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Ronald Miranda (*)
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Resumen

Las exportaciones de los países exportadores de materias primas dependen de la demanda mundial y de los precios de estos bienes, pero la creciente volatilidad del tipo de cambio real (TCR) ha llevado a incluir en los modelos el impacto que la volatilidad del TCR pueda tener sobre estas exportaciones. Así, aquí se estudia el comportamiento de la volatilidad del TCR, modelizándola a través de modelos GARCH, para un conjunto de países exportadores de materias primas: Brasil, Chile, Nueva Zelanda y Uruguay en el período 1990-2013. Luego se estudia para cada país el posible impacto de la volatilidad del TCR en las exportaciones de cada país utilizando la metodología de Johansen y el análisis de las funciones de impulso-respuesta, incluyendo también variables representativas de la demanda mundial y de los precios internacionales de los principales productos de exportación de cada país. Los resultados sugieren que las exportaciones dependen de forma positiva de la demanda mundial y de los precios internacionales, sin embargo no resulta significativa la volatilidad condicional del tipo de cambio real para el conjunto de países seleccionados, con la excepción de Uruguay, en el que tiene efectos negativos tanto en el corto como en el largo plazo.

Palabras clave: Exportaciones, tipo de cambio real, GARCH, cointegración

Código JEL: C55, F31, F41

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Abstract

Raw materials exports depend on global demand and prices, but the increasing volatility of real exchange rates (RER) introduces an additional factor which impact varies according to the situation and the country. Thus, this paper studies the RER volatility dynamics, estimated through GARCH and IGARCH models for Brazil, Chile, New Zealand and Uruguay during the period 1990-2013. Then, for each country, we study the potential impact of exchange rate volatility on total exports using Johansen's methodology and the analysis through impulse response functions, including proxies for global demand and international prices. The results suggest that exports depend positively on global demand and international prices; however conditional RER volatility resulted not significant for the group of selected countries, with the exception of Uruguay, where RER volatility affects negatively exports, in the short and long term.

Palabras clave: Exports, real exchange rate, GARCH, cointegration.

Código JEL: C55, F31, F41

1. Introduction

Raw materials exports depend on global demand and prices, but the increasing volatility of real exchange rates (RER) introduces an influence which impact varies according to the situation and the country.

In line with the theory evidence, exchange rates volatility is a source of risk and has consequences on the volume of international trade, and therefore the balance of payments. The relationship between greater volatility of exchange rates and international trade has been widely analyzed by multiple studies since the 70s (see e.g. Ozturk, I., 2006 for a literature review, and Hooper, P. and Kohlhausen, S., 1978).

The main argument is as follows: greater exchange rate volatility leads to higher costs for risk-averse traders which implies less foreign trade. This is because the exchange rate is agreed at the time of the commercial contract, but payment is not made until delivery actually takes place. If changes in exchange rates become unpredictable, this creates uncertainty about the benefits and, therefore, reduces international benefits from trade. Even if hedging in the forward markets was possible, there are limitations and costs. On the other hand, other theoretical developments suggest that there are situations where you could expect volatility in the exchange rate has both negative and positive effects on trade volumes. De Grauwe, P. (1988) emphasized that if the impact of income effect is greater than substitution effect, this may lead to a positive relationship between trade and exchange rate volatility, which depends on the degree of exporters risk aversion. This is because, if exporters are enough risk takers, increased exchange rate volatility raises expected marginal utility of increased export earnings and thus induces them to increase exports.

Therefore, this paper seeks to estimate the impact of exchange rate volatility on exports for a set of countries: Uruguay, Brazil, Chile and New Zealand, selected as commodity exporting countries. The reporting period is from January 1990 to December 2013. So, this article studies the behavior of the exchange rate volatility, and following the literature (trying to overcome RER heteroscedasticity), estimated by a GARCH model (generalized autoregressive conditional heteroskedasticity model), according to Bollerslev, T. (1986), or IGARCH (integrated GARCH), depending on the case. Then we study for each country the possible impact of estimated RER volatility on each country's exports, using Johansen, S. (1988, 1992) methodology.

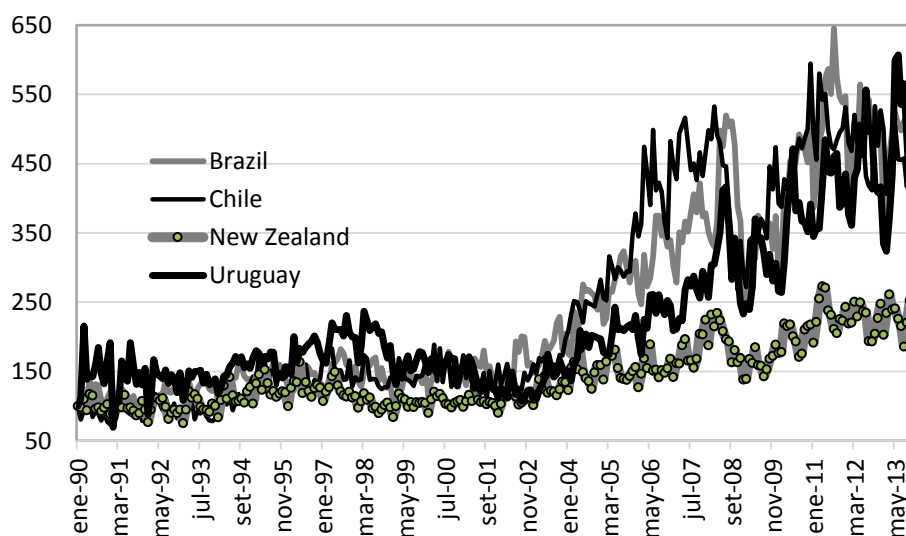
Thus, the article includes Chapter 2 an exports characterization for the different countries considered. In Chapter 3 we include a survey of the main background on the issue, in Chapter 4 we discuss the methodology, in Chapter 5 we define data sources, in Chapter 6 we report the main results and finally, in Chapter 7, we include some conclusions.

2. Exports characterization

- **Evolution**

Figure one shows Brazil, Chile, New Zealand and Uruguay total exports, throughout the period 1990-2013. Analyzed by sub-periods, until early 2000 exports are stagnated and in the case of Uruguay and New Zealand they fall since the late 90's. Since 2003, exports grow, although all recorded a fall in 2008-2009 because of the international crisis.

**Figure 1: Exports in constant dollars 1990-2013
(Jan-90=100)**

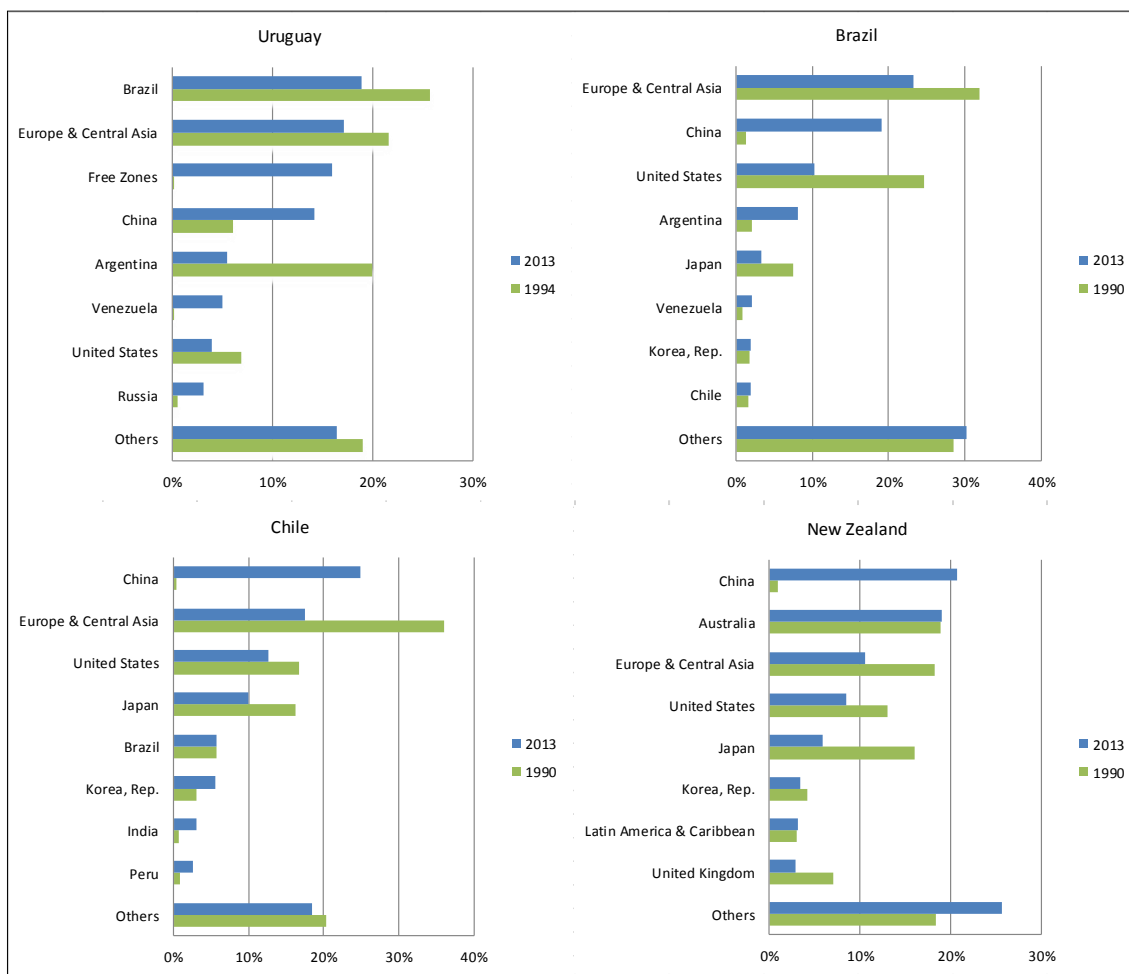


Source: CEI and BLS

- **Exports destinations**

In Figure 2, we can see the main export destinations selected by countries. It compares the year 2013 to 1990.¹

¹ World Bank data for Uruguay is from 1994.

Figure 2: Exports Destinations by countries

Source: Own calculations based on World Bank

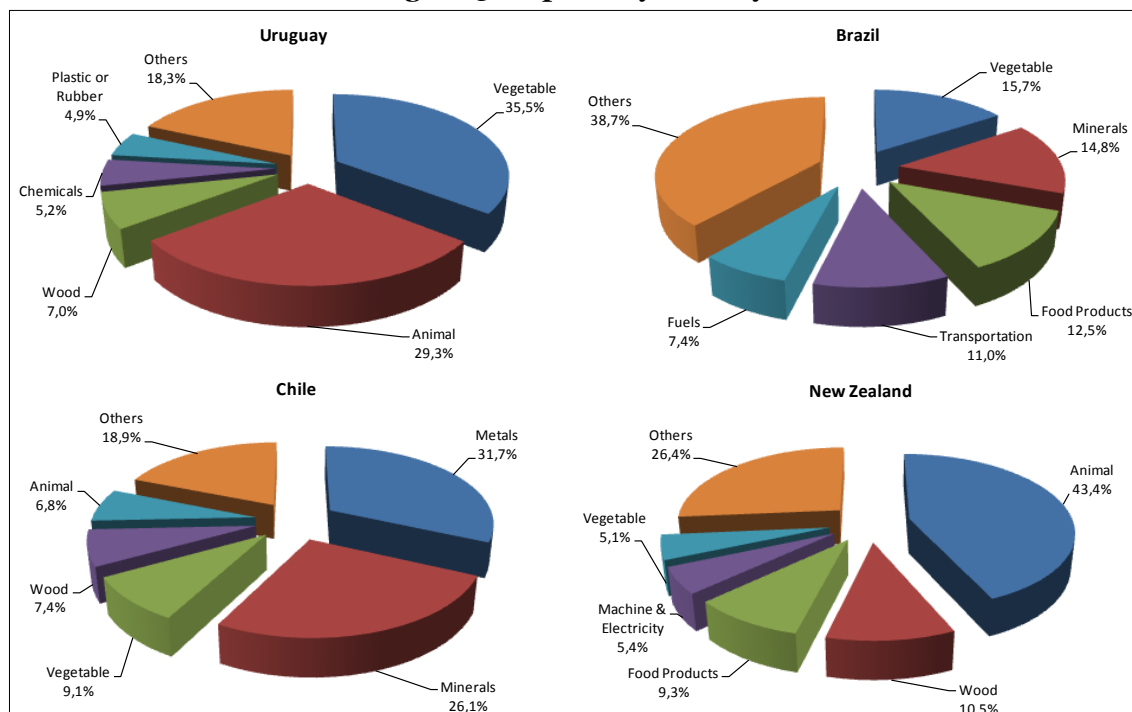
One of the most relevant features of selected countries is the large share of exports to China at the end of the period, when at the beginning sales were virtually nonexistent to this country. On the other hand, we can see a decline in the share of exports to Europe and the United States during the period. In the case of Uruguay, in addition to the high participation of China in exports, it highlighted the loss of share of sales to the region (Argentina and Brazil). Also the importance acquired by the Free Zones, which hardly contained in the 1990, and in 2013 passed to be placed in the third position as a destination of Uruguayan exports, products that are then re-exported to China, Brazil and Argentina, sorted according to their share in the total.

