LONG-RUN EFFECTS OF COMMODITY PRICES ON THE REAL EXCHANGE RATE: EVIDENCE FROM ARGENTINA

HILDEGART AHUMADA AND MAGDALENA CORNEJO

RESUMEN

El último *boom* en el precio de las *commodities* parece haber sido una bendición para muchos países exportadores como Argentina, pero pudo haber tenido efectos adicionales sobre la estructura económica. Siguiendo un enfoque de vectores cointegrados estudiamos un mecanismo de transmisión de los precios al tipo de cambio centrándonos en sus relaciones con las exportaciones agrícolas e importaciones de petróleo. Este enfoque permite obtener estimaciones consistentes de los efectos de largo plazo teniendo en cuenta sus posibles interacciones y evaluando exogeneidad. Encontramos que, controlando por factores domésticos, un aumento de los precios de las *commodities* aprecia el tipo de cambio.

Clasificación JEL: F14, F41

Palabras clave: Enfermedad Holandesa, precios de las materias primas, tipo de cambio real, cointegración.

ABSTRACT

The last commodity boom seems to have been a blessing for many commodity-export countries like Argentina, but it may have also had important effects on the exchange rate and economic structure. We develop a cointegration system approach to study a transmission mechanism of commodity prices on the exchange rate. We focus on their relationships with agricultural exports and also with oil imports. The system approach allows us to obtain consistent estimates of long-run effects taking into account possible interactions and testing exogeneity. We found that a rise in commodity prices appreciates the exchange rate when controlling by domestic determinants.

JEL Classification: F14, F41

Keywords: Dutch disease, commodity prices, real exchange rate, system cointegration.

LONG-RUN EFFECTS OF COMMODITY PRICES ON THE REAL EXCHANGE RATE: EVIDENCE FROM ARGENTINA[*]

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I.   Introduction

The last commodity boom seemed to be a new reality for developing economies that produce and export natural resources. For those countries that faced the positive (and unusually long-lasting) shock of high commodity prices, the resulting export growth of natural resources seemed to be a blessing for their economies, but it may have also had important effects on the exchange rate and, through it, on the economic structure. Furthermore, recurrent patterns of commodity booms and busts have created significant uncertainty for commodity exporting economies, in particular when there are doubts whether the observed behavior of commodity prices during the 2000s would be permanent or transitory (Powell, 2014).

Commodity price shocks are transmitted to an economy through at least two different channels: the fiscal channel (as rising commodity prices boost government revenues, mainly through export taxes) and the foreign exchange market. In this paper, we focus on the latter, although it may be related to the fiscal channel too. The exchange rate, as a decisive link between the internal and the international economy, should be first investigated to understand how commodity prices may finally affect domestic variables. The study of this channel allows us to evaluate the common belief that there exists a negative impact of natural resources on economic growth associated with the idea of the "Dutch disease". In this view, countries with abundant natural resources generate large profits for their producers. This has two major effects: a real

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exchange rate appreciation and an increase in their returns on production relative to other tradable goods. Therefore, there are no incentives to invest in other tradable goods, which results in a highly commodity-specialized economy. Some empirical studies, however, suggest that such a negative linkage does not in fact exist, or that there may even be a significantly positive one (see Brunnschweiler and Bulte, 2008; Alexeev and Conrad, 2009; van der Ploeg and Poelhekke, 2009).

In that vein, Argentina may be considered an interesting case to study as its rapid economic growth during the last decade may be associated with the commodity export boom. Likewise, Argentina's exports have become highly concentrated on a few raw materials and lightly processed primary products as shown in Section III. In 2011, seven out of the ten top export items were raw materials that accounted for 38% of total merchandise exports.[1] In particular, since the early 2000s the Argentine economy seems to have been benefited by the "soybean boom" as soybeans and its derived products have become the main source of external reserves. At the same time, after the large devaluation which took place when a convertibility regime that had lasted ten years was abandoned, a continuous real exchange rate appreciation was observed along with the steady price increase of its main commodity exports.

One particular fact of the recent commodity boom for the Argentine experience is that, while soybeans related products have led export performance and become a significant source of government revenues and international reserves, oil related exports, due to domestic policies, have declined in such a way that Argentina has reversed its hydrocarbon related trade surplus and is currently a net importer of energy. In this way, the commodity boom while positive overall has encountered some stabilizing effects due to the undoing of the next export position in energy. Using this evidence, Navajas (2011) argues that during the past decade energy has acted as a stabilizer of otherwise phenomenal positive terms of trade shock. Therefore, the price of soybeans (mainly) and oil can be identified as the main drivers behind the terms of trade shocks during the last decade. Moreover, the observed changes in the oil related trade flows raise the question if there has been a kind of "an antidote to the Dutch-disease effects".

Therefore our study is motivated to understand the transmission mechanisms of commodity prices on the Argentine economy by exploring the

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first link in the chain of effects to analyze if the economy suffered some symptoms of the Dutch disease. This requires modeling the effect of prices on the real exchange rate and also on exports, as well as how these variables interact. Due to the observed behavior of fuel imports, their relationship with oil prices and the exchange rate is also analyzed.

