lnMIG_t$	$\widehat{lnD_t}$	lnR_t
1	0.010000	10.29086	89.70914	0.000000
2	0.013392	15.91929	78.97690	5.103808
3	0.016672	17.80039	76.08491	6.114700
4	0.018929	18.86412	73.82189	7.313995
5	0.022719	15.43345	79.47093	5.095626
6	0.025790	14.12607	81.81736	4.056570
7	0.028945	13.27492	83.50413	3.220947
8	0.031382	13.43757	83.78495	2.777479
9	0.034757	12.84095	84.53140	2.627650
10	0.037820	12.70816	84.62703	2.664804
Variance Decomposition of lnR_t				
Period	S.E.	$lnMIG_t$	$\widehat{lnD_t}$	lnR_t
1	0.039664	0.247134	4.824364	94.92850
2	0.054833	0.395323	8.823575	90.78110
3	0.064578	1.471838	9.218094	89.31007
4	0.076702	3.020772	9.306249	87.67298
5	0.088001	4.634858	11.08434	84.28080
6	0.096308	6.011834	12.32499	81.66318
7	0.103787	6.988567	13.39014	79.62129

8	0.110184	7.715396	14.42326	77.86134
9	0.115775	8.245699	15.53431	76.21999
10	0.120497	8.724155	16.40750	74.86835
Cholesky Ordering: $lnMIG_t$, $ln\widehat{D}_t$, lnR_t				

Source: author's estimation

In this section, variance decomposition analysis has been modified replacing $\widehat{lnD_t}$ for $\widehat{lnX_t}$. Table 18 shows variance decomposition for the VAR $lnMIG_t$, $\widehat{lnD_t}$ moreover, lnR_t shows the effects of impulse, innovation or shock on $\widehat{lnD_t}$ and on the rest of the variables in the VAR. For the case of innovation in $\widehat{lnD_t}$, we observe minor effects on $lnMIG_t$ moreover, lnR_t. When we impose a shock on lnR_t we observe important effects on the share the variance of error forecast variance on $\widehat{lnD_t}$ as well as on $lnMIG_t$

6. Conclusions

The import demand for intermediate goods, as a function of exports and real exchange rate, shows a unit elasticity concerning exports, reveals the fixed technical coefficients in the imported content to exports, ($lnMIG_{t-1}$ = $1.0575\widehat{lnX_{t-1}}$ $- 1.1775\ lnR_{t-1}$); in the case of the real exchange rate, the elasticity of imported intermediate good is 1.18 which means that a 1% increase in the real exchange rate reduces imports of intermediate goods for 1.18%, and exports perhaps as well. This is confirmed using the variance decomposition analysis. When we impose a shock on lnR_t the effects on the share on error forecast variance significantly reduce the effect on $\widehat{lnX_{t-1}}$ moreover, the effect on $\ln MIG_t$ is minimum.

The import demand for intermediated goods, as a function of domestic demand and real exchange rate ($lnMIG_{t-1}$= 0.8924 $\widehat{lnD_{t-1}}$ - 3.5937 lnR_{t-1}), reveals an inelastic demand for intermediate goods concerning an expansion of 1% in domestic demand. The elasticity is 0.89, very high but less than unity. This also reflects the limited options for intermediate goods in the national market and the high dependence on imported goods top produce for the local market. The estimation of this demand function also reveals a high negative elasticity of imported goods with respect to real exchange rate. This means that imports of intermediate goods for domestic demand could be manipulated trough manipulation of the real f exchange rate, or even better trough a policy of import substitution for domestic production.

The most important result obtained from the econometric model is that exports have fixed coefficients of intermediate goods that are imported, which reflects in unitary elasticity of import demand for intermediate goods when exports expand. Second, price elasticities of imports of intermediate goods for exports are slightly elastic concerning the real exchange rate (1.17%). However, this possible beneficiary partial effect is compensated by the reduction in exports that the depreciation produces. So, there is little hope that we will see a reduction of intermediate goods in exports since a large percentage of exports are manufactured goods which are produced by transnational corporations which have their network of suppliers worldwide.

In the case of imports of intermediate goods for domestic demand, there is more hope. The import demand is slightly inelastic, and the price elasticity is high, which means that trough a support mechanism or an industrial policy advocated supporting local producers to provide inputs for producers that satisfy domestic demand we can generate increase the level of industrialization and growth. During the 1980-2018 period, the average growth rate of GDP per capita was 0.9%, and the weight of manufacturing in total GDP went from 18% in 1980 to 16.5% in 2018. Countries like Germany and Japan register in 2018 a weight of manufacturing of GDP of an order of 20%.

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