• Exports composition

According to the classification used by the World Bank as the main area of origin of products exported in 2013, in the case of Uruguay they are mainly concentrated in the category of vegetable oils (soybeans and cereals) and animal (beef and dairy), representing about 65% of total exports. Meanwhile, Brazil has a more diversified distribution as vegetable exports represented 15.7% (soybeans, corn and sugar), minerals (iron) contributes 14.8%, food products 12.5% transport (cars and boats) 11.0% and fuels (oil) 7.4%, representing approximately 62% of total exports. Chile's main exports are metals (31.7%) and minerals (26.1%), particularly copper and its by-

products, reflecting the importance of the mining sector exports, representing more than 50%. Finally, for New Zealand the most significant share in exports is animals (43.4%), mainly frozen meat and dairy products. Below we present in Figure 3 the composition of exports by country.

Figure 3: Exports by country



Source: Own calculations based on World Bank (for more detail see Annex A)

3. Background

With the adoption of floating exchange rate regimes since 1973, it has increased concerns about the study associated with exchange rate volatility both nominal and real influence international trade. The theoretical and empirical literature is inconclusive regarding the effects of such an impact. The evidence shows positive results, negative, neutral, a combination of the previous three and not significant (Ozturk, I., 2006; Coric, B. and Pugh, G., 2010). This can be consequence of methodological differences in terms of the number of countries considered, the specification of the exchange rate volatility used or the sample periods (Ozturk, I., 2006).

Hooper, P. and Kohlhagen, S. (1978) developed one of the first works that explores the relationship between nominal exchange rate volatility (measured by standard deviation) and trade. The study is for developed countries and covers the period from the mid-sixties to the mid-seventies. The results shed no significant evidence of the sign of the impact. From this work Cushman, D. (1983) advances in a similar line, but analyzing real exchange rate volatility on trade. He finds that an unexpected movement in the RER has a significant and negative effect on trade. Akhtar, M. and Hilton, R. (1984) also found a negative correlation, but unlike previous studies, they use as a measure of volatility the standard deviation of effective exchange rate. The study was

conducted for bilateral trade between the United States and Germany in the period 1974-1981.² Similar results obtained Chowdhury, A. (1993) who finds a negative impact of exchange rate volatility on the volume of exports to the G-7 countries for the 1973-1990 period.³ They build a volatility temporary variable through a moving average of standard deviation of real exchange rate growth rate.

For Asian countries, the evidence of exchange rate volatility impact on exports points to the predominance of adverse effects [Baak, S., et al. (2003), Chit, M., et al. (2010), Masron, T. and Mohd, A. (2009), Ramli, N. and Podivinsky, J. (2011) and Cheung, Y. W. and Sengupta, R. (2012)]. Cheung, Y. W. and Sengupta, R. (2012) studied the effect of RER and RER volatility in export shares of nonfinancial Indian companies for the period 2000-2010. The empirical analysis shows that there has been a significant negative impact of exchange rate volatility in exports of Indian companies. Moreover, Baak, S., et al. (2003) find negative impact of exchange rate volatility (measured by the standard deviation of RER) in exports to four East Asian countries (Hong Kong, South Korea, Singapore and Thailand) and its bilateral trade with Japan and the United States for the period 1990-2001. Similarly Ramli, N. and Podivinsky, J. (2011) conducted a study, but unlike the previous they consider first five countries of the Association of South East Asian Nations (ASEAN) (Malaysia, Singapore, Philippines, Indonesia and Thailand), and its bilateral trade with the United States for the period 1990-2010; secondly they consider the RER volatility estimated through a GARCH (1,1) process. The result they obtain is that the volatility of the bilateral real exchange rate has a significant impact on exports, mainly negative (except for Indonesia that is positive).

Chit, M., et al. (2010) unlike previous studies found a greater number of countries, taking into account bilateral trade in some East Asian countries together (China, Indonesia, Malaysia, Philippines and Thailand), as well as thirteen industrial countries. For this he uses a panel with information for the period 1982-2006, specifying three measures of volatility. They get that regardless of the proxy used as exchange rate volatility, the impact generates a negative effect on exports from emerging countries of East Asia or East Asia. Meanwhile, Masron, T. and Mohd, A. (2009) note that the exchange rate volatility (GARCH (1,1)) has a negative effect on the demand for exports from Malaysia and Turkey for the period 1970- 2004.

However, when studies incorporate a variable reflecting regional economic integration (ASEAN Malaysia, and Turkey with the European Union), the negative impact becomes insignificant in Turkey. Moreover, Zakaria, Z. (2013) points out that the effect is ambiguous for Malaysia, and this is explained on the basis that the exchange rate volatility has a negative effect on bilateral trade with the US, while , with Japan it is positive. Malaysia's exports to the UK and Singapore show no evidence of any connection with exchange rate volatility. The period considered was 2002-2012, and exchange rate volatility is modeled through a GARCH (1,1).^{4 5}

² The effective exchange rate is defined as the exchange rate of a country against other currencies weighted by their importance in the country's trade (Frieden, J. 2014).

³ G-7 group is formed by: Germany, Canada, France, Italy, Japan, United States and United Kingdom. <https://www.imf.org/external/np/exr/facts/spa/groupss.htm#G7>

⁴ Association of South East Asian Nations (ASEAN): Brunei, Darussalam, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. https://www.wto.org/spanish/thewto_s/glossary_s/asean_s.htm

⁵ In Chit, M., et al., 2008 they use the standard deviation of the first difference of the logarithm of the real exchange rate, the moving average of the standard deviation and conditional volatility (GARCH): three measures of volatility for

Moreover, Mustafa K. and Nishat, M. (2004) conducted the study for Pakistan and its major trading partners for the period 1991-2004. They specify the risk associated with RER movements through the standard deviation. They found negative effects of the empirical relationship between the exports' growth and exchange rate volatility for Australia, New Zealand, UK and USA. However, with regard to Bangladesh and Malaysia they found no evidence for this relationship. Mukhtar, F. and Malik, S. (2010) also study the case of Pakistan while addressing global exports and volatility through GARCH specification for the period 1960-2007. They found negative impact, and for India and Sri Lanka, they found similar results.

For Latin America empirical evidence, Adamo, A. and Silva, M. (2008), Aguirre, A., et al. (2007) and Berrettoni, D. and Castresana, S. (2007) study the exchange rate fluctuations impact on manufacturing exports. The first explores for Peru over the 1994-2004 period, the second studies Brazil from 1986 to 2002 and the third analyzes Argentina for 1992-2006 period. They use the standard deviation for modeling exchange rate volatility; additionally, Adamo, A. and Silva, M. (2008) and Aguirre, A., et al. (2007) specify a model with the conditional variance (GARCH). Moreover, Arize, A., et al. (2008) study it for global exports of eight countries in Latin America: Bolivia, Colombia, Costa Rica, Dominican Republic, Ecuador, Honduras, Peru and Venezuela, for the period 1973 - 2004. They use an ARCH (1) specification to model the exchange rate volatility, with the exception of Honduras. They obtain similar results: a significant and negative effect of exchange rate volatility on exports, with the exception of Aguirre, A., et al. (2007) when using the GARCH specification that obtain no significant results. Other study, in Huchet-Bourdon, M. and Korinek, J. (2012), analyze the impact of exchange rates and their volatility on bilateral trade in Chile and New Zealand (small and open economies) with China, Euro Area and U.S. (large partners) for two sectors: agriculture and nonmanufacturing-mining. It finds that exchange volatility (moving standard deviation and GARCH model) impacts trade flows in the small, open economies more than was found for larger economies. Findings do not clearly indicate the direction of the impact (increases or decreases) in all countries and sectors.

The literature also points the existence of works that find positive effects of exchange rate volatility on exports. Bredin, D., et al. (2002) study the impact of exchange rate volatility both short and long term global and sectoral Irish exports to the European Union for the period 1979 to 1992 (Irish national and multinational companies sectors). RER volatility is modeled via moving standard deviation of the growth rate of RER. In the short term, they found that volatility has a negative effect on multinational firms' exports, has no effect on national firms, generating a negative impact on overall exports. In the long, term the exchange rate volatility has no effect on multinational firms' exports, but they found a positive effect on exports of domestic firms, and therefore, the effect on global exports is positive.

Baum, C., et al. (2004) found that on average the effects of exchange rate volatility on exports is positive for a sample of 13 developed countries in the period 1980-1998. The originality of his analysis is the model for the exchange rate volatility from daily frequency by an AR (2) process. Moreover, Baum, C. and Caglayan, M. (2007) analyze the effect of exchange rate volatility (GARCH specification) in bilateral trade and fluctuations in trade flows for a group of developed countries in the 1980-1998 period. They find that the volatility of the exchange rate has both positive and negative impacts on bilateral trade; however, the effect is predominantly positive with respect to fluctuations of trade.

Moreover, the literature also records the existence of no significant impact of exchange rate volatility on global exports. Serenis, D. and Serenis, P. (2008) pointed out by analyzing the case

the exchange rate.

of four European countries: Norway, Poland, Hungary and Switzerland for the period 1973 - 2006. Bouoiyour, J. and Selmi, R. (2014b) estimate through several econometric methods (ordinary least squares, OLS), instrumental variables, autoregressive distributed lag (ARDL), spectral analysis of the evolution and decomposition of wavelet) to relate the volatility of the exchange rate and exports for Tunisia. Regarding exchange rate volatility measures they use the moving average of standard deviation and GARCH model. The overall result is a negative effect in the short term, but no significance in the long term.

With regard to the empirical evidence, a set of meta-analysis present an extensive study regarding the effects of exchange rate volatility on international trade, including Ozturk, I. (2006), was also present, Coric, B. and Pugh, G. (2010) and Bouoiyour, J. and Selmi, R. (2014a). Predominantly they show a negative effect of exchange rate volatility on international trade. Ozturk, I. (2006) conducts a review of 42 documents during the period from 1978 - 2005. Coric, B. and Pugh, G. (2010) consider a set of 49 studies published from 1978 to 2002, and further notes that the dummy variable representing the exchange rate regime, regularly was found significant. Finally, Bouoiyour, J. and Selmi, R. (2014a) analyzed 59 publications from 1984 to 2014. The evidence regarding the impact is: 29 (negative), 6 (positive), 6 (not significant) and 18 (ambiguous).

Moreover, we found no works linking RER volatility and exports in Uruguay, however, in Daude, C., et al. (2000) they study the Uruguay bilateral RER volatility (with Argentina and Brazil) to explain the evolution of the real exchange rate. They found that bilateral RER presents conditional heteroskedasticity and can be modeled through a GARCH.

4. Methodology

4.1 Theoretical model specification

This section presents the main methodological aspects considered in the models. First, we made a univariate analysis of the series analyzing the presence of unit roots through the Dickey and Fuller test, in order to determine the order of integration of each series.

Subsequently, taking into account the results the order of integration of the series, applying Johansen methodology, we made a multivariate analysis to capture the effects of relationships both short and long term between exports and the considered determinants. For this we inquired about the existence of cointegration relationships in the case of countries with all its series integrated of first order, I (1).