The effect of commodity prices on this economy has not often been examined. A few exceptions can be mentioned like the work of Fanelli and Albrieu (2013) in which they depict stylized facts observed during the commodity boom, highlight the positive shock that Argentina experienced in the last decade on its terms of trade, although they warn about how fragile the link between natural resources and sustainable growth may be. In their view, clear symptoms of natural resource curse appeared in the economy, characterized by an over-appropriation of rents and a systematic deterioration of the quality of policies. Thus, twin surpluses disappeared, monetary policy left the auto-insurance strategy, fiscal policy became strongly pro-cyclical, energy and transportation subsidies grew exponentially leading to an energy deficit, and the tax burden rose along with distortionary mechanisms associated with higher domestic inflation relative to foreign inflation (e.g. Frenkel and Rapetti, 2012).[2]

The economic expansion after the 2001-2002 crisis may be due not only to the direct effect of favorable international commodity prices, but also to the expansionary domestic aggregate demand (mainly private and public consumption) that the new government implemented. Large profits were generated by the commodity-export sector and income redistribution took place mainly through the implementation of commodity export taxes.

To understand how the commodity boom has affected the Argentine economy, we econometrically study the effects of commodity prices on the terms of trade. Therefore, the aim of this paper is two-fold. First, we estimate a system of commodity prices along with the exchange rate, exports, domestic consumption and agricultural output. Second, as Argentina's energy net export position has shown a huge and dramatic reversal process we estimate a system of oil imports, prices, real exchange rate and gross domestic product to analyze

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[2] See also Albrieu, López and Rozenwurcel (Coord., 2014) for further research on natural resources and the role of China in Latin American countries.

how negative external shocks, originated in the same commodity-boom, may affect the terms of trade.

Our sample comprises quite different economic regimes during the 1990s and 2000s. During the nineties, the convertibility regime established fixed peso-dollar parity, thus the variations in the real exchange rate were only possible through variations in domestic prices. During the 2001-2002 crisis the convertibility regime was abandoned and a managed float started. Over the last decade, the rise in domestic prices also contributed to the real exchange rate appreciation. Given the different exchange rate regime, the deep trade tax reform and other economic policies, Argentina has undergone major economic changes during the last two decades and this represents a main challenge for the econometric modeling of these relationships.

We apply Johansen's (1996) maximum-likelihood cointegration system approach. This approach allows us to focus on this set of variables (using a partial system) to assess their long-run (cointegration) relationships without losing information due to not modeling other potential determinants of the variables involved. This means that once cointegration is found, the results will remain valid if more variables are added to the model. Also, we can identify which variables are pulling and pushing the different relationships (by testing weak exogenity). We also take into account the effect of changes in the exchange rate by allowing for different deterministic components in the long-run relationships.

The paper is organized as follows: the next section outlines the economic background and discusses the transmission mechanisms of commodity prices on the real exchange rate and exports. Section III describes the data. Section IV presents the econometric approach for estimating the long-run structure and short-run dynamics. Section V discusses the specification of the deterministic components and presents the econometric results. Readers not interested in the econometric details can skip Section IV and V without losing track. Section VI sheds light on the main results of the econometric approach and takes a closer look on the effects of commodity prices on the real exchange rate and exports in the long-run. Finally, Section VI draws our main conclusions.

II.   The economic background

In order to evaluate the effects of commodity prices in the Argentine case, we adopt a framework of a small economy with a commodity-based export structure. We first study the effect of prices on export volumes and the exchange rate and how these variables interact.

We consider a standard commodity-export model in which exports are the difference between domestic supply and demand of exportable goods, taking international prices as given (see Corden and Neary, 1982, Corden, 1984, Arize, 1990, Reinhart, 1995; and for the Argentine case see Ahumada, 1996, Catão and Falcetti, 2002). The small open economy (SOE) assumption implies that this economy has no influence on international commodity prices and commodities produced in the country and abroad are homogenous. We consider the SOE assumption to be relevant for Argentina since this country can be considered to be a price taker in many of its commodities exports. That is, commodity prices are assumed to be exogenous although, in the case of soybeans, this assumption may be doubtful. This assumption will be tested later although we consider an aggregate price index of commodities over the sample period.

Therefore, exports will rise when: (a) there is an increase in the country's capacity to produce commodities, (b) there is an increase in the world price of commodities which makes their production more profitable and discourages the domestic demand for exportable goods, and (c) there is a depreciation of the real exchange rate, having the same effects as in (b).

The SOE assumption also implies that the real exchange rate is the equilibrating force whenever the (domestic) price of exportable goods changes. Periods of growing commodity exports would lead to a large inflow of foreign currency, resulting in an appreciation of the real exchange rate. Therefore, the fact that commodities exports and the real exchange rate may be jointly determined implies that they should be simultaneously modeled.

Many efforts have been made to empirically model exchange rate behavior arising from shocks in fundamental factors (see Frankel and Rose, 1995, and Froot and Rogoff, 1995 for a summary) such as productivity or government expenditure. Empirical studies differ in their choices of underlying real exchange rate fundamentals, depending on data availability and/or the economies analyzed.

As Chen and Rogoff (2003) show, world commodity price movements (exogenous in the SOE case) potentially explain (and may help to forecast) exchange rate fluctuations because primary commodities have a significant weight in their trade accounts. Therefore, an improvement in the terms of trade should tend to appreciate the real exchange rate in line with the hypothesis of the Dutch Disease.

