**TRADE FLOWS AND VOLATILITY OF THEIR FUNDAMENTALS:**
**SOME EVIDENCE FROM MEXICO**

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Abstract: In this paper we investigate the effects of volatility of the fundamental determinants of trade on trade flows in México during the period 1991-2008. Our import and export functions are based on the well known imperfect substitute goods model of trade. We focus on the effects of real exchange rate as well as measures of relative prices and real income and their associated conditional volatility on import and export flows. We consider a vector error-correction model with conditional heteroskedasticity (VEC-GARCH). Our results indicate that the imperfect substitute goods model is a reasonable empirical specification as we find evidence supporting cointegration and obtain income and price elasticities in line with those from previous empirical studies. Quantitatively, we find that while income effects are the most important determinants of trade flows in the long run, there are some non-negligible volatility effects of fundamentals on the short run dynamics.

Keywords: Demand for imports and exports, imperfect substitute goods model, cointegration, vector error-correction, GARCH, VEC-GARCH, volatility of exchange rates.

JEL Classification: F10, F14

## 1. INTRODUCTION

In this paper we investigate the effect of volatility of the fundamental determinants of trade on trade flows in Mexico using monthly data for the period 1991-2008. In general, the recent empirical literature has investigated trade flows in the context of non-stationary processes, using cointegration approaches. On the other hand, research on the effects of volatility on trade flows has modeled trade functions as stationary processes and focused on the effects of volatility of exchange rates only.[1] In this paper we use an approach that simultaneously takes into account both, the non-stationary features of trade flows and their main determinants as well as their associated volatility, measured as conditional heteroskedasticity.

The empirical specification of the import and export demand functions is based on the well known imperfect substitute goods model of trade as summarized in Khan (1985). We adopt this approach because it is simple and considers the fundamental determinants of trade flows. Also, since this model has been widely used in empirical work, we will be able to make comparisons straightforwardly. In order to study the effects of volatility on trade flows we extend the baseline specification to account for conditional heteroskedasticity in a multivariate framework.

The main contribution of this paper to the empirical literature is to consider a multivariate model that simultaneously takes into account cointegration and conditional heteroskedasticity. Specifically, we consider a vector error correction model where the vector of disturbances is allowed to follow a multivariate GARCH process (VEC-GARCH). Seo (2007) has studied the theoretical properties of this type of econometric

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[1] A notable exception is the paper by Grier and Smallwood (2007) who investigate the effects on real exchange rate as well as foreign income on export performance in a sample of 18 countries. The motivation of our paper is similar although we use a different econometric approach.

models showing that the maximum likelihood estimator of the cointegrating vector has a mixture normal asymptotic distribution and, therefore, inference can be made by standard methods. Seo's paper has also shown that the asymptotic distribution of the MLE estimator depends on the conditional heteroskedasticity and kurtosis exhibited by standarized errors and that the efficiency gains of this estimator relative to alternative estimators (that do not take into account explicitly the conditional heteroskedasticy feature of errors) increase as the magnitude of conditional heteroskedasticty increases.

Generally, we find that all the time series processes under study are consistent with the unit root hypothesis. Specifically, these are the logarithm of real imports and exports, relative prices of imports and exports as well as measures of real income of Mexico and the USA. Next, we find evidence of cointegration for both the import and export demand functions and in both cases income effects appear to be the main determinants of trade flows. We also find significant GARCH effects in all cases with some non-negligible effects on the short run dynamics of Mexico's import and export functions.

The rest of the paper is organized as follows. Section 2 provides a review of the literature. Section 3 outlines the econometric model and gives the details of our empirical strategy. Section 4 presents the empirical results and, finally, in section 5 we offer some conclusions.

## 2. SOME BACKGROUND

### 2.1 Empirical Import and Export Demand Functions

The empirical literature on trade flows typically relates the imports a country with import prices, exchange rates and the country's income and general price level. On the other hand, export flows of a country are related with export prices, exchange rates as well as income and price levels prevailing in the foreign partner countries. This approach is known as the imperfect substitute goods model of trade.

The main assumption of this model is that both imports and exports are imperfect substitutes of domestic goods and its applicability is based on two observations about international trade patterns: (i) there exists intra-industry trade between countries and (ii) it is not unlikely to find significant and non-transitory price differentials for the same type of goods within a given country. While some products can be considered perfect substitutes, the imperfect substitute goods model relies on the fact that a significant share of traded goods among countries is not completely homogenous. According to the imperfect substitute goods model, both import and export goods are in the consumption basket of agents together with domestic goods which makes it possible the specification of import and exports as Marshallian demand functions.

From the beginning, the empirical work has focused on quantifying the magnitude and sign of price and income elasticities, using time series of individual countries. The first noticeable round of studies appeared towards the end of the 1960s[2] (Houthakker and Magee, 1969). Although these studies used OLS methods, the observation that the results could be biased due to endogeneity problems caused by the simultaneity of import and export quantities and their corresponding prices, was pointed out since the decade of the 1950s. (Orcutt, 1950; Harberger, 1953). In order to avoid possible endogeneity biases, in the decades of the 1970s and 1980s, some authors such as Goldstein and Khan (1978) and Márquez y McNeilly (1988), used simultaneous equations methods. However, it is important to notice that in general the empirical literature has dealt with the potential

[2] Actually, the first studies about international trade flows could be traced back to the decade of the 1940s from authors such as Adler (1945, 1946) and Chang (1945, 1946) although some of them do not employ a regression analysis as in the case of Adler.

endogeneity problem by assuming that the supply is infinitely elastic with respect to price for both imports and exports. Also, it was generally accepted that the previous assumption could be appropriate for an important number of countries, thus justifying its applicability[3].

The empirical literature produced between 1970 and 1990 has also focused on the potential problems of autocorrelation and efficiency losses of the OLS estimator when working with time series. In this sense, Thursby and Thursby (1984), Goldstein and Khan (1985) and Márquez and McNeilly (1988), proposed the use of time series methodologies and distributed lag models in order to properly take into account the autoregressive and moving average features of the time series under study.

Since the decade of the 1990's the empirical literature based on the imperfect substitute goods model has focused on testing the homogeneity of degree zero of the import and export demand functions (Deyak, Sawyer y Sprinkle, 1993; Narayan y Narayan, 2004). A notable aspect of these and the empirical literature thereafter has probably been to consider explicitly the non-stationary features of the time series as well as the possibility of having spurious relationships.

The studies of Rose (1991), Reinhart (1995), Clarida (1994, 1996), Senhadji (1997), Senhadji and Montenegro (1998) and Garcés (2002) have shown that imports, exports and their respective relative prices are processes with unit roots and have made the characterization of the time series a crucial element in their analysis. Differently than the traditional studies, the new empirical literature uses cointegration analysis. Also, this literature recognizes the fact that in the context of non-stationary time series, despite its super-consistency property, the OLS estimator may lead to inefficient and biased results in

[3] In the context of international trade this assumption is generally accepted when applied to small economies. This is not case, however, for large economies that that use their productive capacities fully and will probably face highly inelastic supply functions, with respect to price. (Goldstein y Khan, 1978).

small samples[4] (Banerjee et. al, 1986) recommending the use of estimators such as the Dynamic OLS (Phillips y Hansen, 1990; Phillips y Loretan, 1991; Saikkonen, 1991; Park, 1992; Stock y Watson, 1993) or the Fully Modified Least Squares FMLS (Phillips y Hansen, 1990). For the multivariate case, the Johansen's (1988, 1997) cointegration approach is used.

**2.2 The Studies for Mexico and other Developing Countries**

Although we can find some studies for developing countries in the early literature on trade flows it is only until de decade of the 1990's that Mexico is taken into account. One of the few exceptions is the study of Houthakker and Magee (1969)[5]. In 1974, Khan published one of the first studies on trade flows for developing countries. This author estimates demand functions of imports and exports for some Latin American countries, among them Argentina, Brasil, Colombia, Uruguay and Costa Rica, but unfortunately Mexico is not included. The case of Mexico is found later in the study by Reinhart (1995) who estimates import and export demand functions for countries of Africa, Asia and Latin America[6], using yearly data for the period 1970-1991, from the International Monetary Fund[7].