Following Enders, W. (1995), cointegration analysis is based on autoregressive vector with a vector error correction (VEC) specified in a model of endogenous variables. The VEC modeling can be represented as:

$$\Delta X_{it} = A_1 \Delta X_{it-1} + \dots + A_k \Delta X_{it-k+1} + \prod X_{it-k} + \mu + \Gamma D_t + \varepsilon_t \quad t = 1, \dots, T$$

where Δ denotes difference variables, X is a vector of endogenous de variables, μ is a vector of constants and D_t contain a set of instrumental variables (*dummies*) seasonal and intervention, ε_t is the error term and is distributed $N(0, \sigma^2)$.

Information on long-term relationships is included in the $\prod = \alpha\beta'$ matrix, where β is the vector of coefficients for the existing equilibrium relations and α is the coefficients vector of the

adjustment mechanism in the short term. Identifying the range of the matrix Π determines the total of existing cointegrating relationships between the variables.

Having examined the long-term relationship, we proceed to the analysis of short-term, showing the adjustment mechanism of the variables in the short run to the long-term equilibrium relationship. The existence of cointegrating vectors is analyzed through the Johansen Test, through the trace and eigenvalues of matrix Π .

Moreover, when countries did not submit all of its series I (1), we proceeded to specify a vector autoregression model (VAR).⁶ A VAR is a system in which each variable is returned on its own constant and delays on each of the other variables. So a VAR would represent the relationship between the variables of interest. A crucial aspect of these models is to select the optimal number of delays; the criteria generally used are the Akaike information criterion and Schwartz. The VAR modeling in general terms can be represented:

$$VAR(p): \quad X_t = c + \sum_{h=1}^p \phi_h X_{t-h} + \gamma Z_t + \tau D_t + \varepsilon_t$$

where X_t is a vector of endogenous variables, c is a vector of constants, D_t contains a set of dummy variables (seasonal and interventions) and p the number of lags of the variables included in the model, ϕ_h is a matrix of autoregression coefficients ($h = 1, 2, \dots, p$), Z_t is a deterministic set of exogenous variables and ε_t is the error term.

The VEC model, unlike VAR includes not only the short-term dynamic adjustment of the variables in the face of unexpected shocks, but also captures the long run dynamic adjustment to restore equilibrium relationship.

4.2 Real exchange rate volatility measurement

The estimate of RER volatility was made through a GARCH Model (generalized autoregressive conditional heteroskedasticity), according to Bollerslev, T. (1986), or IGARCH (integrated GARCH), depending on the case.

In order to analyze the RER impact and its volatility on exports, we estimated cointegration models of each country exports, taken in constants dollars (deflated by the US CPI), the overall RER with major trading partners in each country, its volatility estimated through a GARCH and world demand, estimated by global imports considered in constant dollars.

Regarding the literature on how to measure the RER volatility there is no consensus, therefore, studies choose to use multiple approaches. Among the most common specifications are: the standard deviation, moving average of the standard deviation, and the conditional variance specified by the squared residuals of ARIMA (Autoregressive Conditional Heteroskedasticity processes, ARCH, Engle, R., 1982; Generalized ARCH, GARCH, Bollerslev, T., 1986 or some variant GARCH).

In this work, we consider the RER conditional volatility as a measure of uncertainty, and is estimated through a GARCH process variant, called Integrated GARCH (IGARCH) introduced by Bollerslev, T. and Engel, R. (1986). The GARCH model has been widely used in the literature on time series models to model volatility. Overall, the GARCH model for the exchange rate can be

⁶ The VAR is formulated for stationary variables, hence the importance of knowing the order of integration of the series.

represented as follows:

$$y_t = \delta_0 + \sum_{i=1}^k \delta_i \cdot y_{t-i} + \varepsilon_t; \quad \varepsilon_t \sim N(0, \sigma_t^2)$$

$$GARCH(p, q): \quad \sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \cdot \varepsilon_{t-i}^2 + \sum_{i=1}^p \beta_i \cdot \sigma_{t-i}^2$$

The first equation represents a process autoregressive (AR) of order k , $AR(k)$. Where y_t is the real exchange rate, expressed in logarithm; the parameter δ_0 is the constant, k is the number of delays; and ε_t is the heteroscedastic term of error of the conditional variance (σ_t^2).

The second equation specifies a conditional variance GARCH (p, q), where q is the number of ARCH terms, p is the number of GARCH terms. The conditional variance is represented by three terms: i) the average, α_0 ; ii) the ARCH term, which measures the previous period volatility by squared residuals delays in the first equation; iii) the GARCH term, which captures the previous error variance prediction (σ_{t-i}^2). As the conditional variance is positive, it is required that the parameters, α_0 , α_i y β_i to be ≥ 0 ; and further that $\sum \alpha_i + \sum \beta_i < 1$ to ensure the process to be stationary in covariance.

Moreover, in the literature investigating the empirical relationship between exports and exchange rate volatility, it is widely used GARCH (1,1) for its significant results. However, in some applications it has been found that the estimates of $\hat{\alpha}_1$ and $\hat{\beta}_1$ tend to approach $\hat{\alpha}_1 + \hat{\beta}_1 = 1$, indicating that the GARCH (1,1) process is no longer stationary. That is why it is more appropriate to specify a regressive process IGARCH (1,1) to model the conditional variance, whose expression has the following form:

$$IGARCH(1,1): \quad \sigma_t^2 = \alpha_0 + \sigma_{t-1}^2 + \alpha_1(\varepsilon_{t-1}^2 - \sigma_{t-1}^2)$$

The peculiarity of the regressive process IGARCH (1,1) is the presence of a unit root, that is, the process is I (1), indicating the persistence of the conditional variance over time (Bollerslev, T., et al., 1994).

5. Definition and data sources

In this paper, we consider four countries: Brazil, Chile, Nueva Zealand and Uruguay. The criteria for selecting them respond first of all to analyzed commodities exporting countries, it is a similitude for all; in the second place, Uruguay, Chile and New Zealand have small and open economies' trade –smaller domestic market and depends on international prices- in contrast to Brazil where it have a large economy, included Brazil allowed to contrast both kind of economies; and in the third place we could show the results for some countries in the Latin American region against other country out of them, it is the main reason to include New Zealand.

The starting point considered for this analysis is 1990 when Latin American economies return to growth. At the beginning of the 1980s a profound crisis of external financing in Latin America was resolved at the end of the decade with the implementation of a consistent external opening and the return of international capital, rushed the 1990s with a period of growth led mainly by export growth (CEPAL, 2003a and CEPAL, 2003b).

The series used correspond to total goods exports, world imports, international prices of most important raw materials and real exchange rate (used also to build the real exchange rate

volatility). In all cases it is considered the monthly frequency of the series for the period 1990-2013 (288 observations) and log transformations.

First, as a proxy for world demand we use world imports, measured in constant dollars, deflated by the US CPI. World imports are from the International Monetary Fund (IMF) and the US CPI from the US Bureau of Economic Analysis.

Second, export the data correspond to total goods exports in constant dollars, deflated by the US CPI, provided by the Centre for International Economics (CEI) and the IMF.

The Brazilian real exchange rate is from IPEA, and volatility is calculated from GARCH (1,1) methodology. In the case of Chile's real exchange rate is from ECLAC and volatility is estimated through a IGARCH (1,1). For New Zealand the real change rate is from the Reserve Bank of New Zealand and volatility is calculated using a IGARCH (1,1). Finally, for Uruguay the real exchange rate is from IECON, using retail prices (CPI) and official exchange rates of 9 major trading partners. The volatility of the real exchange rate was calculated from a IGARCH (1,1) process.

Finally, a proxy of the most important export prices for each country was included. In the case of Brazil, New Zealand and Uruguay, the food price index compiled by the IMF and in the case of Chile's metals price index compiled by the Central Bank of Chile. This last one was included, because in Chile more than 50% of exports are metals.

5.1 Series analysis

First, we analyzed the series stationarity through the Dickey-Fuller test. Below in Table 1 and Table 2 we can see the results:

Table 1 – Unit Root Test

| Unit root test – Augmented Dickey-Fuller (ADF) | | | | |
|---|--|---------------------------------------|---|---------------------------------------|
| H_0 = There is a Unit Root | | | | |
| | Statistical value of the series in levels | Reject H_0 at 95% | Statistical value of the series in first differences | Reject H_0 at 95% |
| <i>World imports (LM)</i> | 2.5865 | No | -5.0464 | Yes |
| | (15 lags, no constant) | | (14 lags, no constant) | |
| <i>International food prices index (LPR)</i> | 0.4090 | No | -11.3406 | Yes |
| | (0 lags, no constant) | | (1 lag, no constant) | |
| <i>International metals price index (LPRM)</i> | 0.5116 | No | -11.9865 | Yes |
| | (1 lag, no constant) | | (0 lags, no constant) | |
| The numbers of lags was determined according to the Akaike criterion. | | | | |

From the information provided in Table 1 we conclude that all the variables are first-order integrated, I (1).

Table 2 – Unit Root Test

| Unit root test – Augmented Dickey-Fuller (ADF) | | | | |
|---|---|---------------------|--|---------------------|
| H_0 = There is a Unit Root | | | | |
| | Statistical value of the series in levels | Reject H_0 at 95% | Statistical value of the series in first differences | Reject H_0 at 95% |
| Uruguay | | | | |
| <i>Exports (X_URU)</i> | 1.8648 | No | -4.8120 | Yes |
| | (13 lags, no constant) | | (12 lags, no constant) | |
| <i>RER (RER_URU)</i> | -1.8584 | No | -8.5237 | Yes |
| | (5 lags, no constant) | | (4 lags, no constant) | |
| <i>RER volatility (RERV_URU)</i> | -0.6302 | No | -15.4245 | Yes |
| | (0 lags, no constant) | | (0 lags, no constant) | |
| Brazil | | | | |
| <i>Exports (X_BRA)</i> | 1.8675 | No | -3.9901 | Yes |
| | (13 lags, no constant) | | (15 lags, no constant) | |
| <i>RER (RER_BRA)</i> | 0.5596 | No | -11.8911 | Yes |
| | (2 lags, no constant) | | (1 lags, no constant) | |
| <i>RER volatility (RERV_BRA)</i> | -5.4063 | Si | -9.5735 | Yes |
| | (1 lags, no constant) | | (4 lags, no constant) | |
| Chile | | | | |
| <i>Exports (X_CHI)</i> | 1.2434 | No | -3.4074 | Yes |
| | (13 lags, no constant) | | (15 lags, no constant) | |
| <i>RER (RER_CH)</i> | -2.6344 | No | -10.2483 | Yes |
| | (3 lags, with constant) | | (2 lags, no constant) | |
| <i>RER volatility (RERV_CHI)</i> | -0.4942 | No | -5.8877 | Yes |
| | (5 lags, no constant) | | (4 lags, no constant) | |
| New Zealand | | | | |
| <i>Exports (X_NZEL)</i> | 1.2617 | No | -4.1282 | Yes |
| | (13 lags, no constant) | | (15 lags, no constant) | |
| <i>RER (RER_NZEL)</i> | 0.4558 | No | -7.4189 | Yes |
| | (3 lags, no constant) | | (2 lags, no constant) | |
| <i>RER volatility (RERV_NZEL)</i> | 0.4459 | No | -7.4459 | Yes |
| | (0 lags, no constant) | | (3 lags, no constant) | |
| The numbers of lags was determined according to the Akaike criterion. | | | | |

In the case of Uruguay, New Zealand and Chile all the series studied were not stationary, integrated of first order. As a result, the study was done via the methodology of Johansen, S. (1988), trying to find a long-term relationship through a cointegrating vector, estimating an error correction model (VECM Model) (Engle, R. and Granger, C., 1987 and Johansen, S., 1992).

In the case of Brazil the series of exports and the real exchange rate were not stationary and integrated of first order, although exchange rate volatility was stationary, so it was included as exogenous in the model.⁷

⁷ See Annex C for cointegration results.