Furthermore, an increase in domestic consumption (the sum of domestic private and public expenditure) may produce an appreciation of the real exchange rate. An increase in private or government expenditure raises the relative price of non-tradable goods because of a higher demand for non-tradable goods over their supply. Using quarterly data, Rogoff (1992) found that government spending appeared to be highly correlated with the real yen/dollar rate, but it does not enter significantly into the regressions once one controls for shocks to the world price of oil. De Gregorio, Giovanni and Wolf (1994) also found that government spending is highly significant for OECD countries. De Gregorio and Wolf (1994) have extended this analysis to incorporate terms of trade shocks which were found to be important empirically, though productivity and government spending differentials continue to be important too.

An increase in world commodity prices improves the current account as commodity exports become more competitive and tends to appreciate the real exchange rate through income or wealth effects. A rise in the commodity sector's productivity may raise the relative price of non-tradable goods (appreciate the real exchange rate) as the productivity increase is biased towards tradable goods. This may be indicative of the Balassa-Samuelson effect. However, the empirical evidence in favor of such an effect is weaker than commonly believed (Froot and Rogoff, 1995). [3]

During the commodity boom period, the economic policy based on highly subsidized domestic prices of energy and transport led to a decline in oil

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[3] Given that our aim is to study the relationship between commodity prices and the real exchange rate, we focus on a partial system that considers the determinants previously described. However, other determinants such as the external debt, foreign direct investment, among other, may also be relevant. The cointegration approach we followed allows us to consistently estimate the effect of commodity prices on the real exchange rate as explained in Section IV.

related exports in such a way that Argentina has reversed its hydrocarbon related trade surplus and became a net importer of energy. To understand the behavior of energy imports and to evaluate their relationship with the exchange rate, we specify an import demand for energy model as a typical demand function. That is, we study a long-run relationship in which fuel and lubricants imports are explained by the gross domestic product (a proxy to economic activity), the international oil price (which should be considered as given in a small-open economy) and the real exchange rate. Our system approach allows us to consider the potential effect of oil imports on the real exchange rate too and thereby, to evaluate if energy has acted as a stabilizer of otherwise phenomenal positive terms of trade shock.

   We econometrically study the depicted relationships in the following sections.

III.   Data description

   The data are quarterly over 1993Q1 to 2013Q4 (T=84). Figure 1 shows the behavior of the commodity export volume (x), an index of commodity prices (p^x), the real peso/dollar exchange rate (e), the agricultural sector GDP (y_agri)[4], the domestic consumption (d), the oil imports of Argentina (m), the gross domestic product (y) and the oil price (p^{oil}) (see Appendix A for sources and definitions).

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[4] Only the agricultural sector GDP was seasonally adjusted by X12-ARIMA due to a marked stochastic seasonality. Fixed seasonality is later addressed by using centered seasonal dummies in the system estimation.

Figure 1. The data
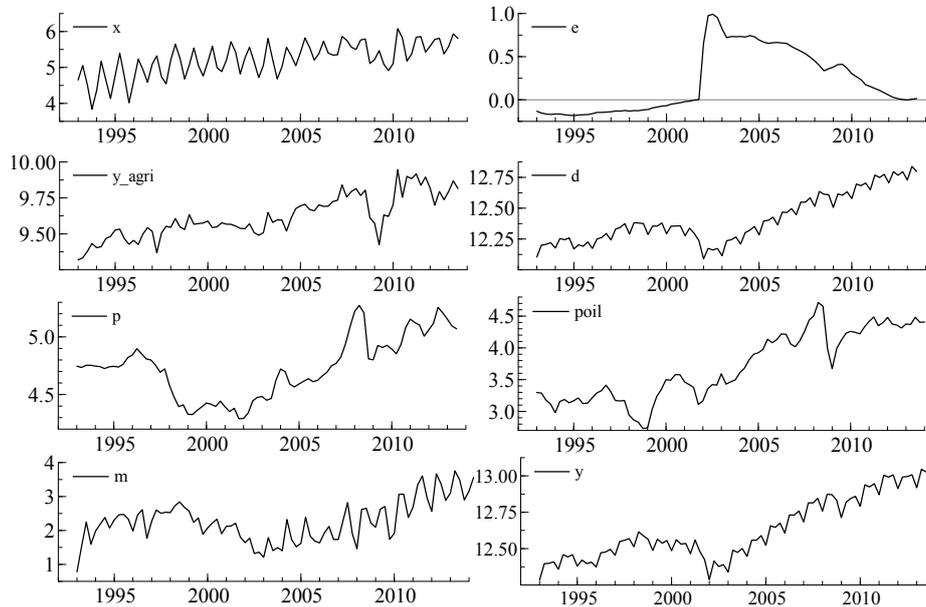
Note: data in logs.

As Figure 1 illustrates, the Argentine economy went through major changes in its economic policy and structure over the last two decades. We can distinguish two periods according to the evolution of the real peso/dollar exchange rate which marked two different macroeconomic policy frameworks. These periods also show the different behavior of commodity prices. The first period (1993-2001) was characterized by a convertibility regime which backed the monetary base with external reserves to guarantee the one peso to one dollar rate of exchange.