Similarly than Rose (1991) and Clarida (1994), Reinhart (1995) applies unit root and cointegration approaches verifying that most of the relevant variables are consistent with unit root processes and finding evidence on cointegration. In her study Reinhart finds that the estimates of price and income elasticities of imports were consistent with economic theory. The former was in the range of -1.36 (Colombia) and -0.15 (Congo) while the later were all positive and in the range of 2.75 (Brasil) and 0.89 (Mexico). The price elasticity of

[4] It is important to notice that by using annual data, most studies end up with very short sample sizes given the limited availability of long time series.
[5] Notwithstanding, the results for the case of Mexico are not reported in this study.
[6] These countries are Congo, Kenia, Marruecos, Hong Kong, Indonesia, Pakistán, Sri Lanka, Argentina, Brasil, Colombia, Costa Rica and México.
[7] IMF *World Economic Outlook*.

imports for Mexico was -0.39. In the case of export demand functions, the price elasticities have the expected negative sign for all countries but Mexico which had a positive and statistically significant value. These elasticities had values between -0.97 (Pakistan) and 0.31 (Mexico). All income elasticity values were positive and statistically significant varying between 4.41 (Hong Kong) and 0.88 (Sri Lanka). For the case of Mexico the income elasticity of exports was 3.37.

Senhadji (1997) estimates import demand functions for 77 countries including developed and developing countries, using the BESD data base from the World Bank for the period 1960-1993. Senhadji's log-linear empirical specification is derived from an intertemporal utility maximization model for a representative agent in the context of the imperfect substitute goods model. This author also finds that for most countries, the logarithm of imports, relative prices and real GDP are consistent with unit root processes and proceeds consequently to test for cointegration rejecting the null of no cointegration in only 49 cases. The estimates of the long-run elasticities were obtained using the FMLS estimator of Phillips and Hansen (1990). The price elasticities of imports are between -0.02 (Chile) and -6.74 (Benin) with a mean value of -1.08. On the other hand, the income elasticities are in the range of 0.03 (Zaire) to 5.48 (Uruguay) with a mean value of 1.45. For the particular case of Mexico the author finds price and income elasticities of -0.77 and 1.31 respectively, both statistically significant at the 5%. However the author did not find cointegration in the case of Mexico and thus the regression results for México are considered spurious.

Senhadji and Montenegro (1998) carried out a similar exercise as in Senhadji (1997) in order to estimate the long-run run elasticities of export demand functions for 70 countries over the period 1960-1993, using data on National Accounts from the World

Bank together with a disaggregated data base on trade flows from the United Nations (UNSO-COMTRADE). The reported price elasticities obtained by using the FMLS estimator vary between -0.02 (Peru) and -4.72 (Turkey) with a mean value of -1.00 while the income elasticity values are found between 0.17 (Ecuador) and 4.34 (Korea) with a mean value of 1.48. It is important to mention that only in 51 cases there was cointegration and, hence, the estimation results had a proper interpretation. Unfortunately, in the case of Mexico the price and income elasticities did no have the expected signs and were excluded without being reported and also no information is reported on cointegration tests.

Garces (2002) studies the import and export demand functions for the case of Mexico during the period 1980-2000, in the context of the bilateral trade relationship with the USA. The aim of this study is to investigate the evolution of trade flows following the important institutional changes due to the entrance of Mexico to the GATT (1985) and NAFTA (1994) treaties. Similarly than in the previous studies, it is found that all Mexican time series are consistent with unit root processes. It is important to notice that this author uses monthly data[8]. Using Johansen's (1988) cointegration approach he finds income and real exchange rate elasticities of 2.80 and 0.32 for the case of exports. For the case of imports, these values are 0.94 and -0.14 respectively. Using the FMLS estimation method similar values are found. These are 2.86 and 0.23 respectively for the export demand function and 1.12 and -0.28 for the case of imports.

Table 1 summarizes the estimation results of the import and export demand functions for the cases of Mexico and USA which is Mexico's main commercial partner. A noticeable result is that it has not been possible to find a negative value for the price elasticity in the case of exports.

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[8] Most data is obtained from the Banco de Mexico (The Mexican Central Bank or so called Banxico).

Table 1. Elasticities of import and export demand functions for Mexico and USA.

| Study | Country | Period | Methodology | Income Elasticity[a] | Price Elasticity[a] |
|---|---|---|---|---|---|
| **Imports** | | | | | |
| Houthakker and Magee, 1969. | USA | 1951-1966 | OLS | 1.51 | -0.54 |
| Murray and Ginman, 1976. | USA | 1961-1968 | OLS | 1.94 | -1.23 |
| Reinhart, 1995. | Mexico | 1970-1991 | DOLS [b] | 0.89 | -0.39 |
| Senhadji, 1997. | Mexico | 1960-1993 | FMLS [c] | 1.31 | -0.77 |
| | USA | 1960-1993 | FMLS | 2.45 | -0.52 |
| Garcés, 2002.[d] | Mexico | 1991-2000 | Johansen | 0.94 | -0.41 |
| | | 1991-2000 | FMLS | 1.12 | -0.28 |
| **Exports.** | | | | | |
| Houthakker y Magee, 1969. | USA | 1951-1966 | MCO | 0.99 | -1.51 |
| Khan, 1974. | USA | 1955-1970 | FIML [e] | 1.01 | -2.31 |
| Reinhart, 1995. | Mexico | 1970-1991 | DOLS | 3.37 | 0.312 |
| Senhadji y Montenegro, 1998. | Mexico | 1960-1993 | FMLS | N.A. | N.A. |
| | USA | 1960-1993 | FMLS | 1.04 | -0.73 |
| Garces, 2002. | Mexico | 1990-2000 | Johansen | 2.80 | 0.32 |
| | | 1990-2000 | FMLS | 2.86 | 0.23 |

(a) Long-run Elasticities.
(b) DOLS: *Dinamic Ordinary Least Squares* (Stock y Watson, 1993).
(c) FMLS: *Fully Modified Least Squares* (Phillips y Hansen, 1990).
(d) This study considers real exchange rate instead of relative prices
(e) *Full Information Maximum Likelihood.*

It is important to recognize that Garces (2002) finds the correct signs using real exchange rates in pesos for dollar. This finding seems to point to potential problems in the measures of relative prices of imports used. Although the interpretation of relative prices of imports and exports and real exchange rates differ, their construction is somehow similar. They are both based on price indexes and nominal exchanges rates and it might well be the case that the later works as a better approximation of relative prices in the case of Mexico.

**2.3 Trade flows and volatility**

The literature in this area mainly focuses on the effects of exchange rate volatility on imports or exports, esentially on methodological and empirical issues. A few relevant references are, among others, Hooper and Koalhagen (1978), Bailey, Tavlas and Ulan (1987), Koray and Lastrapes (1989), Chowdhury (1993), Cote (1994), Arize (1995, 1997), Broll and Eckwert (1999), Arize, Osang and Slottje (2000, 2004) and Grier and Smallwood (2007). At the risk of not making justice of all these contributions on this topic we could argue that, in general, the dominant specification of the trade functions includes measures of scale, real exchange rates or relative prices and a measure of volatility of real exchange rate.[9] The justification for this specification goes back to the work by Gotur (1985) who derived such a relationship in the context of demand-supply analysis. Empirically, we find that the econometric models used have included distributed lag models, vector autorregressions and lately unit root and cointegration analysis. In most cases, the measure of volatility is simply treated as a separate variable and is obtained as a moving average of the squares of the rate of growth of exchange rates. In some cases the ARCH methodology has also been used. In the unit root and cointegration approaches the empirical

[9] As we noted before, a notable exception in the recent empirical literarture is the paper by Grier and Smallwood (2007) who consider measures of both real exchange rate and foreign income uncertainty from univariate GARCH models and evaluate their effects on export performance in a sample of 18 countries.

methodology usually proceeds as follows. First, unit root testing is performed on all variables, including the volatility measures. Second, the long run demand functions are estimated in the usual way, using the well-known Engle-Granger or Johansen approaches. Finally, an error-correction model is estimated. In general, the finding that volatility of exchange rate affects negatively trade flows does not seem to be clear cut in the empirical literature.