6. Main results

Table 3 summarizes the main results of Johansen cointegration test for Brazil, Chile, New Zealand and Uruguay:

Table 3 - Johansen cointegration test results

| Country | H_0) | $r = 0$ | $r \leq 1$ | $r \leq 2$ |
|---|---------|---------------------|---------------------|---------------------|
| Trace Test | | | | |
| Brazil | | 34.3377 (0.0140) | 6.6631 (0.6171) | 0.0757 (0.7831) |
| Chile | | 68.0501 (0.0002) | 21.8260 (0.3083) | 7.5592 (0.5137) |
| New Zealand | | 61.0786 (0.0105) | 33.0221 (0.0842) | 10.9865 (0.5434) |
| Uruguay | | 53.6809 (0.0129) | 15.6916 (0.7338) | 5.0212 (0.8066) |
| Maximum eigenvalue test | | | | |
| Brazil | | 27.6747 (0.0052) | 6.5873 (0.5390) | 0.0757 (0.7831) |
| Chile | | 46.2241 (0.0001) | 14.2669 (0.3435) | 7.1923 (0.4666) |
| New Zealand | | 28.0417 (0.0437) | 14.0695 (0.3594) | 2.9080 (0.9527) |
| Uruguay | | 37.9893 (0.0016) | 10.6704 (0.6801) | 5.0098 (0.7406) |
| Notes: r represents the number of cointegrating vectors. p-value in parentheses. The significance level for rejecting H_0 is 5%. | | | | |

Since cointegration tests indicate a long-term relationship for each country exports equation, we estimated a vector error correction model (VECM) for each country.

In the case of **Uruguay**, the final adjustment was for the period January 1993 to December 2013, because the Uruguayan economy had strong adjustments in the early 90s, due to high inflation and beginning the stabilization plan with exchange rate anchor. After adjusting the residuals, including seasonal dummies, and to dummies to correct outliers in the series. After exclusion tests performed for coefficients β , the RER was not significant in the equation, and it was not significant

as an exogenous variable so the cointegrating vector for Uruguay was:

$$X_{URU_t} = 0.5024LM_t + 0.9279LPR_t - 0.1917RERV_URU_t - 5.1385$$

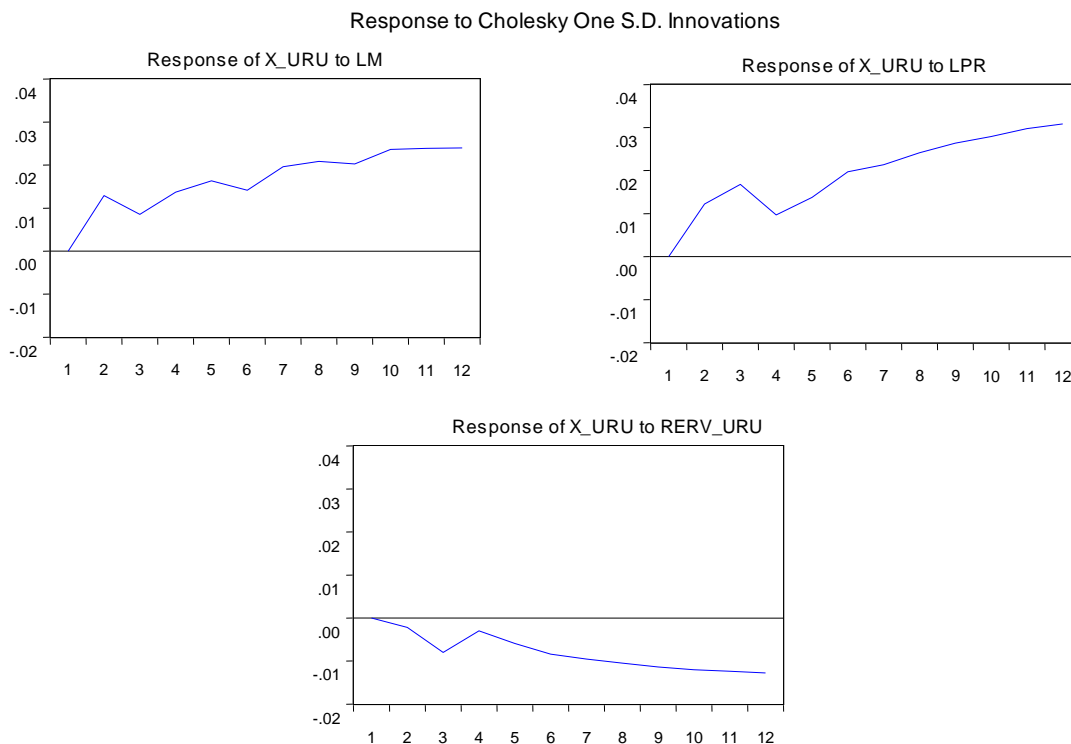
(5.220) (6.935) (-5.067)

From the tests of weak exogeneity LM and LPR coefficients were zero, so only RER volatility acts in the short term on exports, with a coefficient of -0.20.

The cointegrating equation represents the long-term relationship between the variables, where the impact of global demand, represented by world imports (LM) is positive and equal to 0.50, while international food prices (LPR) impact with a 0.93 coefficient and RER volatility (RERV_URU) has a negative impact, with a 0.19 coefficient. The full model is presented in Annex D.

According to this result, it is not rejected the existence of a cointegrating vector among the variables, and the sign of the coefficients are as expected. In addition, we made the corresponding exclusion tests for β and α for weak exogeneity.

Figure 2: Impulse-response functions



Analyzing impulse-response functions (Figure 2) from exports to international food prices, global demand and exchange rate volatility, the positive and permanent effect of the first two variables is confirmed, reaching 3% in the first 12 months for international food prices and 2.4% for global demand. Moreover, the impact is negative and permanent when a shock on RER volatility, reaching 1.3% after 12 months.

In the case of **Brazil**, as the volatility of the real exchange rate was stationary, I (0), the model is estimated for the other four variables (X_{BRA} , RER_{BRA} , LM and LPR), with RER volatility as exogenous. However, we could not detect statistically significant relationship between RER or RER volatility and exports in the model, similar results found Aguirre, A., et al. (2007) in the case of GARCH model for the RER volatility, so the resulting equation for Brazil is:

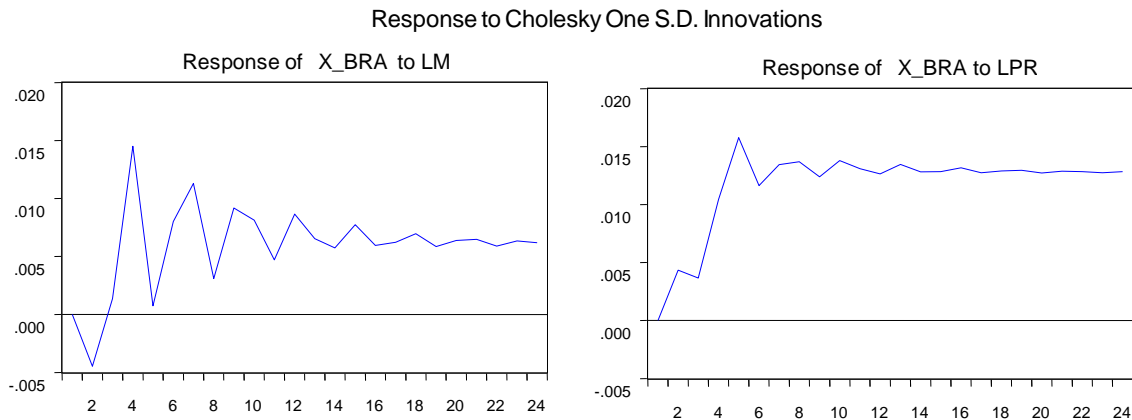
$$X_{BRA_t} = 1.071LM_t + 0.452LPR_t - 7.586$$

(15.673) (4.293)

According to the coefficients estimated value, the greatest impact in the case of Brazil comes from global demand, with an elasticity of about 1, while food international prices have a significant impact, but less so, with a coefficient 0.45.

Below they are presented in Figure 3 the impulse response functions:

Figure 3: impulse-response functions



The impact of a shock to either variables on exports is positive after 12 periods for global demand and impact below 1% and 6 periods for prices, with a close final effect 1.5 %.

In the case of **Chile**, after analyzing the series stationarity included in the model (Tables 1 and 2), all variables were not stationary, so we investigated the existence of co-integration between variables and estimated a cointegration vector, where volatility was not significant and the real exchange rate was significant, but with negative sign.

So the resulting equation is:

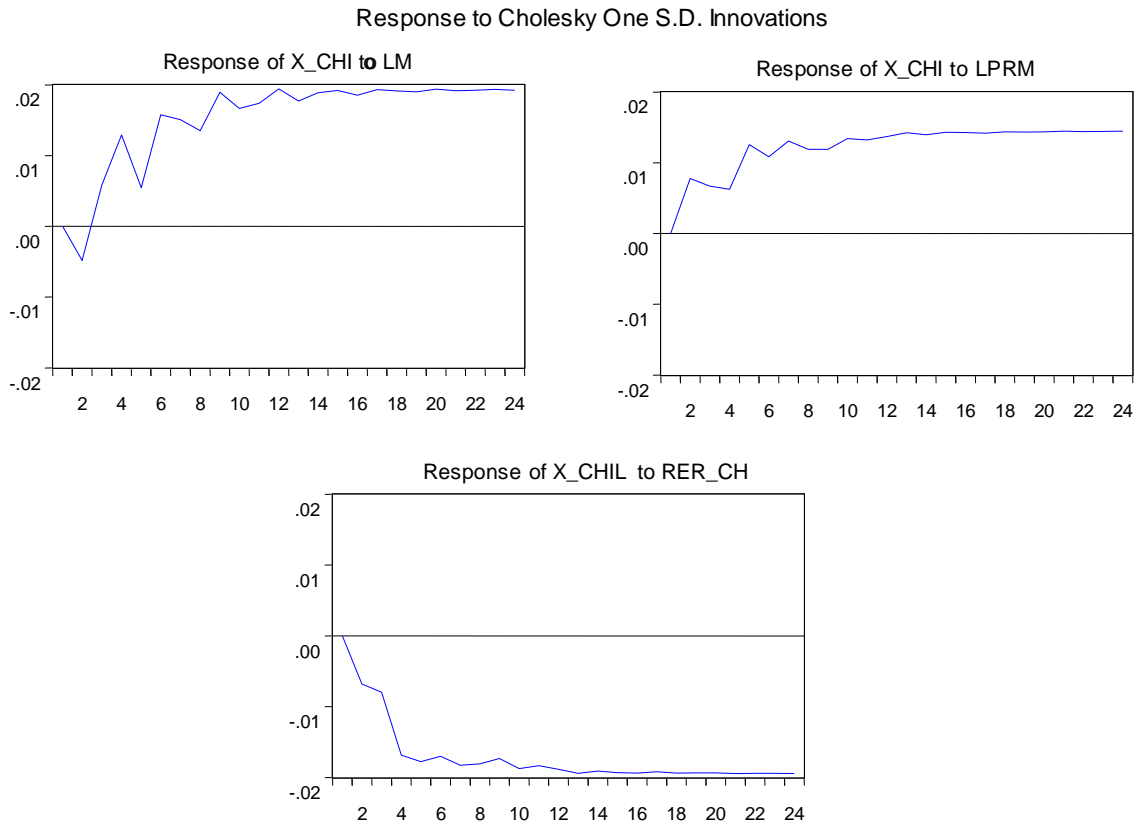
$$X_{CHI_t} = 1.317LM_t + 0.167LPRM_t - 0.539RER_{CH_t} - 8.041$$

(14.819) (2.354) (−3.622)

The cointegrating vector estimated for Chilean exports shows a positive coefficient 1.3 for world imports, near 0.15 for international metals prices, and negative near 0.5 for RER . Similar results found Huchet-Bourdon, M. y Korinek, J. (2012) for the impact of RER on exports in Chile, they

explain that for the bilateral trade between Chile and China's price inelastic demand and the impact of the copper price on the Chilean peso.

Figure 4: impulse response functions



In the impulse-response functions, which show the shock impact of different variables on exports indicate that despite an initial negative impact on global demand then the impact is positive, reaching 2%. In the case of metals prices, the impact is from the early months and remains positive, somewhat below 2%. In the case of the real exchange rate, the impact is negative, coming from 4 months to an effect of 2%.