The exchange rate regime finally collapsed in January 2002, after the government announced a default on its sovereign debt and the abandonment of convertibility. The real exchange rate jumped 93% on a quarterly basis.

Argentina's impressive recovery since 2002 coincides with a period of historically high commodity prices. We can observe that the growth rate of domestic consumption (private and public consumption) has intensified since

2003 when expansionary demand policies were also followed by the new government. The initial sharp real depreciation of 2002 was followed by a long period of continuous appreciation.

It is worth noting that the world crisis that started in 2008 affected Argentina through commodity prices, but not through financial restrictions as no large volumes of new debt had been acquired after the default. In this context, expansionary fiscal and monetary policies stimulated economic growth.

Over the last decade, Argentina's exports became more concentrated on primary products reverting the trend showed during the 1990s when the export structure tended to be more diversified. The Figure 2 shows the evolution of the Herfindahl-Hirschman export concentration index (HHI).

Figure 2. Herfindahl-Hirschman export concentration index (HHI)
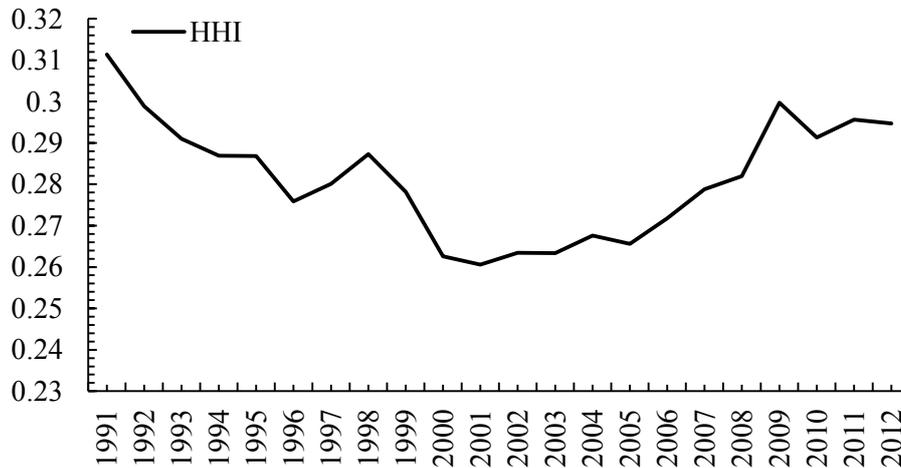
During this decade, Argentina gained from being exporter of agricultural commodities with the steady increase in international commodity prices. However, Argentina became a net importer of energy since 2011. Unlike in the food sector, where the country enjoys a structural surplus position given

productivity differentials and high commodity prices of soybeans, Argentina's energy net export position has shown a huge and dramatic reversal process and has added –given highly subsidized domestic prices of energy and transport- to a substantial increase in public expenditures. Figure 1 shows the positive trend of oil imports over the second half of the sample period. In the last years there has also been a growing concern that the spillovers arising from the disequilibrium in energy markets are contributing to a substantial weakening of macroeconomic conditions and that the challenges posed by negative external shocks might be compounded by the macroeconomic imbalances that energy policies have created. This situation led to focus on the so-called "new terms of trade" measured by the ratio of agricultural to oil prices.

Due to the economic instability of the studied period, the specification of the deterministic components, such as trends, broken trends (to reflect different rates of growth) and dummies (mainly for outliers), and how they enter the model is a key issue to be considered in the empirical modelling. This is because the chosen specification is likely to strongly affect the reliability of the model estimates and to change the asymptotic distribution of the cointegration test. We discuss the deterministic components in Section V (see also Appendix A). Furthermore, for an appropriate cointegration analysis, we test for multivariate stationarity of the variables entering both systems. These results are also shown in Section V. In accordance with these statistics, after including two linear broken trends for the first system and a linear trend for the second system, we can estimate a first order integrated - I(1) - system to study cointegration in both cases, as shown in the next section. However, readers not interested in the econometric methodology can jump to Section VI where we discuss the main results obtained.

IV.   The econometric approach

We start by estimating two systems: a 5-dimensional VAR model for $z'_t=[x_t; e_t; d_t; p^x_t; y\_agri_t]$ and a 4-dimensional VAR model for $z'_t=[m_t; e_t; y_t; p^{oil}_t]$. Small letters denote their logarithmic values. Given that the variables may grow at different rates (shown in Figure 1 in Section III), we use step dummies (and broken trends in the cointegration space) to control for these effects.

From the estimation of these systems we try to identify cointegration relationships which may represent the long run equilibria from the economic structure. A great advantage of this approach is the invariance of the cointegration property to the extension of the information set (see Juselius, 2006, chapter 19). This means that once cointegration is found among a set of variables, the cointegration results will remain valid if more variables are added to the system. Therefore, no omitted variable effects are present for cointegration when we adopt a specific-to-general strategy. The model is structured around r cointegration relations (the endogenous or pulling forces) corresponding to p-r stochastic trends (the exogenous or pushing forces). Therefore, the pulling force is formulated as a dynamic adjustment model in growth rates and equilibrium errors, the so-called Vector Equilibrium Correction Model (VEqCM),

$$\Delta z_t = \alpha\beta'z_{t-1} + \Gamma_1 z_{t-k} + \Phi D_t + \varepsilon_t \qquad\qquad (3)$$

where z_t is a p-dimensional vector of economic variables, D_t is a mx1 vector of m deterministic terms, $\varepsilon_t \sim$Niid(0; Ω) is a px1 vector of errors, Δ is the first difference operator, α, β are pxr coefficient matrices, Γ_1 is a pxp matrix of short-run adjustments coefficients, Φ is a pxm matrix of coefficients, and the lag length k in the corresponding VAR.