## 3. THE ECONOMETRIC MODEL

In the present research we focus on the short run effects of volatility of the fundamental determinants of trade on trade flows. As pointed out before, our baseline specificaction is beased on the well known imperfect substitute goods model of trade, as summarized in Khan (1985)[10]. Especifically, the import and export demand functions are formulated respectively as:

$$\ln M = \beta_{01} + \beta_{11} \ln \frac{Y_D}{P_D} + \beta_{21} \ln \frac{eP_M}{P_D} + u^M \quad (1)$$

$$\ln X = \beta_{02} + \beta_{12} \ln \frac{Y_F}{P_F} + \beta_{22} \ln \frac{P_X}{eP_F} + u^X \quad (2)$$

In equation (1) $M$ denotes que quantity of imports, $Y_D$ is the nominal income in the domestic country, which is Mexico in this case, $P_D$ is the price of domestic substitutes, $P_M$ is the price of imports in foreign currency and $e$ denotes the exchange rate in Mexican pesos per U.S. dollar. Likewise, in the case of equation (2) $X$ denotes que quantity of

[10] It is important to emphasize that this specification has been extensively used in empirical work in order to estimate income and price elasticities of the imports and exports functions. See, for example, the papers by Magee (1969), Khan (1974), Senhadji (1997), Senhadji and Montenegro (1998), Reinhart (1995), Garcés (2002) and Narayan and Narayan (2004).

exports, $Y_F$ is the nominal income in the foreign country (the U.S.), $P_F$ is the price of domestic substitutes in the foreign country, that is the price of goods in the U.S. that compete with Mexican exports[11], $P_X$ is the price of exports in foreign currency and $e$ denotes the exchange rate, as defined previously.[12] The terms $u^M$ and $u^X$ are the error or disturbance terms which are going to be allowed to exhibit conditional heteroskedasticity as we will explain next, but before doing so it will be useful to simplify the previous notation. Let $m = \ln M$, $y^d = \ln(Y_D / P_D)$, $p^m = (eP_M / P_D)$, $x = \ln X$, $y^f = \ln(Y_F / P_F)$ and $p^x = \ln(P_X / eP_F)$. The previous functions can therefore be rewritten more compactly as:

$$m_t = \beta_{01} + \beta_{11} y_t^d + \beta_{21} p_t^m + u_t^m \qquad (1a)$$

$$x_t = \beta_{02} + \beta_{12} y_t^f + \beta_{22} p_t^x + u_t^x \qquad (2a)$$

In what follows we specify the econometric model for the case of the imports function given by (1a). Let's assume that $m_t$, $y_t^d$ and $p_t^m$ are integrated to order 1, that is these variables have a unit root, and that they are cointegrated with one cointegrating vector. Let's also assume that the vector $\mathbf{z}_t = \begin{bmatrix} m_t & y_t^d & p_t^m \end{bmatrix}^\tau$, where $\tau$ is the matrix transposition operator, follows a vector autorregression of order $p$, denoted $VAR(p)$. In a multivariate setting, the corresponding vector error-correction ($VEC$) model can be written as:

$$\Delta \mathbf{z}_t = \mathbf{\Gamma}_1 \Delta \mathbf{z}_{t-1} + \ldots + \mathbf{\Gamma}_{t-p+1} \Delta \mathbf{z}_{t-p+1} + \boldsymbol{\alpha} \boldsymbol{\beta}^\tau \mathbf{z}_{t-1} + \mathbf{u}_t \qquad (3)$$

Under the previous assumptions, $\boldsymbol{\alpha}$ is a 3 by 1 vector with each of its elements measuring the change in the corresponding element of $\mathbf{z}_t$ in response to a disequilibrium in the long

[11] Some authors such as Magee (1969) and Narayan and Narayan (2004) use the price of exports of comercial partners that compete with the exporter country.

[12] Our especifications do not consider the tarif structure on international trade and other trade restrictions. In general, the empirical literature has abstracted from these issues, although this is not a justification and certainly considering them may lead to different results.

run relationship that occurs in the previous period, which is given by $\boldsymbol{\beta}^{\tau}\mathbf{z}_{t-1}$. The vector $\boldsymbol{\beta}^{\tau} = \begin{bmatrix} 1 & -\beta_{01} & -\beta_{11} & \beta_{21} \end{bmatrix}$ is the cointegrating vector and includes an intercept in this case. Correspondingly, the vector $\mathbf{z}_{t-1}$ is defined as $\mathbf{z}_{t-1} = \begin{bmatrix} m_{t-1} & 1 & y_{t-1}^{d} & p_{t-1}^{m} \end{bmatrix}^{\tau}$. It is important to notice that the parameters $\beta_{11}$ and $\beta_{21}$ are the long run income and price elasticities of imports respectively.

The error vector $\mathbf{u}_t$ is allowed to have conditional heteroskedasticity by assuming that it follows a multivariate normal distribution with zero-mean vector and a conditional covariance matrix $\mathbf{H}_t$. Following the multivariate GARCH literature a variety of specifications can be adopted to describe the dynamics of the conditional covariance matrix but for practical reasons we assume here the well known constant conditional correlation specification (CCC) proposed by Bollerslev (1990). In this case the conditional variances and covariances are specified as

$$h_{it} = \alpha_i + \delta_i h_{it-1} + \gamma_i u_{it-1}^2, \qquad \text{for } i = 1,2,3 \tag{4}$$

$$h_{ijt} = \rho_{ij}(h_{it}h_{jt})^{1/2}, \qquad \text{for } i \neq j \tag{5}$$

It is important to remark that the model given by equations (3), (4) and (5) is a multivariate GARCH model of dimension $3$ and can be called accordingly. However, since the conditional mean equation (3) is in fact a vector error correction model, we will refer to the full model as VEC-GARCH. For this type of models Seo (2007) has shown that the maximum likelihood estimator of the cointegrating vector has a mixture normal asymptotic distribution and, therefore, inference can be made by standard methods. This author also shows that the asymptotic distribution of the MLE estimator depends on the conditional heteroskedasticity and kurtosis exhibited by standarized errors and that the efficiency gains of this estimator relative to alternative estimators (that do not take into account explicitly the conditional heteroskedasticy feature of errors) increase as the magnitude of conditional heteroskedasticty increases. Thus, in this research we will estimate the previus model by maximum likelihood.

In the context of the import function we are considering, $h_{1t}$, $h_{2t}$ and $h_{3t}$ are the conditional variances of $m_t$ (imports), $y_t^d$ (real domestic income) and $p_t^m$ (relative import price) respectively. The model, thus, allow us to study in addition to the long run elasticities of the import functions the effects of the conditional variances, which can be regarded as measures of uncertainty. For this purpose we specify the following GARCH-in-mean model for the conditional mean process:

$$\Delta\mathbf{z}_t = \mathbf{\Gamma}_1\Delta\mathbf{z}_{t-1} + \ldots + \mathbf{\Gamma}_{t-p+1}\Delta\mathbf{z}_{t-p+1} + \mathbf{\Phi}\mathbf{h}_t + \boldsymbol{\alpha}\boldsymbol{\beta}^{\tau}\mathbf{z}_{t-1} + \mathbf{u}_t \qquad (3a)$$

Where $\mathbf{h}_t = \begin{bmatrix} h_{1t} & h_{2t} & h_{3t} \end{bmatrix}^{\tau}$ and $\mathbf{\Phi}$ is a 3 by 3 matrix of GARCH-in-mean coefficients. According to equation 3a, the short run dynamics of each variable can be affected by its own volatility as well as the volatility of the other two variables.