For **New Zealand** exports cointegrating vector, estimated RER volatility resulted not significant.

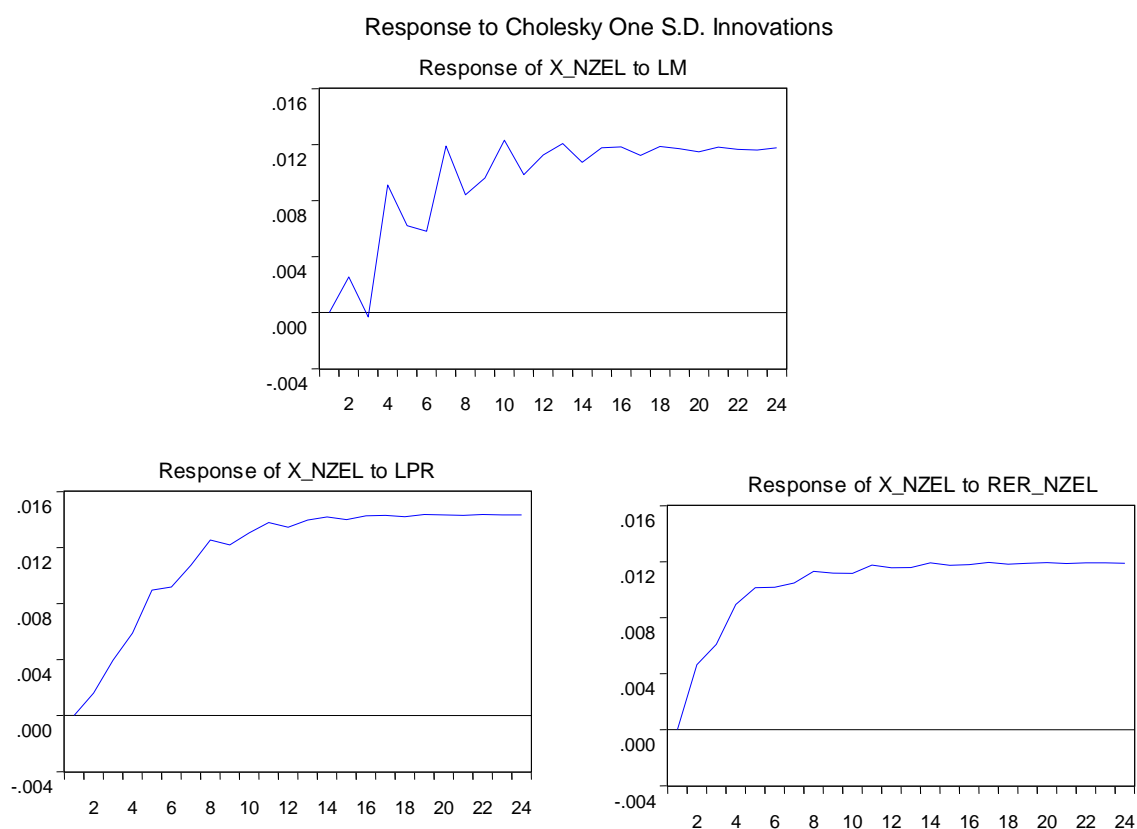
$$X_{NZEL_t} = 0.4484LM_t + 0.3176LPR_t + 0.235RER_{NZEL_t} - 1.6093$$

(11.0534) (2.6943) (2.0505)

The global demand coefficient was somewhat higher than 0.4, the international food prices coefficient close to 0.3 while the elasticity of response of exports to changes in the real exchange rate was estimated slightly above 0.2. We found similar results as Huchet-Bourdon, M. y Korinek, J. (2012) for the RER positive effects (as economic theory) and RER volatility insignificant effects on the exports, since commodities exports depends on international prices in this kind of economic.

The following figure presents the impulse response functions:

Figure 5: impulse-response functions



Impulse response functions show a moderate impact of the three variables, but positive and sustained over time, somewhat higher in the case of food prices than international demand and real exchange rate.

Finally, it is necessary to check the direction of the causality to determine whether it is from the variables (World imports (LM), International food prices index (LPR) or International metals price index (LPRM), real exchange rate (RER) and RER volatility (RERV)) to the exports or vice versa.

The Granger causality F -statistics tests for the variables in levels are presented in Table 4:

Table 4: Granger causality F -statistics in levels

| Variable/Exports | Brazil | Chile | New Zealand | Uruguay |
|------------------|----------|----------|-------------|----------|
| LM | 8.24834* | 4.87922* | 10.8901* | 4.30695* |
| LPR/LPRM | 5.03617* | 7.12267* | 4.34733* | 3.05936* |
| RER | ----- | 1.07848 | 6.41637* | ----- |
| RERV | ----- | ----- | ----- | 2.37653* |
| Exports/Variable | LM | LPR/LPRM | RER | RERV |
| Brazil | 2.73805* | 1.97013* | ----- | ----- |
| Chile | 8.78288* | 3.36855* | 1.08574 | ----- |
| New Zealand | 7.13552* | 2.66992* | 0.82036 | ----- |
| Uruguay | 3.73174* | 1.03228 | ----- | 1.04823 |

Notes: H_0 : X_{it} does not Granger cause X_{jt} ($i \neq j$), where X_{it} represents the variables in the row and X_{jt} represents the variables in the column. 12 lags. 276 observations in each series. Sample: 1990.01 – 2013.12.
 *significant at 5%.

Source: Own elaboration.

According to the Granger test, in the case of the Brazilian economy, we found non-causality of global demand and international prices for Brazilian exports but also is rejected causality in the other direction, so from this test we cannot draw conclusions. This result may be because Brazil is a large economy and exports affect both global demand and international food prices.

In the case of Chile, Granger test provides no results, as all options are rejected (except for RER which is statistically insignificance), so we reject that some variables do not cause the other, but in every way.

For New Zealand is rejected (in the sense of Granger) both international food prices and global demand, they do not cause the country's exports. Respect to the real exchange rate it is rejected that the real exchange rate does not cause exports.

Finally, for Uruguay, according to the Granger test, it rejected that volatility does not affect exports. It is also rejected that global imports and international food prices do not cause, in the sense of Granger, Uruguayan exports.

7. Final remarks

While in economic literature there is consensus on the sign of global demand and international prices affecting exports, the evidence is less conclusive when real exchange rate volatility is incorporated to the analysis. From this work, we can conclude that global demand and international prices influence goods exports for all the selected countries. But only in the case of Uruguay the impact of RER volatility was significant both in the short and long-term and with a negative sign.

In the case of Brazil, Chile and New Zealand we did not find evidence of RER volatility impact on exports. This fact could indicate that the exchange rate uncertainty does not affect the export decisions in these countries, as if it happens in Uruguay, although in the case of New Zealand and Chile it was found impact of real exchange rate in exports. Although the sign of the coefficient was negative in the case of Chile.

In the case of Uruguay, which is a small open economy, the RER volatility negative impact on exports may suggest that economic policy must not disregard the importance of preserving the real exchange rate stability as a source of export stability, hence exports impact on macroeconomic variables.

Additionally, the failure to find evidence of the relationship between exchange rate volatility and exports in the rest of the studied countries can respond to the methodology used, remains to test in future studies as other volatility specifications that may modify the models.

8. References

- Adamo, A. & Silva, M., 2008. El impacto de la volatilidad del tipo de cambio sobre el nivel de exportaciones manufactureras en el Perú: 1994-2004. *Seminario de Investigación*. Universidad del Pacífico. <http://www.zonaeconomica.com/files/peru-tdc.pdf>
- Aguirre, A., Ferreira, A. & Notini, H., 2007. The impact of exchange rate volatility on Brazilian manufactured exports, *Económica*, vol. 0 (1-2), pp. 3-19.
- Akhtar, M. & Hilton, R., 1984. Effects of exchange rate uncertainty on German and U.S. trade. *Federal Reserve Bank of New York Quarterly Review*, vol. 9, pp. 7-16.
- Arize, A., Osang, T. & Slottje, D., 2008. Exchange-rate volatility in Latin America and its impact on foreign trade. *International Review of Economics y Finance*, Elsevier, vol. 17 (1), pp. 33-44.
- Baak, S., Al-Mahmood, A. & Vixathap, S., 2003. Exchange rate volatility and exports from East Asian countries to Japan and the United State. *Working Papers EMS_2003_01*, Research Institute, International University of Japan.
- Baum, C. & Caglayan, M., 2007. Effects of exchange rate volatility on the volume and volatility of bilateral exports. *Money Macro and Finance (MMF) Research Group Conference 2006*.
- Baum, C., Caglayan, M. & Ozkan, N., 2004. Nonlinear effects of exchange rate volatility on the volume of bilateral exports. *Journal of Applied Econometrics*, John Wiley & Sons, Ltd., vol. 19 (1), pp. 1-23.
- Berrettoni, D. & Castresana, S., 2007. Exportaciones y tipo de cambio real: el caso de las manufacturas industriales argentinas. *Revista de Comercio Exterior e Integración*, Centro de Economía Internacional (CEI), Buenos Aires, vol. 9, pp. 101-117.
- Bollerslev, T., 1986. Generalized autoregressive conditional heteroskedasticity. *Journal of Econometrics*, vol. 31, pp. 307-327.
- Bollerslev, T. & Engle, R., 1986. Modeling the persistence of conditional variances. *Econometric Reviews*, vol. 5, pp. 1-50.
- Bolleslev, T., Engle, R. & Nelson, D., 1994. Arch models. *Handbook of Econometrics*, vol. 4, Chapter 49, North Holland.
- Bouoiyour, J. & Selmi, R., 2014a. How does exchange rate uncertainty interact with international trade? A meta-analysis revisited. *MPRA Paper 56201*, University Library of Munich, Germany.
- Bouoiyour, J. & Selmi, R., 2014b. How robust is the connection between exchange rate uncertainty and Tunisia's exports? *MPRA Paper 57505*, University Library of Munich, Germany.

- Bredin, D., Fountas, S. & Murphy, E., 2002. An empirical analysis of short-run and long-run Irish export functions: Does exchange rate volatility matter? *Research Technical Papers* 1/RT/02, Central Bank of Ireland.
- CEPAL, 2003a. Proyecciones de América Latina y el Caribe. *Estudios estadísticos y prospectivos*, División de Estadística y Proyecciones Económicas, No. 19.
- CEPAL, 2003b. Tendencias y extrapolación del crecimiento en América Latina y el Caribe. *Estudios estadísticos y prospectivos*, División de Estadística y Proyecciones Económicas, No. 23.
- Cheung, Y. W. & Sengupta, R., 2012. Impact of exchange rate movements on exports: an analysis of Indian non-financial sector firms, *MPRA Paper* 43118, University Library of Munich, Germany.
- Chit, M., Rizov, M. & Willenbockel, D., 2010. Exchange rate volatility and exports: New empirical evidence from the emerging East Asian economies. *The World Economy*, vol. 33 (2), pp. 239–263.
- Chowdhury, A., 1993. Does exchange rate volatility depress trade flows? Evidence from error correction models. *The Review of Economics and Statistics*, MIT Press, vol. 75(4), pp. 700–706.
- Coric, B. & Pugh, G., 2010. The effects of exchange rate variability on international trade: a meta-regression analysis. *Applied Economics, Taylor & Francis Journals*, vol. 42 (20), pp. 2631–2644.
- Cushman, D., 1983. The effects of real exchange rate risk on international trade. *Journal of International Economics*, Elsevier, vol. 15(1-2), pp. 45–63.
- Daude, C., Lorenzo, F. & Noya, N., 2000. Tipos de cambio reales bilaterales y volatilidad: La experiencia uruguaya con los socios del Mercosur. Centro de Investigaciones Económicas (CINVE).
- Enders, W., 1995. *Applied Econometric Time Series*. Iowa State University, John Wiley & Sons, Inc. Editors.
- De Grauwe, P., 1988. Exchange rate variability and the slowdown in growth of international trade. *Staff Papers-International Monetary Fund*, vol. 35 (1), pp. 63–84.
- Engle, R., 1982. Autoregressive conditional heteroskedasticity with estimates of the variance of U.K. inflation. *Econometrica*, vol. 50, pp. 987–1008.
- Engle, R. & Granger, C., 1987. Co-integration and error correction: Representation, estimation, and testing. *Econometrica*, vol. 55 (2), pp. 251–276.
- Frieden, J., 2014. Currency politics: The political economy of exchange rate policy. Introductory Chapters, Princeton University Press, p. 12.
- Gracia-Diez, M. & Novales, A., 1993. Guía para la estimación de modelos ARCH. *Estadística Española*, vol. 35 (132), pp. 5–38.