This model is designed to distinguish between influences that move equilibria (pushing forces) and influences that correct deviations from equilibrium (pulling forces) which give rise to long-run relations (see Juselius, 2006).

After determining the cointegration rank, the r-column vectors of β (the eigenvectors) allow us to find the long run solutions for economic models. But cointegration by itself does not indicate which variable adjusts to reach the equilibrium. The coefficients in α give the information about which variables adjust and thereby weak exogenity can be tested by zero restrictions in the respective coefficient, as suggested by Johansen (1992) and Urbain (1992).

Finally, it is important to note that the inclusion of deterministic components (trend, broken trends, different kind of dummies for the whole period and sub-periods) in the models is critical for the rank determination. In the case of the Argentine series, the choice of deterministic components is a particularly difficult task. The following sections focus on analyzing the appropriate deterministic components to be included in the system.

V. Econometric results

This section first presents cointegration results we obtained when considering broken linear trends and other deterministic components for the estimation of the two systems previously described. Therefore, the purpose of this section is to discuss how we applied the econometric approach described in Section IV in the context of the changing economic regimes of Argentina to take into account the possibility of simultaneous effects.

Cointegration analysis

First, to estimate the 5-dimensional VAR model for commodity exports, domestic demand, commodity prices, agricultural GDP and real exchange rate from the data previously described, based on prior knowledge of relevant historical events and the time properties of the series, we introduced the following deterministic components: i) centered seasonal dummies to control for the observed (fixed) seasonal pattern in x and d, ii) a linear trend for the whole sample and iii) two broken linear trends for the period 2002Q1-2013Q4 and 2008Q3-2013Q4, respectively. A set of impulse dummies is included unrestrictedly in the system.[5] The trends are restricted to enter the cointegration space since the variables can cointegrate but have different deterministic trends (see Juselius, 2006, p.98). In the case we analyzed, the deterministic trend differences would appear after 2002 when a completely new economic regime started (the convertibility regime was abandoned) and since third quarter of 2008 when the world crisis started. A step dummy 2002Q1-2013Q4 was also incorporated (unrestrictedly) to allow the growth

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[5] We included the following eleven impulse dummies (most of them were necessary to control for the exchange rate changes): 1995Q2, 1997Q2, 2002Q1, 2001Q4, 2002Q3, 2003Q1, 2003Q2, 2008Q4, 2009Q2, 2010Q2 and 2012Q3.

rates to change due to the similarity conditions of the broken trend, as suggested by Nielsen and Rahbek (2000).[6]

Second, for the 4-dimensional VAR model of oil imports, oil prices, gross domestic product and real exchange rate we also included centered seasonal dummies to control for the observed (fixed) seasonal pattern in *m* and a linear trend for the whole. A set of impulse dummies is included unrestrictedly in the system[7] as well as a step dummy for the period between 2002Q1 and 2013Q4, while the linear trend is restricted to enter the cointegration space.

After considering the extraordinary events over the sample period, the information criteria suggested different values of *k* for both systems. We prefer the Schwarz criterion for selecting the most parsimonious model with *k*=2 lags. After including the deterministic components as previously described, the VAR system passes most of the usual diagnostic tests reported in Table 1.[8]

Table 1. Specification tests for the unrestricted VAR(2) models (p-values)

Test	First System	Second System
Autocorrelation	0.91 (0.68)	1.13 (0.26)
Normality	15.91 (0.10)	5.87 (0.66)
Heteroskedasticity	1.76 (0.00)	0.94 (0.61)

Note: p-values are reported in parentheses.

Because the asymptotic distribution for the rank test depends on the deterministic components included in the model, we followed Johansen, Mosconi and Nielsen (2000) to empirically test cointegration in the presence of two broken linear trends for the first system. We compute critical values

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[6] An unrestricted step dummy since 2008Q3 was also initially included, but it was not significant.
[7] We included the following impulse dummies (most of them were necessary to control for the exchange rate changes): 1995Q1, 2002Q1, 2002Q3, 2003Q1, 2003Q3, 2005Q4, 2008Q4.
[8] The statistical inference is still valid in the cointegrated VAR in case of residual heteroscedasticity (see Juselius, 2006, Ch. 5).

using the response surface function from their Monte Carlo study. The correct choice of the cointegration rank, r, will influence all subsequent econometric analysis and may very well be crucial for whether or not we reject our prior economic hypotheses (Juselius, 2006: p.140).

Table 2 reports the estimates for eigenvalues, λ_i and the 95th percentile of the Γ-distribution when considering two broken trends and a shift dummy in the cointegration relations, $C_{.95}$ (see Nielsen, 1997 and Doornik, 1998).