As we mentioned before, the full model will be estimated by maximum likelihood. However it is important to remark that the potentially huge numer of parameters to be estimated makes estimation a difficult task. For example the original VEC-GARCH model will have $3^2 p + 10$ coefficients while the VEC-GARCH-M model will have $3^2 p + 19$ parameters. For practical reasons in this version of the paper we carry out estimation as follows. First we estimate the first model and obtain (besides all parameter values) the estimated conditional variances. Then we estimate model (3a) as a multivariate system without GARCH effects. This is certainly not a full GARCH-in-mean system so the results from this stage should be considered as premliminary only.

The empirical strategy proceeds as follows. First, we examine the order of integration of the series by means of unit root tests. Second, we perform a cointegration analysis following the well-known Johansen approach. Finally, we estimate the vector error correction model with GARCH effects as discussed before and focus on the estimates of the long run elasticities as well as on the effects of volatility of the fundamental determinants of trade on the short run dynamics. We should mention that although we concentrate on short run effects we are considering a multivariate model which allows us to investigate the potential effects of the other determinants of trade besides exchange rates, opening a new avenue of research on trade flows and volatility.

## 4. EMPIRICAL RESULTS

### 4.1 Data

For this research we use monthly data for the period 1990.01 through 2008.02. We give next the variable names as well as the corresponding data sources.

(i) Value of total imports for Mexico in US dollars (Banxico)

(ii) US dollar value of total exports (Banxico)

(iii) Index of total volumen of industrial production in México (INEGI)

(iv) Index of total volumen of industrial production in the U.S. (*Federal Reserve*, *Board of Governors*)

(v) National consumer price index in México (Banxico)

(vi) Consumer price index in the U.S. (*Bureau of Labor Statistics*)

(vii) Export price index in U.S. dollars (Banxico)

(viii) Import price index in U.S. dollars (Banxico).

(ix) Nominal exchange rate in pesos per dollar (Banxico)

Using the previous series we construct measures for the variables that enter the import and export functions as follows. The variable $m$ (IMP) is the logarithm of the ratio of the dollar value of total Mexican imports (i) to the import price index (viii). $p^m$ (PIMP) is equal to the logarithm of the ratio of the product of the nominal exchange rate (ix) times the import price index (viii) to the Mexican consumer price index (v). $y^d$ (YMEX) is simply approximated by Mexican industrial production index (iii). Similarly $x$ (EXP) is measured as the logarithm of the ratio of the total dollar value of Mexican exports (ii) to the export price index (vii), while the relative price of exports $p^x$ (PEXP) is approximated as the logarithm of the ratio of the export price index (vii) to the U.S. consumer price index (vi). Finally the relevant foreign income level $y^f$ (YUSA) is approximated by the U.S. industrial production index (iv). It is important to mention that our study is made in the context of the bilateral trade relationship between Mexico and the U.S. only, as in the study by Garces (2002).

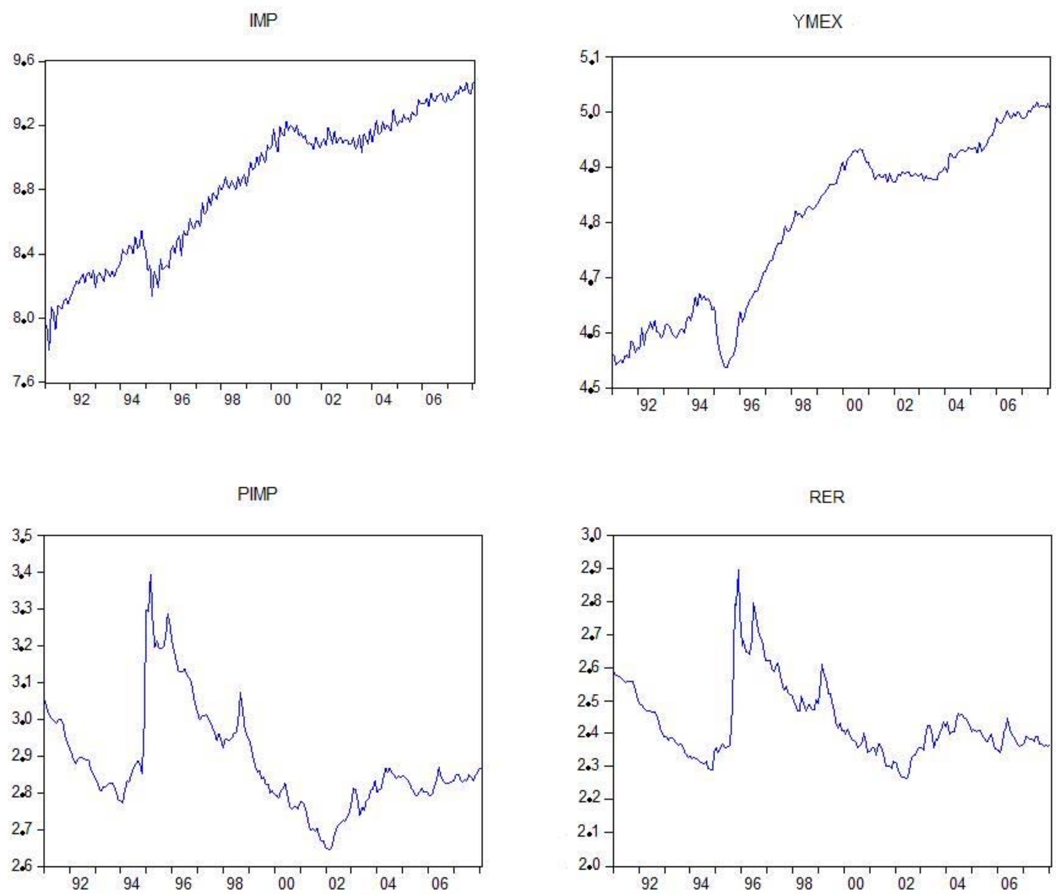
### 4.2 Unit root analysis

In this subsection we analize the time series behaviour of the variables previously defined. These are IMP (total real imports), PIMP (relative import price), YMEX (Mexican real income), EXP (total real exports), PEXP (relative export price) and YUSA (US real income). A graphical description of the series and the unit root testing analysis come next.