- Hooper, P. & Kohlhagen, S., 1978. The effect of exchange rate uncertainty on the prices and volume of international trade. *Journal of International Economics*, Elsevier, vol. 8(4), pp. 483-511.
- Huchet-Bourdon, M. & Korinek, J., 2012. Trade Effects of Exchange Rates and their Volatility: Chile and New Zealand. *OECD Trade Policy Papers*, OECD Publishing, vol. 136, pp. 1-48.
- Johansen, S., 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, vol. 12 (2-3), pp. 231-254.
- Johansen, S., 1992. Cointegration in partial systems and the efficiency of single-equation analysis. *Journal of Econometrics*, vol. 52 (3), pp. 389-402.
- Masron, T. & Mohd, A., 2009. Export, economic integration and exchange rate volatility in Turkey and Malaysia. *Journal of International Finance and Economics*, vol. 5 (9), pp. 42-54.
- Mukhtar, F. & Malik, S., 2010. Exchange rate volatility and export growth: Evidence from selected South Asian countries. *Zagreb International Review of Economics and Business*, Faculty of Economics and Business, University of Zagreb, vol. 13 (2), pp. 27-37.
- Mustafa, K. & Nishat, M., 2004. Volatility of exchange rate and export growth in Pakistan: The structure and interdependence in regional markets. *The Pakistan Development Review*, Pakistan Institute of Development Economics, vol. 43(4), pp. 813-828.
- Ozturk, I., 2006. Exchange rate volatility and trade: A literature survey. *International Journal of Applied Econometrics and Quantitative Studies*, Euro-American Association of Economic Development, vol. 3 (1), pp. 85-102.
- Ramli, N. & Podivinsky, J., 2011. The effects of exchange rate volatility on exports: Some new evidence for regional ASEAN countries. *The Economic and Social Data Service (ESDS)*, International Annual Conference Institute of Materials, London.
- Serenis, D. & Serenis, P., 2008. The impact of exchange rate volatility on exports: Evidence four European Countries. In: *International Conference on Applied Economics – ICOAE*. Kastoria, Greece 15 - 17 May 2008.
- Zakaria, Z., 2013. The relationship between export and exchange rate volatility: Empirical evidence based on the trade between Malaysia and its major trading partners. *Journal of Emerging Issues in Economics, Finance and Banking (JEIEFB)*, An Online International Monthly Journal (ISSN: 2306-367X), vol. 2 (2).

Annex A – Exports characterization

Table A.1: Exports share by country or destination area

| Origin: Uruguay | | | Origin: Chile | | |
|------------------------|-------------|-------------|-----------------------|-------------|-------------|
| Destination | 2013 | 1994 | Destination | 2013 | 1990 |
| Brazil | 18,9% | 25,8% | China | 24,8% | 0,4% |
| Europe & Central Asia | 17,2% | 21,6% | Europe & Central Asia | 17,4% | 36,0% |
| Free Zones | 16,0% | 0,1% | United States | 12,7% | 16,8% |
| China | 14,2% | 6,0% | Japan | 9,9% | 16,2% |
| Argentina | 5,4% | 20,0% | Brazil | 5,7% | 5,8% |
| Venezuela | 4,9% | 0,1% | Korea, Rep. | 5,5% | 3,0% |
| United States | 3,9% | 6,9% | India | 3,0% | 0,7% |
| Russia | 3,1% | 0,5% | Peru | 2,5% | 0,9% |
| Others | 16,4% | 19,1% | Others | 18,4% | 20,3% |

| Origin: Brazil | | | Origin: New Zealand | | |
|-----------------------|-------------|-------------|----------------------------|-------------|-------------|
| Destination | 2013 | 1990 | Destination | 2013 | 1990 |
| Europe & Central Asia | 23,3% | 31,9% | China | 20,7% | 1,0% |
| China | 19,0% | 1,2% | Australia | 19,0% | 19,0% |
| United States | 10,3% | 24,6% | Europe & Central Asia | 10,6% | 18,2% |
| Argentina | 8,1% | 2,1% | United States | 8,5% | 13,1% |
| Japan | 3,3% | 7,5% | Japan | 5,9% | 16,1% |
| Venezuela | 2,0% | 0,9% | Korea, Rep. | 3,4% | 4,2% |
| Korea, Rep. | 2,0% | 1,7% | Latin America & Caribbean | 3,2% | 3,0% |
| Chile | 1,9% | 1,5% | United Kingdom | 2,9% | 7,0% |
| Others | 30,2% | 28,6% | Others | 25,7% | 18,4% |

Note: The term "Other" refers to the rest of the World.

Source: Own elaboration, data from World Bank.

The following table details the composition of the exported products:⁸

Table A.2: Description of exported products

| Product group | Product group description | Product group | Product group description |
|-------------------|---|-----------------------|---|
| Animal | Live animals Meat and edible meat offal Fish & crustacean, mollusc & other aquatic Dairy prod; birds' eggs; natural honey Products of animal origin, nes or included | Textiles and Clothing | Silk Wool, fine/coarse animal hair Cotton Other vegetable textile fibres; paper yarn Man-made filaments Man-made staple fibres Wadding, felt & nonwoven; yarns; twine Carpets and other textile floor coverings Special woven fab; tufted tex fab; lace Impregnated, coated, cover/laminated textile Knitted or crocheted fabrics Art of apparel & clothing access, knitted Art of apparel & clothing access, not knitted Other made up textile articles; sets |
| Vegetable | Live tree & other plant; bulb, root Edible vegetables and certain roots and tubers Edible fruit and nuts; peel of citrus fruit Coffee, tea, mati and spices Cereals Prod.mill.indust; malt; starches; inulin Oil seed, oleagi fruits; miscell grain, seed Lac; gums, resins & other vegetable saps & ext Vegetable plaiting materials; vegetable produc Animal/veg fats & oils & their cleavage produc | Footwear | Footwear, gaiters and the like Headgear and parts thereof Umbrellas, walking-sticks, seat-sticks, whips Prepr feathers & down; arti flower |
| Food Products | Prep of meat, fish or crustaceans, molluscs Sugars and sugar confectionery Cocoa and cocoa preparations Prep.of cereal, flour, starch/milk; pastrycook Prep of vegetable, fruit, nuts or other parts Miscellaneous edible preparations Beverages, spirits and vinegar Residues & waste from the food indust Tobacco and manufactured tobacco substitutes | Stone and Glass | Art of stone, plaster, cement, asbestos Ceramic products Glass and glassware Natural/cultured pearls, prec stones & metals |
| Minerals | Salt; sulphur; earth & ston; plastering mat Ores, slag and ash | Metals | Iron and steel Articles of iron or steel Copper and articles thereof Nickel and articles thereof Aluminium and articles thereof Lead and articles thereof Zinc and articles thereof Tin and articles thereof Other base metals; cermets; articles thereof Tool, implement, cutlery, spoon & fork Miscellaneous articles of base metal |
| Fuels | Mineral fuels, oils & product of their distill | Mach and Elec | Nuclear reactors, boilers Electrical mchy equip parts thereof |
| Chemicals | Inorgn chem; compds of prec mtl, radioact element Organic chemicals Pharmaceutical products Fertilisers Tanning/dyeing extract; tannins & derivs Essential oils & resinoids; perf, cosmetic Soap, organic surface-active agents Albuminoid subs; modified starches; glues Explosives; pyrotechnic prod; matches Photographic or cinematographic goods Miscellaneous chemical products | Transportation | Railw/tramw locom, rolling-stock Vehicles o/t railw/tramw roll-stock, pts Aircraft, spacecraft, and parts thereof Ships, boats and floating structures |
| Plastic or Rubber | Plastics and articles thereof Rubber and articles thereof | Miscellaneous | Optical, photo, cine, meas, checking Clocks and watches and parts thereof Musical instruments Arms and ammunition; parts and accessories Furniture; bedding, mattress, matt support Toys, games & sports requisites; parts Miscellaneous manufactured articles Works of art, collectors' pieces and antiques UN Special Code UN Special Code |
| Hides and Skins | Raw hides and skins (other than furskins) Articles of leather; saddlery/harness Furskins and artificial fur | | |
| Wood | Wood and articles of wood; wood charcoal Cork and articles of cork Manufactures of straw, esparto Pulp of wood/of other fibrous cellulosic Paper & paperboard; art of paper pulp, paper Printed books, newspapers, pictures | | |

Source: World Bank.

⁸<http://wits.worldbank.org/referencedata.html>

Annex B – Modeling conditional heteroskedasticity

It is usually assumed distribution process variance as a constant series over time (homoskedasticity), however, not all series have constant variance over time (heteroscedasticity).

That is why in this study the conditional variance of the real exchange rate is modeled through a GARCH variant process, introduced by Bollerslev, T. (1986), and widely used to estimate the volatility of some variables in time series models.

Consider a univariate stochastic process AR (1):

$$y_t = \delta_0 + \delta_1 \cdot y_{t-1} + \varepsilon_t \quad t = 1, \dots, n$$

where ε_t is a white noise $\varepsilon_t \sim i.i.d.N(0, \sigma_\varepsilon^2)$

and $Cov(\varepsilon_t, \varepsilon_s) = 0$ if $t \neq s$ (no serial autocorrelation)

so that the process y_t to be stationary it must satisfy that $|\delta_1| < 1$.

The mathematical unconditional (or marginal) expectation of the stochastic process y_t can be expressed as:

$$E(y_t) = E(\delta_0 + \delta_1 \cdot y_{t-1} + \varepsilon_t) = \delta_0 + \delta_1 \cdot E(y_{t-1}) \rightarrow E(y_t) = \frac{\delta_0}{1 - \delta_1}$$

and the unconditional variance of the stochastic process y_t is:

$$V(y_t) = V(\delta_0 + \delta_1 \cdot y_{t-1} + \varepsilon_t) = \delta_1^2 \cdot V(y_{t-1}) + V(\varepsilon_t) = \delta_1^2 \cdot \sigma_y^2 + \sigma_\varepsilon^2 \rightarrow$$

$$\sigma_y^2 = \delta_1^2 \cdot \sigma_y^2 + \sigma_\varepsilon^2 \rightarrow \sigma_y^2 = \frac{\sigma_\varepsilon^2}{1 - \delta_1^2}$$

Moreover, it could also determine the conditional expectation and variance, conditional understood in the term of the variable past information or until the previous period $t - 1$.

Consider Ω_{t-1} the set of information including all last variable y_t : $\Omega_{t-1} = \{y_{t-1}, y_{t-2}, \dots, y_{t-n}\}$. The conditional expectation and variance can be represented respectively as follows:

$$E(y_t|\Omega_{t-1}) = E_{t-1}(y_t) = \delta_0 + \delta_1 \cdot y_{t-1}$$

$$V(y_t|\Omega_{t-1}) = Var_{t-1}(y_t) = E_{t-1}[y_t - E_{t-1}(y_t)]^2 = E_{t-1}(\varepsilon_t^2) = \sigma_\varepsilon^2$$

In this case shows that both conditional and unconditional variance are constant over time, however, the conditional variance need not to be constant over time (Gracia-Diez, M. and Novales, A., 1993).

ARCH model

The univariate ARCH processes (autoregressive conditional heteroskedasticity) allow the conditional variance error term ε_t changing over time, for it is considered the set of information available at the time t-1, $\sigma_\varepsilon: \Omega_{t-1} = \{\varepsilon_{t-1}, \varepsilon_{t-2}, \dots, \varepsilon_{t-n}\}$ and a specification of the square of the prediction errors of previous periods $\sigma_\varepsilon^2 = \sigma_t^2 = f(\varepsilon_{t-1}^2, \varepsilon_{t-2}^2, \dots)$. This way it is assigned greater weight to more recent past.