Table 2. The rank test of cointegration

		First System					Second System		
r	p-r	l	λ_i	Test	r	p-r	l	λ_i	Test
0	5	1	0.67	233.32**	0	4	1	0.41	82.17**
1	4	2	0.61	141.24*	1	3	2	0.22	39.96
2	3	3	0.34	64.25	2	2	3	0.12	20.10
3	2	4	0.21	29.95	3	1	4	0.11	9.34
4	1	5	0.12	10.37					

Notes: ** and * indicate significance at the 1% and 5% level, respectively. Critical values for the First System were computed using the response surface function of Johansen, Mosconi and Nielsen (2000). At the 95% confidence level the corresponding critical values are: 125.61 (for r=0), 93.64 (for r=1), 65.78 (for r=2), 41.81 (for r=3) and 21.49 (for r=4).

Therefore, the tests for cointegration rank supports r=2 for the first system and r=1 for the second system. That is, two cointegration vectors can be obtained, which have a suitable economic interpretation as later explained. In Figure 3 we can see the recursive eigenvalues. Although for the first system there might be a third vector in the first part of the sample, it was not significant for the whole period.

Figure 3. Recursive eigenvalues
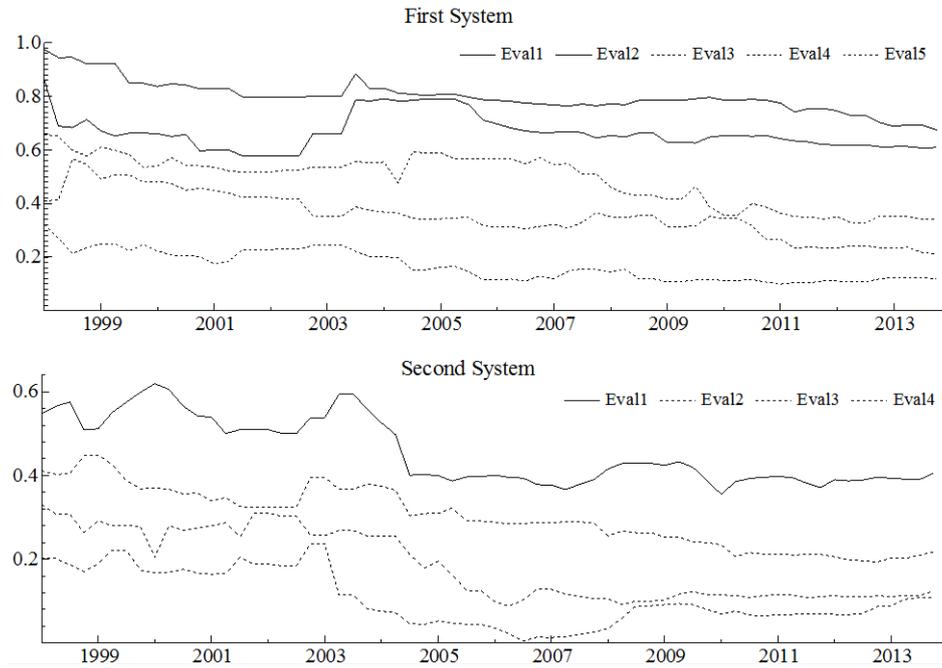
Table 3 reports the values of the multivariate statistic for testing trend stationarity of the variables entering the two systems. Specifically, this statistic tests the restriction that the cointegrating vector contains all zeros except for a unity corresponding to the designated variable and an unrestricted coefficient of the trend and broken trends.

Table 3. Multivariate stationary test

	x	e	d	p^x	y_agri	p^{oil}	m	y
First System $\chi^2(3)$	46.45**	31.39**	63.70**	60.21**	44.83**	--	--	--
Second System $\chi^2(4)$	--	36.40**	--	--	--	33.67**	28.96**	32.47**

Notes: ** and * indicate significance at the 1% and 5% level, respectively.

All tests reject the null of stationarity. By being multivariate, these statistics may have higher power than their univariate counterparts (see Appendix B). Also, the null hypothesis is the stationarity of a given variable rather than the nonstationarity thereof, and stationarity may be a more appealing null hypothesis.

After the cointegration rank has been determined, the cointegrated VAR can be estimated and the dimensions of the α and β matrices can also be defined. We proceed with our cointegration analysis by first imposing the long-run economic structure on the unrestricted cointegration relations. Table 4 shows the long-run effects of the first system, while Table 5 shows the estimated long-run relationship of the second system.

Table 4 shows the unrestricted β coefficients in the first two columns of the two cointegration vectors we found. Then we identified the β parameters (as shown in Column (3) and (4)) by imposing the following restrictions: a zero restriction on the domestic consumption coefficient and the broken trend since 2002 in the first vector and a zero restriction on the agricultural GDP in the second vector. The rationale for the identification of the long-run structure responds to both empirical and economic issues. First, we considered that the first vector would correspond to an export supply function and thus private and government expenditure is not expected to be a direct long run determinant of export volumes once we control for prices, exchange rate and production capacity. Furthermore domestic consumption and the broken trend since 2002 were not significant in the reduced-form. Moreover, the broken trend since 2002 showed the same behavior of the real exchange rate and when we restricted its coefficient to zero, the real exchange rate became significant and with the expected sign. We also considered the second vector as the equation of the exchange rate determination in this partial system. In this vector, the agricultural GDP was also not significant in the reduced-form. Once the (not rejected) restrictions are imposed, we obtained the standard errors of the identified β coefficients. We next impose restriction on the adjustment coefficients (α). Finding weakly exogenous variables by testing the hypothesis that certain variables do not adjust to long-run relations is helpful in order to identify the common driving trends. Therefore, columns (5) and (6) report the restricted adjustment coefficients. We found that commodity prices and the

domestic consumption are weakly exogenous in the two vectors.[9] Also commodity exports do not adjust in the real exchange rate vector.[10]