#### 4.2.1 Graphical inspection of the series

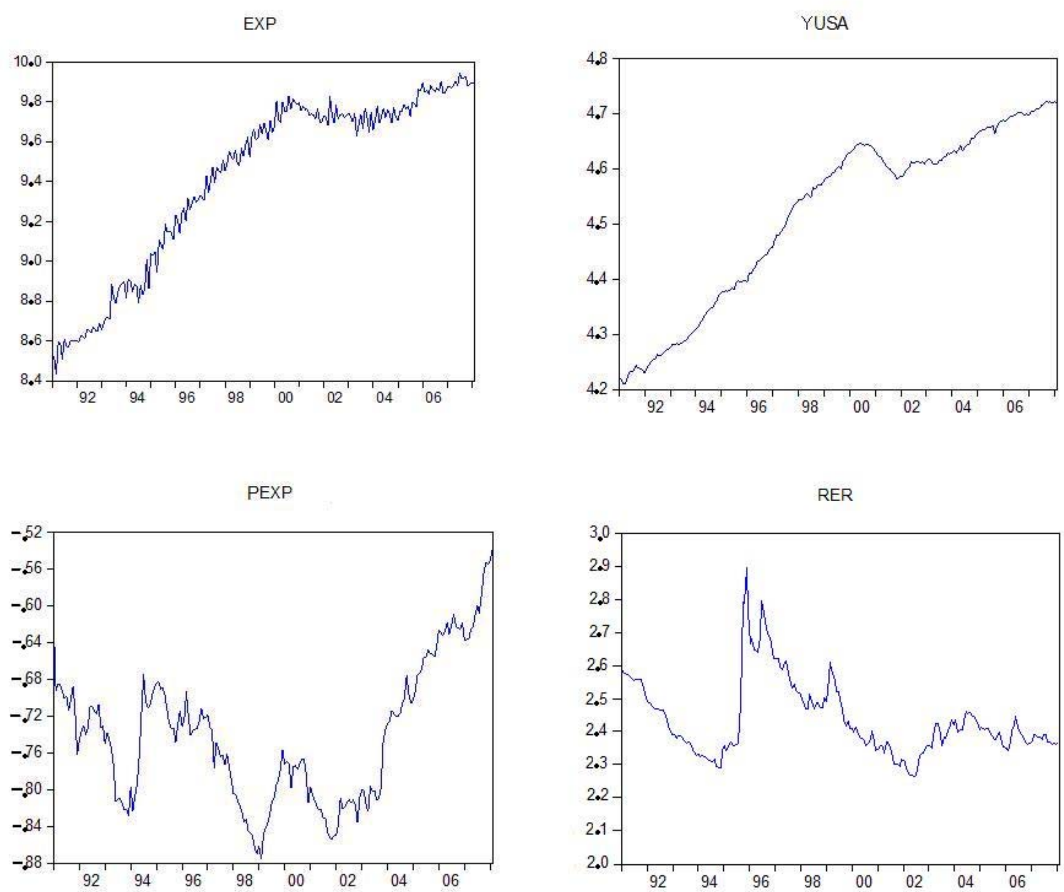
In charts 1 and 2 below we plot the series for the import and export functions respectively. For the case of imports, we observe that both imports (IMP) and domestic real income (YMEX) seem to have positive trends although they are abruptly interrupted following the so called tequila crisis. The apparent high correlation of these two series is a well recognized fact for the Mexican economy and is included explicitly in open economy macroeconomic models (Rivera-Bátiz y Rivera-Bátiz, 1985). From chart 1 it is also apparent a negative relationship between relative prices and total imports. Thus the behaviour of the previous series over time seems to be consistent with the predictions of the theory.

Chart 1. Time series of the import demand function in logarithms.
Period: 1991:01 2008:02.



In Chart 2 we observe that total real exports (EXP) have shown a positively trending behavious as well, although it also seems apparent that this behaviour has slowed down considerably during the last decade or so. Differently than in the case of imports, total exports were not drastically affected by the tequila crisis. It is also apparent that Mexico's export performance has been directly linked to the performance of the U.S. economy. Thus, the lower growth of exports experienced after year 2000 could be explained by the desceleration of the U.S. economy around that time.

Chart 2. Time series of the export demand function, in logarithms.
Period: 1991:01 2008:02.



The graphical evidence seems to indicate that indeed the U.S. real income (proxied here by its industrial production index, YUSA) wich is the biggest commercial partner of Mexico is highly correlated with total Mexican exports and this fact provides justification for studying the export flows of Mexico in the context of the U.S.-Mexico trade relationship only. As far as the link between exports and its relative price index (PEXP) no clear relationship seems to be apparent. While total exports exhibit a positive trend we do not observe a clear pattern for its relative price.

### 4.2.2 Unit root testing

In tables A1 and A2 in the Appendix section we report the unit root tests applied to the level (in logarithms) of the series. We consider the so called Augmented Dickey-Fuller (ADF), Dickey-Fuller-GLS (ADF-GLS) and Kwiatowsky-Phillips-Shin-Schmidt (KPSS) tests using a significance level of five percent. The inclusion of deterministic components (constant or constant and time trend) in the model was based on the sequential procedure given in Perron (1988). In contrast with the ADF and ADF-GLS tests the null hypothesis of the KPSS test is that the series is stationary. Thus we consider the last test in order to arrive to more robust conclusions. Given that the KPSS test cannot be implemented without deterministic components, in those cases where the deterministic components were discarded by Perron’s procedure the test was implemented including a constant in the model.

The general result is that all series have unit roots, which is in line with previous findings by Rose (1991), Reinhart (1995), Clarida (1994, 1996), Senhadji (1997), Senhadji and Montenegro (1998), Garcés (2002) and Narayan and Narayan (2004). In tables A3 and A4 we show the results of the same unit root tests applied to the first differences of the series to verify the possibility of multiple unit roots. As we expected, the ADF and ADF-GLS unit root tests applied on the first differences of the series reject the unit root hypothesis while the KPSS test accepts the stationarity hypothesis. Thus we can safely conclude that all series are integrated to order one.

### 4.3 Cointegration analysis with Johansen's approach

#### 4.3.1 Cointegration tests results

Table A5 in the appendix shows the results of the Johansen trace and maximum eigenvalue cointegration tests for the import and export demand functions. In all cases but one both the trace and maximum eigenvalue tests indicate the existence of one cointegration at the five percent level. The exception was one specification of the import demand function where the trace statistics indicates the existence of two cointegration vectors.

#### 4.3.2 Estimated long run elasticities

The estimates of the cointegrating vectors for the import and export demand function are reported in the second panel of tables A6 and A7 respectively in the appendix. For comparison, in the first panel of these tables we present the corresponding OLS estimates. For the case of the import function we find that only the OLS estimates for the period 1995-2008 show negative price elasticities. The long run income elasticity of imports is statistically significant and ranges between 2.35 and 2.80 (the OLS estimates are between 2.49 and 2.89). For the export demand function the estimates for the income elasticity are between 0.9 and 2.32 (the OLS estimates are much higher ranging between 1.86 and 2.81), in line with economic theory. However, the price elasticity of exports has a negative sign only for the period 1995-2008 and only the elasticity with respect to the real exchange rate is statistically significant (-0.4). The elasticity with respect to relative export price is also negative (-0.13) but not significant.[13] Regarding income elasticities for both the import and export demand functions it is interesting to note that in all specifications the estimates for the period 1995-2008 tend to be smaller compared to the period 1991-2008.

### 4.4 VEC-GARCH estimation results

#### 4.4.1 Long run elasticities

The long run eslasticities from the VEC-GARCH model, which was estimated by maximum likelihood, are shown in the last panel of tables A6 and A7. In all cases the income elasticities are in line with economic theory and they are similar to the ones obtained with Johansen's approach. In the case of imports these range between 1.54 and 2.9 while in the case of exports they are between 1.82 and 2.51. The estimates of the price elasticity of imports were found positive but none of them was statistically significant. For the case of exports, in all estimations but one we find negative estimates of price elasticities. It should be noticed that the estimates for the second specification for 1995-2005 are virtually the same as Johansen's estimates (compare the last row of the third and fourth panels in table A7).

#### 4.4.2 GARCH (1, 1) estimates

Table A8 in the appendix shows the GARCH (1, 1) estimates of the VEC-GARCH model. We generally find significant ARCH and or GARCH coefficients. In some cases, we find GARCH coefficients around the value of one indicating that the conditional variances could be characterized as highly persistent processes or even as integrated processes (IGARCH) although we have not explored this possibility. In general we observe that the GARCH processes appear to be less persistent for the period 1995-2008 than for the period

[13] Incorrectly signed price elasticities can be also found in the works by Senhadji and Montenegro (1998) and Reinhart (1995).

1991-2008 and this pattern might be due to the fact that the larger time span includes the highly volatile period experienced by the Mexican economy during the so called “tequila crisis”.