Consider the univariate model ARCH (1):

$$\sigma_t^2 = \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2$$

with $\delta_0 \geq 0$ and $\delta_1 \geq 0$, where conditional variance depends on one lag of ε_t . The conditional distribution of ε_t , assuming normality is:

$$\varepsilon_t|\Omega_{t-1} \sim N(0, \sigma_t^2)$$

$\sigma_t^2 > 0$ is the conditional variance of $\varepsilon_t \rightarrow \alpha_1$ must be non-negative.

Estimating the expectation $E(\sigma_t^2) = \alpha_0 + \alpha_1 \cdot E(\varepsilon_{t-1}^2)$, the ARCH (1) process must satisfy $|\alpha_1| < 1$ to obtain a stationary model in variance and prevent σ_t^2 to be explosive.

From equation $\sigma_t^2 = \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2$, appears that a high value of $\varepsilon_{t-1}^2 \rightarrow$ the variance σ_t^2 conditioned to that value of ε_{t-1}^2 would be higher \rightarrow a high σ_t^2 .

In a generalized way we can expressed an ARCH (q) as follows:

$$\sigma_t^2 = \delta_0 + \sum_{i=1}^q \delta_i \cdot \varepsilon_{t-i}^2$$

with $\delta_0 \geq 0, \delta_i \geq 0 \quad i = 1, \dots, q$

GARCH model

The GARCH (p, q) process (Generalized Autoregressive Conditional Heteroskedasticity) is a technique developed by Bollerslev, T. (1986) from the works of Engel, R. (1972) that allows the conditional variance (volatility) of the y_t sequence constitutes an ARMA process. For it is estimated $\{y_t\}$ as an ARMA process. If the model is suitable $\{y_t\}$, the autocorrelation function (ACF) and partial autocorrelation function of residuals should behave like a white noise process. The ACF of the squared residuals helps to identify the order of the GARCH process.

The conditional variance GARCH specification of $\varepsilon_t: \{\sigma_t^2\}$ depends on the residuals lags and the their own values lags:

As $E_{t-1} \cdot \varepsilon_t^2 = \sigma_t^2$, is possible to write:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^q \alpha_i \cdot \varepsilon_{t-i}^2 + \sum_{i=1}^p \beta_i \sigma_{t-i}^2$$

This equation is similar to an ARMA (p, q) in the sequence $\{\varepsilon_t^2\}$. If there are conditional heteroskedasticity, the correlogram should continue the process.

GARCH (1,1) model

Following Gracia-Diez, M. and Novales, A. (1993), considerer the GARCH (1,1) specification:

$$\begin{aligned} \sigma_t^2 &= \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2 + \beta_1 \cdot \sigma_{t-1}^2 \\ \alpha_0 &> 0, \alpha_1 > 0, \beta_1 > 0 \\ \text{and } \varepsilon_t | \Omega_{t-1} &\sim N(0, \sigma_t^2) \end{aligned}$$

Observe that $|\beta_1| < 1$ is a necessary condition for the stability of the model:

$$\begin{aligned} \sigma_t^2 - \beta_1 \cdot \sigma_{t-1}^2 &= \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2 \\ \sigma_t^2 - \beta_1 L \sigma_t^2 &= \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2 \\ (1 - \beta_1 L) \sigma_t^2 &= \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2 \\ \sigma_t^2 &= \frac{\alpha_0}{1 - \beta_1} + \frac{\alpha_1}{1 - \beta_1 L} \cdot \varepsilon_{t-1}^2 \end{aligned}$$

and the GARCH (1,1) process can be approximated by an ARCH (p) process if p is large.

Moreover, in a horizon of forecast s for the GARCH (1,1) we have that:

$$E_t \sigma_{t+s}^2 = \alpha_0 + \alpha_1 E_t \varepsilon_{t+s-1}^2 + \beta_1 E_t \sigma_{t+s-1}^2 = \alpha_0 + (\alpha_1 + \beta_1) E_t \sigma_{t+s-1}^2$$

Therefore, for the conditional variance process to be stationary that must be satisfied $|\alpha_1 + \beta_1| < 1$.

IGARCH model

It is common to find empirical evidence that GARCH (1,1) models introduced an estimation of the parameters $\hat{\alpha}_1$ and $\hat{\beta}_1$ values of $|\alpha_1 + \beta_1|$ close to one, which makes the process integrated in variance and no stationary. In the literature is called IGARCH (*Integrated GARCH*).

Consider a GARCH (1,1) process:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \cdot \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

if $\alpha_1 + \beta_1 = 1$, we have:

$$\begin{aligned} \sigma_t^2 &= \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + (1 - \alpha_1) \sigma_{t-1}^2 \\ \sigma_t^2 &= \alpha_0 + \sigma_{t-1}^2 + \alpha_1 \varepsilon_{t-1}^2 - \alpha_1 \sigma_{t-1}^2 \\ IGARCH(1,1): \quad \sigma_t^2 &= \alpha_0 + \sigma_{t-1}^2 + \alpha_1 (\varepsilon_{t-1}^2 - \sigma_{t-1}^2) \end{aligned}$$

Annex C – Johansen cointegration test results

Table C.1: Uruguayan model

| Cointegration test of unrestricted range (Trace) | | | | |
|---|------------|-----------------------|------------------------|---------|
| Hypothesis Nº of Eq(s) | Eigenvalue | Trace | 0.05 Critical value | Prob.** |
| None * | 0.140975 | 53.68091 | 47.85613 | 0.0129 |
| At least 1 | 0.041784 | 15.69157 | 29.79707 | 0.7338 |
| At least 2 | 0.019840 | 5.021150 | 15.49471 | 0.8066 |
| At least 3 | 4.52E-05 | 0.011308 | 3.841466 | 0.9151 |
| Cointegration test of unrestricted range (Maximum eigenvalue) | | | | |
| Hypothesis Nº of Eq(s) | Eigenvalue | Maximum eigenvalue | 0.05 Critical value | Prob.** |
| None * | 0.140975 | 37.98934 | 27.58434 | 0.0016 |
| At least 1 | 0.041784 | 10.67042 | 21.13162 | 0.6801 |
| At least 2 | 0.019840 | 5.009842 | 14.26460 | 0.7406 |
| At least 3 | 4.52E-05 | 0.011308 | 3.841466 | 0.9151 |

Table C.2: Brazilian model

| Cointegration test of unrestricted range (Trace) | | | | |
|--|------------|-----------------------|------------------------|---------|
| Hypothesis Nº of Eq(s) | Eigenvalue | Trace | 0.05 Critical value | Prob.** |
| None * | 0.104005 | 34.33773 | 29.79707 | 0.0140 |
| At least 1 | 0.025802 | 6.663086 | 15.49471 | 0.6171 |
| At least 2 | 0.000301 | 0.075740 | 3.841466 | 0.7831 |
| Cointegration test of unrestricted range (Maximum eigenvalue) | | | | |
| Hypothesis Nº of Eq(s) | Eigenvalue | Maximum eigenvalue | 0.05 Critical value | Prob.** |
| None * | 0.104005 | 27.67465 | 21.13162 | 0.0052 |
| At least 1 | 0.025802 | 6.587346 | 14.26460 | 0.5390 |
| At least 2 | 0.000301 | 0.075740 | 3.841466 | 0.7831 |

Table C.3: Chilean model

| Cointegration test of unrestricted range (Trace) | | | | |
|--|------------|--------------------|------------------------|---------|
| Hypothesis Nº de Eq(s) | Eigenvalue | Trace | 0.05 Critical value | Prob.** |
| None * | 0.153694 | 68.05011 | 47.85613 | 0.0002 |
| At least 1 | 0.050201 | 21.82604 | 29.79707 | 0.3083 |
| At least 2 | 0.025631 | 7.559157 | 15.49471 | 0.5137 |
| Cointegration test of unrestricted range (Maximum eigenvalue) | | | | |
| Hypothesis Nº de Eq(s) | Eigenvalue | Maximum eigenvalue | 0.05 Critical value | Prob.** |
| None * | 0.153694 | 46.22407 | 27.58434 | 0.0001 |
| At least 1 | 0.050201 | 14.26688 | 21.13162 | 0.3435 |
| At least 2 | 0.025631 | 7.192327 | 14.26460 | 0.4666 |

Table C.4: New Zealand model

| Cointegration test of unrestricted range (Trace) | | | | |
|--|------------|--------------------|------------------------|---------|
| Hypothesis Nº de Eq(s) | Eigenvalue | Trace | 0.05 Critical value | Prob.** |
| None * | 0.094067 | 61.07859 | 54.07904 | 0.0105 |
| At least 1 | 0.074656 | 33.02212 | 35.19275 | 0.0842 |
| At least 2 | 0.028089 | 10.98649 | 20.26184 | 0.5434 |
| Cointegration test of unrestricted range (Maximum eigenvalue) | | | | |
| Hypothesis Nº de Eq(s) | Eigenvalue | Maximum eigenvalue | 0.05 Critical value | Prob.** |
| None * | 0.094020 | 28.04172 | 27.58434 | 0.0437 |
| At least 1 | 0.048333 | 14.06953 | 21.13162 | 0.3594 |
| At least 2 | 0.010187 | 2.908050 | 14.26460 | 0.9527 |

Annex D – Models Results

Table D.1: Uruguayan model

| | | | | |
|---|--------------------------------------|--------------------------------|--------------------------------|--------------------------------------|
| Vector Error Correction Estimates | | | | |
| Sample (adjusted): 1993M03 2013M12 | | | | |
| Included observations: 250 after adjustments | | | | |
| Standard errors in () & t-statistics in [] | | | | |
| Cointegration Restrictions: | | | | |
| B(1,1)=1, A(2,1)=0, A(3,1)=0, | | | | |
| Convergence achieved after 6 iterations. | | | | |
| Restrictions identify all cointegrating vectors | | | | |
| LR test for binding restrictions (rank = 1): | | | | |
| Chi-square(2) | 1.551365 | | | |
| Probability | 0.460389 | | | |
| CointegratingEq: | CointEq1 | | | |
| X_URU(-1) | 1.000000 | | | |
| LM(-1) | -0.502423 (0.09624) [-5.22027] | | | |
| LPR(-1) | -0.927918 (0.13380) [-6.93516] | | | |
| RERV_URU(-1) | 0.191734 (0.03784) [5.06706] | | | |
| C | 5.138552 | | | |
| Error Correction: | D(X_URU) | D(LM) | D(LPR) | D(RERV_URU) |
| CointEq1 | -0.207329 (0.04668) [-4.44137] | 0.000000 (0.00000) [NA] | 0.000000 (0.00000) [NA] | -0.203877 (0.06048) [-3.37071] |

Residual test:**Normality**

| VEC Residual Normality Tests | | | | |
|--|-------------|----------|--------|--------|
| Orthogonalization: Cholesky (Lutkepohl) | | | | |
| Null Hypothesis: residuals are multivariate normal | | | | |
| Sample: 1993M03 2013M12 | | | | |
| Included observations: 250 | | | | |
| Component | Skewness | Chi-sq | df | Prob. |
| 1 | -0.085123 | 0.301916 | 1 | 0.5827 |
| 2 | -0.144562 | 0.870763 | 1 | 0.3507 |
| 3 | 0.108172 | 0.487549 | 1 | 0.4850 |
| 4 | 0.994500 | 41.20961 | 1 | 0.0000 |
| Joint | | 42.86983 | 4 | 0.0000 |
| Component | Kurtosis | Chi-sq | df | Prob. |
| 1 | 3.237702 | 0.588564 | 1 | 0.4430 |
| 2 | 3.190737 | 0.378966 | 1 | 0.5382 |
| 3 | 3.085267 | 0.075734 | 1 | 0.7832 |
| 4 | 4.216044 | 15.40378 | 1 | 0.0001 |
| Joint | | 16.44704 | 4 | 0.0025 |
| Component | Jarque-Bera | df | Prob. | |
| 1 | 0.890480 | 2 | 0.6407 | |
| 2 | 1.249729 | 2 | 0.5353 | |
| 3 | 0.563283 | 2 | 0.7545 | |
| 4 | 56.61338 | 2 | 0.0000 | |
| Joint | 59.31687 | 8 | 0.0000 | |