Table 4. Cointegration vectors for the first system

	Unrestricted β and α		Restricted β		Restricted β and α	
Eigenvectors, β						
	(1)	(2)	(3)	(4)	(5)	(6)
Variable	Vector 1	Vector 2	Vector 1	Vector 2	Vector 1	Vector 2
x	1.000	0.050	1.000	0.090 (0.040)	1.000	0.110 (0.040)
e	0.070	1.000	-1.150 (0.170)	1.000	-1.140 (0.170)	1.000
d	0.040	0.600	--	0.590 (0.170)	--	0.550 (0.170)
p^x	-0.230	0.150	-0.420 (0.120)	0.140 (0.040)	-0.420 (0.120)	0.130 (0.040)
y_agri	-1.820	0.060	-2.320 (0.210)	--	-2.380 (0.220)	--
$trend$	-0.020	-0.008	-0.010 (0.002)	-0.009 (0.002)	-0.010 (0.002)	-0.010 (0.001)
$trend_{2002Q1}$	0.020	0.010	--	0.010 (0.003)	--	0.010 (0.003)
$trend_{2008Q3}$	0.004	0.003	--	0.003 (0.001)	--	0.003 (0.001)
$\chi^2(j)$				1.690		
p-value				0.430		
j				2		
Adjustment coefficients, α						
	(1)	(2)	(3)	(4)	(5)	(6)

[9] Each restriction were tested separately too. The likelihood ratio (LR) test for commodity prices is $\chi^2(3)$=2.02, p-value=0.57 and for the domestic consumption: $\chi^2(3)$=3.99, p-value=0.26.
[10] Although the vectors were identified as exports and exchange rate equations, since the agricultural GDP also adjusts in both vectors and the real exchange rate adjust in the export function, the equations can be re-parameterized by normalizing on each of these variables and still have an economic interpretation.

Variable	Vector 1	Vector 2	Vector 1	Vector 2	Vector 1	Vector 2
x	-1.020	0.880	-0.870	0.030	-0.830	--
	(0.130)	(0.350)	(0.110)	(0.370)	(0.100)	
e	0.010	-0.260	0.020	-0.250	0.020	-0.270
	(0.010)	(0.030)	(0.010)	(0.030)	(0.010)	(0.030)
d	0.010	-0.070	0.010	-0.050	--	--
	(0.020)	(0.040)	(0.020)	(0.040)		
p^x	0.010	-0.200	0.001	-0.200	--	--
	(0.060)	(0.160)	(0.050)	(0.170)		
y_agri	0.150	0.250	0.150	0.390	0.130	0.410
	(0.060)	(0.150)	(0.050)	(0.150)	(0.040)	(0.130)
$\chi^2(j)$					8.530	
p-value					0.290	
j					7	

Notes: standard errors reported in parenthesis. Other unrestricted variables included are centered seasonals, a step dummy for 2002Q1-2013Q4 and the same impulse dummies of the VAR(2).

Thus, for the first system as a whole, commodity prices as well as domestic consumption were empirically detected as weakly exogenous, that is, these variables influenced the long-run stochastic path of the other variables in the system, while at the same time not being influenced by them.

Table 5. Cointegration vectors for the second system

	Unrestricted β and α	Restricted α	Restricted β and α
Eigenvectors, β			
Variable	(1)	(2)	(3)
m	1.000	1.000	1.000
p^{oil}	0.520	0.510	0.510
	(0.140)	(0.140)	(0.140)
y	-1.920	-1.730	-1.860
	(0.680)	(0.650)	(0.410)

Variable	(1)	(2)	(3)
e	1.390 (0.260)	1.380 (0.250)	1.360 (0.240)
$trend$	0.003 (0.006)	-0.002 (0.006)	--
$\chi^2(j)$			
p-value			
j			

Adjustment coefficients, α

Variable	(1)	(2)	(3)
m	-0.950 (0.170)	-0.980 (0.150)	-0.980 (0.150)
p^{oil}	-0.030 (0.080)	--	--
y	-0.010 (0.010)	--	--
e	0.010 (0.010)	--	--
$\chi^2(j)$		1.66	1.74
p-value		0.65	0.78
j		3	4

Notes: standard errors reported in parenthesis. Other unrestricted variables included are centered seasonals, a step dummy for 2002Q1-2013Q4 and the same impulse dummies of the VAR(2).

Regarding the second system, only oil imports adjust to deviations from the long run relationship, the other variables were empirically detected as weakly exogenous. In particular, we found no evidence of any compensating effects of oil imports on the real exchange rate appreciation.

VI.   Discussing the long-run transmission effects of commodity prices

As the main aim of our econometric analysis is to understand the long-run transmission effects of commodity prices on the real exchange rate and

exports, in this section we discuss the results we found (reported in Section V). We also discuss the interactions between these variables and which variables adjust to the deviations from the steady-state.