In some few cases we observe quite sharp differences between estimates for the two periods considered. For example for the case of the import function, the GARCH parameter for the real exchange rate equation (RER) is -0.90 for the period 1991-2008 and changes to 1.04 when considering the shorter period of 1995-2008. Also, in the case of the import function it is interesting to note that while in the longer period most processes appear to be more consistent with a GARCH (1, 1) model, in the shorter period they seem to be more in line with ARCH (1) processes. This is the case of imports (IMP), relative price of imports (PIMP) as well as Mexican income (YMEX), proxied by industrial production in this study. In the case of the real exchange rate (RER) we have found the abrupt change pointed out before.

When looking at the GARCH processes estimated in the context of the export function, we find that exports (EXP) and real exchange rates (RER) appear to be consistent with a GARCH (1, 1) representation in both periods, although they show less persistence during 1995-2008. On the other hand, while the US income (YUSA) seems to be consistent with an ARCH (1) process in all cases, all other processes appear to be consistent with a GARCH (1, 1) during the whole period (1991-2008) and with an ARCH (1) only for the shorter period (1995-2008). Although we have not made explicit tests, the previous results point to possible structural change or perhaps they are reflecting some specification problems. In any case, more empirical investigation is necessary in this direction.

### 4.4.3 Volatility effects

In tables A9 and A10 we show the volatility effects for the cases of the import and export functions respectively. As outlined before in the empirical strategy, the unobserved conditional heteroskedasticity was estimated using the VEC-GARCH estimation results and then we re-estimated the VEC models as a 3 equation system including the measures of conditional volatility previously mentioned. This not the ideal approach but allows us to overcome the difficulties of estimating a full trivariate VEC-GARCH-M system. Thus, the results here should be taken as preliminary. For practical reasons, we will concentrate mainly on the results on the import and export equations only.

In the case of imports we find two significant short run effects. The first one is that, in the corresponding specifications, the volatility of relative price of imports and the real exchange rate have a negative effect on import growth (see the corresponding entries in the fisrt column, first and third panels of table A9). The second effect is that the volatility of both, relative prices and real exchange rates are negatively related to Mexican output growth. This last result has been documented by Grier and Hernandez (2004) in a study on real exchange rates and output growth in Mexico. Thus the previous results indicate that volatility of relative price of imports or exchange rates have a negative effect on import growth both directly and indirectly by affecting negatively GDP growth which in turn will affect negatively imports. This effect might be important given that the income elasticity of imports is positive, sizeable and strongly significant. Certainly, the indirect effect previously mentioned is only possible in a multivariate framework such as the one used here. However, it is important to remark that the previous results only show for the 1991-2008 period and further research is necessary to verify their robustness.

In the case of the export function we can see in table A10 that only two volatility effects are significant. The first one indicates that the more volatile has been export growth the higher the export growth rates although this result only shows for the 1991-2008 period. The second significant effect is picked up for the period 1995-2005 and in this case we find that the more volatile has become GDP in the US economy the lower the mean growth rate of Mexican exports.[14] Although not conclussive, this study finds that, in the long run, the trade flows between Mexico and the U.S. seem to be directly linked to the corresponding levels of economic activity (measured by industrial output) and possibly to the corresponding relative prices or real exchanges rates, as it seems to be in the case of exports. At the same time, we have found some non-negligible effects of volatility of fundamentals on the short run dynamics of imports and exports.

## 5. CONCLUSIONS

In this paper we have studied the import and export demand functions of the Mexican economy using, in each case, a vector error correction model with conditional heteroskedasticity (VEC-GARCH). We have obtained long run income elasticities consistent with the predictions from the imperfect substitute goods model although the results for relative price or exchange rate elasticities are not clear cut. Clearly, the income effects appear to be the main determinants of trade flows as we find sizable, positive and statistically significant income elasticities for both the import and export functions. We have also obtained significant GARCH effects in all cases and some results indicate that volatility affects non- negligibly the short run dynamics, that is volatility of fundamentals

[14] It is worth noting that this result is in line with the finding of Grier and Smallwood (2007) for the case of Mexico, although our approach is not directly comparable to theirs.

seems to affect the average growth of imports and exports. It remains to show how robust are the results to alternative specifications and or time periods as well as alternative measures of volatility and the possible long run effects of volatility.

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## Appendix

Table A1. Unit root tests for the import function series

| | IMP | YMEX | PIMP | RER |
|---|---|---|---|---|
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -2.42 | -1.89 | -2.62 | -2.84 |
| p-value[a] | (0.37) | (0.66) | (0.27) | (0.18) |
| Number of lags | 14 | 14 | 14 | 14 |
| Deterministic components | c, t | c, t | c, t | c,t |
| | | | | |
| Test of joint hypothesis of unit root and no trend | | | | |
| F-Statistic | 4.46 | 1.93 | 6.84 | 4.04 |
| Critical value (5%)[b] | [6.410] | [6.410] | [6.410] | [6.410] |
| | | | | |
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -1.55 | -1.01 | n.a. | -2.61 |
| p-value[a] | (0.51) | (0.75) | n.a. | (0.09) |
| Number of lags | 0 | 0 | n.a. | 14 |
| Deterministic components | C | c | n.a. | C |
| | | | | |
| Test of joint hypothesis of unit root and no constant | | | | |
| F-Statistic | 2.68 | 4.95 | n.a. | 3.45 |
| Critical value (5%)[b] | [4.675] | [4.675] | n.a | [4.675] |
| | | | | |
| Augmented Dickey-Fuller | | | | |
| t-Statistic | 2.91 | n.a. | n.a. | -0.43 |
| p-value[a] | (0.999) | n.a. | n.a. | (0.526) |
| Number of lags | 13 | n.a. | n.a. | 0 |
| Deterministic components | none | n.a. | n.a. | None |
| | | | | |
| DF-GLS | | | | |
| Statistic | 1.439 | 1.09 | -2.32 | -1.47 |
| Critical-value (5%)[a] | [-1.942) | [-1.942] | [-2.929] | [-1.942] |
| Deterministic components | C | c | c,t | C |
| | | | | |
| KWPSS | | | | |
| Statistic | 1.751*** | 1.698*** | 0.138* | 0.337 |
| Critical value (5%)[c] | [0.463] | [0.463] | [0.146] | [0.463] |
| Deterministic components | C | c | c,t | C |

[a] MacKinnon (1996) p-values.
[b] Critical values are extrapolated from Perron (1988, table b7).
[c] Asymptotic critical values from Kwiatkowski-Phillips-Schmidt-Shin (1992, table 2).
The number of lags for the ADF and DF-GLS tests is based on the modified AIC. The KWPSS test use a Newey-West window lag. The joint tests for unit root and deterministic components follow the sequential procedure by Perron (1988). The null hipótesis of the KWPSS test is that the series is stationary.
*, ** and *** denote significance levels at the 10%, 5% and 1% respectively.

Table A2. Unit root tests for the export function series

| | EXP | YUSA | PEXP | RER |
|---|---|---|---|---|
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -0.50 | -1.34 | -0.76 | -2.84 |
| p-value[a] | (0.98) | (0.88) | (0.97) | (0.18) |
| Number of lags | 14 | 14 | 14 | 14 |
| Deterministic components | c, t | c, t | c, t | c,t |
| | | | | |
| Test of joint hypothesis of unit root and no trend | | | | |
| F-Statistic | 4.25 | 3.05 | 2.01 | 4.04 |
| Critical value (5%)[b] | [6.410] | [6.410] | [6.410] | [6.410] |
| | | | | |
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -2.03 | -2.16 | -0.50 | -2.61 |
| p-value[a] | (0.28) | (0.22) | (0.89) | (0.09) |
| Number of lags | 0 | 0 | 14 | 14 |
| Deterministic components | C | c | c | C |
| | | | | |
| Test of joint hypothesis of unit root and no constant | | | | |
| F-Statistic | 3.65 | 27.95 | 0.38 | 3.45 |
| Critical value (5%)[b] | [4.675] | [4.675] | [4.675] | [4.675] |
| | | | | |
| Augmented Dickey-Fuller | | | | |
| t-Statistic | 2.27 | n.a. | -0.14 | -0.43 |
| p-value[a] | (0.995) | n.a. | (0.64) | (0.526) |
| Number of lags | 13 | n.a. | 0 | 0 |
| Deterministic components | none | n.a. | none | None |
| | | | | |
| DF-GLS | | | | |
| Statistic | 0.72 | 0.49 | -0.65 | -1.47 |
| Critical-value (5%)[a] | [-1.942) | [-1.942] | [-2.929] | [-1.942] |
| Deterministic components | C | c | c | C |
| | | | | |
| KWPSS | | | | |
| Statistic | 1.638*** | 1.689*** | 0.462* | 0.337 |
| Critical value (5%)[c] | [0.463] | [0.463] | [0.463] | [0.463] |
| Deterministic components | C | c | c | C |