Autocorrelation

| VEC Residual Serial Correlation LM Tests | | |
|---|----------|--------|
| Null Hypothesis: no serial correlation at lag order h | | |
| Sample: 1993M03 2013M12 | | |
| Included observations: 250 | | |
| Lags | LM-Stat | Prob |
| 1 | 23.70344 | 0.0962 |
| 2 | 20.09245 | 0.2161 |
| 3 | 30.80591 | 0.0142 |
| 4 | 25.95701 | 0.0546 |
| 5 | 17.49204 | 0.3545 |
| 6 | 21.10790 | 0.1744 |
| 7 | 22.66119 | 0.1231 |
| 8 | 11.49250 | 0.7781 |
| 9 | 16.73246 | 0.4031 |
| 10 | 23.35148 | 0.1047 |
| 11 | 22.07018 | 0.1409 |
| 12 | 28.93485 | 0.0244 |
| Probs from chi-square with 16 df. | | |

Table D.2: Brazilian model

| | | | |
|--|--------------------------------------|-------------------------------------|-------------------------------------|
| Vector Error Correction Estimates | | | |
| Sample (adjusted): 1990M06 2013M12 | | | |
| Included observations: 283 after adjustments | | | |
| Standard errors in () & t-statistics in [] | | | |
| Cointegrating Eq: | CointEq1 | | |
| X_BRA(-1) | 1.000000 | | |
| LM(-1) | -1.070672 (0.06831) [-15.6731] | | |
| LPR(-1) | -0.452393 (0.10537) [-4.29324] | | |
| C | 7.586089 | | |
| Error Correction: | D(X_BRA) | D(LM) | D(LPR) |
| CointEq1 | -0.118187 (0.05965) [-1.98123] | 0.044218 (0.02315) [1.91019] | 0.056922 (0.01851) [3.07458] |

Residual test:**Normality**

| VEC Residual Normality Tests | | | | |
|--|-------------|----------|--------|--------|
| Orthogonalization: Cholesky (Lutkepohl) | | | | |
| Null Hypothesis: residuals are multivariate normal | | | | |
| Sample: 1990M01 2013M12 | | | | |
| Included observations: 283 | | | | |
| Component | Skewness | Chi-sq | df | Prob. |
| 1 | -0.078317 | 0.289296 | 1 | 0.5907 |
| 2 | 0.061815 | 0.180226 | 1 | 0.6712 |
| 3 | 0.201455 | 1.914208 | 1 | 0.1665 |
| Joint | | 2.383731 | 3 | 0.4967 |
| Component | Kurtosis | Chi-sq | df | Prob. |
| 1 | 3.700502 | 5.786212 | 1 | 0.0162 |
| 2 | 3.217635 | 0.558514 | 1 | 0.4549 |
| 3 | 3.139177 | 0.228406 | 1 | 0.6327 |
| Joint | | 6.573132 | 3 | 0.0868 |
| Component | Jarque-Bera | df | Prob. | |
| 1 | 6.075508 | 2 | 0.0479 | |
| 2 | 0.738741 | 2 | 0.6912 | |
| 3 | 2.142614 | 2 | 0.3426 | |
| Joint | 8.956863 | 6 | 0.1760 | |

Autocorrelation

| VEC Residual Serial Correlation LM Tests | | |
|---|----------|--------|
| Null Hypothesis: no serial correlation at lag order h | | |
| Sample: 1990M01 2013M12 | | |
| Included observations: 283 | | |
| Lags | LM-Stat | Prob |
| 1 | 4.997619 | 0.8345 |
| 2 | 10.17259 | 0.3367 |
| 3 | 13.65610 | 0.1351 |
| 4 | 9.110659 | 0.4271 |
| 5 | 10.85226 | 0.2860 |
| 6 | 5.165150 | 0.8197 |
| 7 | 5.296782 | 0.8077 |
| 8 | 10.18649 | 0.3356 |
| 9 | 21.84128 | 0.0094 |
| 10 | 8.604039 | 0.4746 |
| 11 | 7.826809 | 0.5517 |
| 12 | 10.79665 | 0.2899 |
| Probs from chi-square with 9 df. | | |

Table D.3: Chilean model

| | | | | |
|---|--------------------------------------|--------------------------------|-------------------------------------|--------------------------------------|
| Vector Error Correction Estimates | | | | |
| Sample (adjusted): 1990M06 2013M12 | | | | |
| Included observations: 277 after adjustments | | | | |
| Standard errors in () & t-statistics in [] | | | | |
| Cointegration Restrictions: | | | | |
| B(1,1)=1, A(2,1)=0, | | | | |
| Convergence achieved after 4 iterations. | | | | |
| Restrictions identify all cointegrating vectors | | | | |
| LR test for binding restrictions (rank = 1): | | | | |
| Chi-square(1) | 1.769021 | | | |
| Probability | 0.183503 | | | |
| Cointegrating Eq: | CointEq1 | | | |
| X_CHI(-1) | 1.000000 | | | |
| LM(-1) | -1.316998 (0.08887) [-14.8189] | | | |
| LPRM(-1) | -0.166941 (0.07093) [-2.35376] | | | |
| RER_CH(-1) | 0.539220 (0.14887) [3.62200] | | | |
| C | 8.040838 | | | |
| Error Correction: | D(X_CHI) | D(LM) | D(LPRM) | D(RER_CH) |
| CointEq1 | -0.233239 (0.05856) [-3.98285] | 0.000000 (0.00000) [NA] | 0.074113 (0.02656) [2.79033] | -0.043966 (0.01238) [-3.55260] |

Residual test:**Normality**

| VEC Residual Normality Tests | | | | |
|--|-------------|----------|--------|--------|
| Orthogonalization: Cholesky (Lutkepohl) | | | | |
| Null Hypothesis: residuals are multivariate normal | | | | |
| Sample: 1990M01 2013M12 | | | | |
| Included observations: 277 | | | | |
| Component | Skewness | Chi-sq | df | Prob. |
| 1 | -0.185299 | 1.585161 | 1 | 0.2080 |
| 2 | -0.071681 | 0.237211 | 1 | 0.6262 |
| 3 | -0.183284 | 1.550878 | 1 | 0.2130 |
| 4 | 0.105833 | 0.517099 | 1 | 0.4721 |
| Joint | | 3.890348 | 4 | 0.4210 |
| Component | Kurtosis | Chi-sq | df | Prob. |
| 1 | 2.859900 | 0.226540 | 1 | 0.6341 |
| 2 | 3.220555 | 0.561440 | 1 | 0.4537 |
| 3 | 3.772636 | 6.889987 | 1 | 0.0087 |
| 4 | 3.346623 | 1.386701 | 1 | 0.2390 |
| Joint | | 9.064667 | 4 | 0.0595 |
| Component | Jarque-Bera | df | Prob. | |
| 1 | 1.811701 | 2 | 0.4042 | |
| 2 | 0.798651 | 2 | 0.6708 | |
| 3 | 8.440865 | 2 | 0.0147 | |
| 4 | 1.903800 | 2 | 0.3860 | |
| Joint | 12.95502 | 8 | 0.1134 | |

Autocorrelation

| VEC Residual Serial Correlation LM Tests | | |
|---|----------|--------|
| Null Hypothesis: no serial correlation at lag order h | | |
| Sample: 1990M01 2013M12 | | |
| Included observations: 277 | | |
| Lags | LM-Stat | Prob |
| 1 | 23.87143 | 0.0924 |
| 2 | 22.28878 | 0.1341 |
| 3 | 14.32512 | 0.5745 |
| 4 | 22.42527 | 0.1300 |
| 5 | 19.72569 | 0.2328 |
| 6 | 23.05194 | 0.1124 |
| 7 | 21.49179 | 0.1604 |
| 8 | 10.93513 | 0.8135 |
| 9 | 28.45800 | 0.0279 |
| 10 | 35.92216 | 0.0030 |
| 11 | 18.85981 | 0.2760 |
| 12 | 24.14159 | 0.0865 |
| Probs from chi-square with 16 df. | | |

Table D.4: New Zealand model

| | | | | |
|---|--------------------------------------|--------------------------------|-------------------------------------|--------------------------------|
| Vector Error Correction Estimates | | | | |
| Date: 05/13/15 Time: 17:03 | | | | |
| Sample (adjusted): 1990M05 2013M12 | | | | |
| Included observations: 284 after adjustments | | | | |
| Standard errors in () & t-statistics in [] | | | | |
| Cointegration Restrictions: | | | | |
| B(1,1)=1, A(2,1)=0, A(4,1)=0 | | | | |
| Convergence achieved after 4 iterations. | | | | |
| Restrictions identify all cointegrating vectors | | | | |
| LR test for binding restrictions (rank = 1): | | | | |
| Chi-square(2) | 1.135440 | | | |
| Probability | 0.566816 | | | |
| Cointegrating Eq: | CointEq1 | | | |
| X_NZEL(-1) | 1.000000 | | | |
| LM(-1) | -0.448953 (0.04062) [-11.0538] | | | |
| LPR(-1) | -0.315355 (0.11802) [-2.67199] | | | |
| RER_NZEL(-1) | -0.236838 (0.11478) [-2.06342] | | | |
| C | 1.614207 | | | |
| Error Correction: | D(X_NZEL) | D(LM) | D(LPR) | D(RER_NZEL) |
| CointEq1 | -0.323280 (0.07324) [-4.41382] | 0.000000 (0.00000) [NA] | 0.061456 (0.02884) [2.13080] | 0.000000 (0.00000) [NA] |

Residual test:**Normality**

| VEC Residual NormalityTests | | | | |
|--|-------------|----------|--------|--------|
| Orthogonalization: Residual Covariance (Urzua) | | | | |
| Null Hypothesis: residuals are multivariate normal | | | | |
| Sample: 1990M01 2013M12 | | | | |
| Included observations: 284 | | | | |
| Component | Skewness | Chi-sq | df | Prob. |
| 1 | -0.019800 | 0.018953 | 1 | 0.8905 |
| 2 | -0.056990 | 0.157008 | 1 | 0.6919 |
| 3 | 0.130703 | 0.825848 | 1 | 0.3635 |
| 4 | -0.090402 | 0.395077 | 1 | 0.5296 |
| Joint | | 1.396887 | 4 | 0.8447 |
| Component | Kurtosis | Chi-sq | df | Prob. |
| 1 | 2.779313 | 0.497113 | 1 | 0.4808 |
| 2 | 2.879669 | 0.122941 | 1 | 0.7259 |
| 3 | 3.471625 | 3.027686 | 1 | 0.0819 |
| 4 | 3.568841 | 4.340417 | 1 | 0.0372 |
| Joint | | 7.988157 | 4 | 0.0920 |
| Component | Jarque-Bera | df | Prob. | |
| 1 | 0.516066 | 2 | 0.7726 | |
| 2 | 0.279949 | 2 | 0.8694 | |
| 3 | 3.853534 | 2 | 0.1456 | |
| 4 | 4.735494 | 2 | 0.0937 | |
| Joint | 48.84045 | 55 | 0.7077 | |

Autocorrelation

| VEC Residual Serial Correlation LM Tests | | |
|---|----------|--------|
| Null Hypothesis: no serial correlation at lag order h | | |
| Date: 05/14/15 Time: 18:56 | | |
| Sample: 1990M01 2013M12 | | |
| Included observations: 284 | | |
| Lags | LM-Stat | Prob |
| 1 | 17.97660 | 0.3253 |
| 2 | 30.22301 | 0.0169 |
| 3 | 17.69669 | 0.3420 |
| 4 | 19.83141 | 0.2279 |
| 5 | 24.78242 | 0.0738 |
| 6 | 16.33738 | 0.4297 |
| 7 | 18.52146 | 0.2943 |
| 8 | 13.14609 | 0.6620 |
| 9 | 24.39440 | 0.0812 |
| 10 | 33.53211 | 0.0063 |
| 11 | 30.55773 | 0.0153 |
| 12 | 40.59445 | 0.0006 |
| Probs from chi-square with 16 df. | | |

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