[a] MacKinnon (1996) p-values.
[b] Critical values are extrapolated from Perron (1988, table b7).
[c] aAsymptotic critical values from Kwiatkowski-Phillips-Schmidt-Shin (1992, table 2).
The number of lags for the ADF and DF-GLS tests is based on the modified AIC. The KWPSS test use a Newey-West window lag. The joint tests for unit root and deterministic components follow the sequential procedure by Perron (1988). The null hipótesis of the KWPSS test is that the series is stationary.
*, ** and *** denote significance levels at the 10%, 5% and 1% respectively.

Table A3. Unit root tests for the import function series (first differences)

| | IMP | YMEX | PIMP | RER |
|---|---|---|---|---|
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -24.35*** | -14.72*** | -3.68*** | -11.58*** |
| p-value[a] | (0.00) | (0.00) | (0.01) | (0.00) |
| Number of lags | 0 | 0 | 14 | 0 |
| Deterministic components | none | none | c | None |
| | | | | |
| DF-GLS | | | | |
| Statistic | -15.24*** | -13.87*** | -10.20*** | -10.51*** |
| Critical-value (5%)[a] | [-1.942) | [-1.942] | [-1.942] | [-1.942] |
| Deterministic components | C | c | c | C |
| | | | | |
| KWPSS | | | | |
| Statistic | 0.50** | 0.078 | 0.088 | 0.054 |
| Critical value (5%)[b] | [0.463] | [0.463] | [0.146] | [0.463] |
| Deterministic components | C | c | c | C |

[a] MacKinnon (1996) p-values.
[b] Asymptotic critical values from Kwiatkowski-Phillips-Schmidt-Shin (1992, table 2).
The number of lags for the ADF tests was based on the modified AIC. The KWPSS tests use a Newey-West window lag. The null hipótesis of the KWPSS test is that the series is stationary.
*, ** and *** denote significance levels at the 10%, 5% and 1% respectively.

Table A4. Unit root tests for the export function series (first differences)

| | EXP | YUSA | PEXP | RER |
|---|---|---|---|---|
| Augmented Dickey-Fuller | | | | |
| t-Statistic | -25.50*** | -11.14*** | -12.41*** | -11.58*** |
| p-value[a] | (0.00) | (0.00) | (0.00) | (0.00) |
| Number of lags | 0 | 0 | 0 | 0 |
| Deterministic components | none | none | none | None |
| | | | | |
| DF-GLS | | | | |
| Statistic | -24.71*** | -4.96*** | -8.72*** | -10.51*** |
| Critical-value (5%)[a] | [-1.942] | [-1.942] | [-2.929] | [-1.942] |
| Deterministic components | C | c | c | C |
| | | | | |
| KWPSS | | | | |
| Statistic | 0.392* | 0.403* | 0.619** | 0.054 |
| Critical value (5%)[b] | [0.463] | [0.463] | [0.463] | [0.463] |
| Deterministic components | C | c | c | C |

[a] MacKinnon (1996) p-values.
[b] aAsymptotic critical values from Kwiatkowski-Phillips-Schmidt-Shin (1992, table 2).
The number of lags for the ADF tests was based on the modified AIC. The KPSS test uses a Newey-West window lag. The null hipótesis of the KWPSS test is that the series is stationary.
*, ** and *** denote significance levels at the 10%, 5% and 1% respectively.

Tabla A5. Johansen Cointegration tests for the import and export demand functions

| No of CE(s) | Eigenvalue | Trace stat (p-val) | Max-Eig stat (p-val) |
|---|---|---|---|
| IMPORT FUNCTION: $IMP = const + \beta_1 YMEX + \beta_2 PIMP$ | | | |
| None | 0.120847 | **46.10 (0.0023)** | **26.53 (0.0121)** |
| At most 1 | 0.058308 | 19.56 (0.0623) | 12.38 (0.1652) |
| At most 2 | 0.034263 | 7.18 (0.1171) | 7.18 (0.1171) |
| IMPORT FUNCTION: $IMP = const + \beta_1 YMEX + \beta_2 RER$ | | | |
| None | 0.120522 | **48.80 (0.0010)** | **26.46 (0.0124)** |
| At most 1 | 0.067228 | **22.35 (0.0255)** | 14.34 (0.0864) |
| At most 2 | 0.038141 | 8.01 (0.0823) | 8.01 (0.0824) |
| EXPORT FUNCTION: $EXP = const + \beta_1 YUSA + \beta_2 PEXP$ | | | |
| None | 0.175068 | **54.27 (0.0002)** | **39.65 (0.001)** |
| At most 1 | 0.045602 | 14.62 (0.2489) | 9.62 (0.3707) |
| At most 2 | 0.024009 | 5.01 (0.2827) | 5.01 (0.2827) |
| EXPORT FUNCTION: $EXP = const + \beta_1 YUSA + \beta_2 RER$ | | | |
| None | 0.231976 | **71.02 (0.0000)** | **54.37 (0.0000)** |
| At most 1 | 0.048653 | 16.65 (0.1462) | 10.27 (0.3100) |
| At most 2 | 0.030463 | 6.37 (0.1638) | 6.37 (0.1638) |

Both the import and export functions include a constant term in the cointegration relationship. In all cases 2 lagged differences where included which was determined based on the Schwarz Criterion in a preliminary VAR model. Numbers in bold indicate that the correspondent statistic is significant. In all cases but one the tests indicate one cointegration relationship at the 5% significance level.

Table A6. Long run elasticities for the import demand function

| PERIOD | YMEX | PIMP | RER |
|---|---|---|---|
| | Engle-Granger approach (OLS) | | |
| 1991.01 2008.02 | 2.89 (76.83) | 0.08 (1.89) | n.a. |
| 1995.06 2008.02 | 2.52 (41.01) | -0.12 (-2.31) | n.a |
| 1991.01 2008.02 | 2.88 (88.30) | n.a. | 0.13 (2.90) |
| 1995.06 2008.02 | 2.49 (38.58) | n.a. | -0.18 (-2.61) |
| | Johansen approach (reduced rank regression) | | |
| 1991.01 2008.02 | 2.80 (17.33) | 0.24 (1.37) | n.a. |
| 1995.06 2008.02 | 2.28 (7.14) | 0.52 (1.98) | n.a. |
| 1991.01 2008.02 | 2.77 (21.79) | n.a. | 0.27 (1.54) |
| 1995.06 2008.02 | 2.35 (5.98) | n.a. | 0.91 (2.13) |
| | VEC-GARCH model (MLE) | | |
| 1991.01 2008.02 [a] | 2.84 (23.45) | 0.02 (0.20) | n.a. |
| 1995.06 2008.02 | 2.19 (2.88) | 0.30 (0.43) | n.a. |
| 1991.04 2008.02 [a] | 2.90 (25.69) | n.a. | 0.03 (0.19) |
| 1995.06 2008.02 | 1.54 (4.21) | n.a. | 0.78 (0.57) |

[a] In this case the variance process was specified as a diagonal BEKK model, otherwise we followed the diagonal CCC specification

Table A7. Long run elasticities for the export demand function

| PERIOD | YUSA | PEXP | RER |
|---|---|---|---|
| | Engle-Granger approach (OLS) | | |
| 1991.01 2008.02 | 2.81 (114.6) | -0.51 (-9.83) | n.a. |
| 1995.06 2008.02 | 2.45 (53.49) | -0.32 (-6.32) | n.a. |
| 1991.01 2008.02 | 2.79 (92.88) | n.a. | 0.08 (1.98) |
| 1995.06 2008.02 | 1.86 (30.30) | n.a. | -0.50 (-9.68) |
| | Johansen approach (reduced rank regression) | | |
| 1991.01 2008.02 | 0.90 (1.82) | 0.61 (0.62) | n.a. |
| 1995.06 2008.02 | 1.93 (17.37) | -0.13 (1.08) | n.a. |
| 1991.01 2008.02 | 2.32 (12.5) | n.a. | 1.07 (3.99) |
| 1995.06 2008.02 | 1.76 (19.43) | n.a. | -0.41 (5.23) |
| | VEC-GARCH model (MLE) | | |
| 1991.01 2008.02 | 2.51 (12.78) | -0.29 (-1.01) | n.a. |
| 1995.06 2008.02 | 2.15 (20.68) | -0.16 (-1.47) | n.a. |
| 1991.01 2008.02 | 2.50 (288.3) | n.a. | 0.58 (1.97) |
| 1995.06 2008.02 | 1.82 (25.80) | n.a. | -0.40 (-6.87) |

The conditional variance in the VEC-GARCH model was specified as a diagonal CCC in all cases.

Table A8. GARCH (1, 1) estimates of import and export functions

| | IMPORT FUNCTION | | | | | |
|---|---|---|---|---|---|---|
| COEFF | IMP | YMEX | PIMP | IMP | YMEX | RER |
| | VEC-GARCH [a] (1991.01-2008.02) | | | VEC-GARCH [a] (1991.04-2008.02) | | |
| CONST | 4E-05*** | 4E-05*** | 4E-05*** | 1.8E-05** | 1.8E-05** | 1.8E-05** |
| ARCH | -0.08 | 0.07 | 0.99*** | 0.20*** | -0.20*** | 0.49*** |
| GARCH | 0.98*** | 0.79*** | -0.54*** | 0.97*** | 0.89*** | -0.90*** |
| | VEC-GARCH (1995.07-2008.02) | | | VEC-GARCH (1995.06-2008.2) | | |
| CONST | 1.3E-03 | 4E-05*** | 2E-04*** | 1.5E-03 | 4E-05*** | 3.6E-04 |
| ARCH | -0.11* | 0.51*** | 0.53*** | -0.11** | 0.51*** | -0.06 |
| GARCH | 0.13 | 0.03 | -0.16 | -0.04 | 0.03 | 1.04*** |

| | EXPORT FUNCTION | | | | | |
|---|---|---|---|---|---|---|
| COEFF | EXP | YUSA | PEXP | EXP | YUSA | RER |
| | VEC-GARCH (1991.04-2008.02) | | | VEC-GARCH (1991.01-2008.02) | | |
| CONST | -6.4E-06 | 2E-05** | 2E-04*** | -5E-06 | 1.6E-05* | 6.2E-05** |
| ARCH | -0.006 | 0.24** | 0.44*** | -0.02 | 0.24* | 0.27*** |
| GARCH | 1.01*** | 0.04 | -0.14** | 1.02*** | 0.02 | 0.68*** |
| | VEC-GARCH (1995.06-2008.02) | | | VEC-GARCH (1995.06-2008.02) | | |
| CONST | 1.4E-04 | 2E-05*** | 2E-04*** | -2.4E-05 | 2E-05*** | 4E-04*** |
| ARCH | -0.07 | 0.34* | 0.23 | 0.15*** | 0.38** | 0.39*** |
| GARCH | 0.93*** | -0.14 | -0.30 | 0.88*** | -0.18 | -0.36* |

[a] In this case we used the diagonal BEKK model for the conditional variance, otherwise we used diagonal CCC model.

Table A9. Volatility effects in the case of imports

| CONDITIONAL VARIANCE OF | VOLATILITY EFFECTS ON $\Delta IMP$ | $\Delta YMEX$ | $\Delta PIMP$ | $\Delta RER$ |
|---|---|---|---|---|
| | | 1991.01-2008.02 (sur) | | |
| $\Delta IMP$ | 0.34 (0.26) | -0.10 (0.59) | -0.19 (0.48) | n.a |
| $\Delta YMEX$ | 1.14 (0.53) | 1.73 (0.23) | 1.58 (0.35) | n.a. |
| $\Delta PIMP$ | -0.28 (0.02)** | -0.17 (0.00)*** | -0.07 (0.46) | n.a. |
| | | 1995.07-2008.02 (ols) | | |
| $\Delta IMP$ | -0.56 (0.22) | -0.76 (0.09)* | -0.22 (0.62) | n.a |
| $\Delta YMEX$ | -0.66 (0.37) | 0.06 (0.93) | -0.66 (0.37) | n.a. |
| $\Delta PIMP$ | 0.32 (0.31) | -0.11 (0.73) | -1.16 (0.00)*** | n.a. |
| | | 1991.04-2008.2 | | |
| $\Delta IMP$ | 0.49 (0.08)* | 0.05 (0.71) | n.a | -0.08 (0.87) |
| $\Delta YMEX$ | -1.54 (0.50) | -0.98 (0.56) | n.a. | -0.37 (0.89) |
| $\Delta RER$ | -0.42 (0.02)** | -0.32 (0.00)*** | n.a. | -0.44 (0.01)** |
| | | 1995.06-2008.02 | | |
| $\Delta IMP$ | -0.35 (0.34) | -0.33 (0.11) | n.a | -0.28 (0.30) |
| $\Delta YMEX$ | -0.38 (0.72) | -0.27 (0.29) | n.a. | -1.25 (0.05)** |
| $\Delta RER$ | 0.56 (0.31) | -0.001 (0.996) | n.a. | 0.07 (0.87) |

Table A10. Volatility effects in the case of exports

| CONDITIONAL VARIANCE OF | VOLATILITY EFFECTS ON Δ*EXP* | Δ*YUSA* | Δ*PEXP* | Δ*RER* |
|---|---|---|---|---|
| | | 1991.01-2008.02 | | |
| Δ*EXP* | 4.28 (0.00)*** | n.a. | -1.91 (0.03)** | n.a. |
| Δ*YUSA* | -0.39 (0.84) | 0.52 (0.80) | 1.06 (0.52) | n.a. |
| Δ*PEXP* | -0.26 (0.44) | n.a. | 0.13 (0.69) | n.a. |
| | | 1995.06-2008.02 | | |
| Δ*EXP* | -0.08 (0.87) | n.a. | -0.14 (0.65) | n.a. |
| Δ*YUSA* | -2.44 (0.10)* | 0.42 (0.77) | 0.68 (0.62) | n.a. |
| Δ*PEXP* | 0.43 (0.55) | n.a. | 0.41 (0.50) | n.a. |
| | | 1991.01-2008.2 | | |
| Δ*EXP* | 0.49 (0.72) | n.a. | n.a | -0.22 (0.49) |
| Δ*YUSA* | -0.42 (0.87) | 0.15 | n.a. | 1.91 (0.32) |
| Δ*RER* | 0.06 (0.70) | n.a. | n.a. | -0.20 (0.08)* |
| | | 1995.06-2008.02 | | |
| Δ*EXP* | 0.48 (0.14) | n.a | n.a | -0.10 (0.67) |
| Δ*YUSA* | -2.37 (0.11) | 0.32 (0.82) | n.a. | 2.81 (0.02)** |
| Δ*RER* | -0.38 (0.27) | n.a. | n.a. | -0.64 (0.02)** |