From the first estimated system, we identify two long-run (cointegration) relations which are,

$$x_t = constant + \underset{(0.17)}{1.14}\ e_t + \underset{(0.12)}{0.42}\ p_t^x + \underset{(0.22)}{2.38}\ y\_agri_t + \underset{(0.002)}{0.01}\ trend \quad (4)$$

$$e_t = constant - \underset{(0.04)}{0.11}\ x_t - \underset{(0.04)}{0.13}\ p_t^x - \underset{(0.17)}{0.55}\ d_t + \underset{(0.001)}{0.01}\ trend$$
$$- \underset{(0.003)}{0.01}\ trend_{2002Q1} - \underset{(0.0005)}{0.003}\ trend_{2008Q3} \quad (5)$$

These cointegration relations (also reported in Table 4) show the factors affecting both exports volume and real exchange rate in the long run, respectively. But which are the variables that adjust to deviations in each long-run relation? The econometric analysis (in Section V) allowed us to test weak exogeneity, rather than assuming from the outset which variables are exogenous and which are not. We found that in the first equation the commodity export volume, the agricultural production and the real exchange rate adjust to the deviations from the steady-state export supply function. In the second relation, both the real exchange rate and the agricultural production adjust to correct the deviations from the long run real exchange rate.

Commodity prices as well as domestic expenditure can be considered as given in (4) and (5).[11] The result of weak exogenous commodity prices validates the small country assumption and the price-taking hypothesis holds. We tested this assumption because the increasing Argentine participation in the soybean trade may suggest that commodity prices are not exogenous for the commodity-export model of Argentina. Furthermore, in this study we use an export-weighted commodity price index which might have implied that commodity prices were not exogenously determined in the export model.

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[11] Garegnani (2008) found effects of the exchange rate on consumption instead. However, they modeled private expenditure and the exchange rate has only short run effect effects.

The adjustment of more than one variable in each of the two equations shows the empirical value of a system approach to obtaining consistent estimates of the long-run effects, as next discussed.

From Equation (4) we can observe that the export volumes of commodities positively depends on the exchange rate, that is, a depreciation of the real exchange rate (an increase of the real peso/US dollar) leads to an increase in the exported quantity of raw materials as Argentine commodities exports become more competitive. Also a significant and positive effect of real commodity prices on exports is found. An increase in commodity prices will encourage commodity exports. It is worth noting that exports are more elastic to variations in the real exchange rate (1.14) than in the world price (0.42).

Furthermore, we found that an increase of the agricultural sector GDP raises the commodity export supply (the elasticity is near 2). We also detected that a linear trend for the whole sample is significant. This result indicates that the variables grow at different rates over the sample.

From Equation (5) it can be seen that the real exchange rate negatively depends on domestic consumption. An increase in domestic consumption (say 10%) implies an increase in non-tradable good prices pushing down the real exchange rate (in 5.5%). Regarding the effects of commodity prices, we found that a 10% increase in international commodities prices leads to a 1.3% appreciation of the real exchange rate. In this way, an improvement in the terms of trade tends to appreciate the real exchange rate, a result in line with the hypothesis of Dutch Disease. It should be noticed that the effect of domestic consumption on the exchange rate is also significant and the elasticity with respect to domestic demand is much higher than the elasticity with respect to commodity prices. This higher elasticity may be due to the effect of domestic inflation on the real exchange rate associated with increases in the excess of aggregate consumption over potential output.

Furthermore, no evidence of the Balassa-Samuelson effect was found when we used the agricultural production as an (imperfect) proxy of trade sector productivity. For the real exchange rate we found three significant linear trends: one for the whole sample and two broken trends: since 2002Q1 (after the default) and since 2008Q3 (world crisis).

Therefore, our results show that commodity prices have been a pushing force that has influenced the long-run (stochastic) path of both the exchange

rate and exports. For increases in commodity prices we could expect both increases in export volumes and an appreciation of the real exchange rate, which in turn discourages a rise in exports. We found this transmission effect in a sample period in which the aggregate domestic expenditure has been another pushing variable of the exchange rate, leading to a larger appreciation of the exchange rate.

From the second estimated system, we identify only one long-run (cointegration) relationship,

$$m_t = constant - \underset{(0.14)}{0.51} \; p_t^{oil} - \underset{(0.24)}{1.36} \; e_t + \underset{(0.41)}{1.86} \; y_t \qquad (6)$$

Oil imports negatively depend on the exchange rate, that is, a depreciation of the real exchange rate (an increase of the real peso/US dollar) leads to a decrease in the imported fuel and lubricants in Argentina.[12] Also a significant and negative effect of real oil prices on imports is found. As in the export case, oil imports are more elastic to variations in the real exchange rate (1.36) than in the international price (0.51). Finally, an increase of the gross domestic product raises oil imports (1.86).

One important finding of the second system estimation is that the exchange rate does not adjust to oil imports over the sample period.[13] Therefore, we cannot find evidence of attenuation of the appreciation process of the exchange rate due to high commodity prices. The rise in oil prices, in turn, tended to offset the gains derived from the export performance given the changes in the energy trade balances.

VII.   Conclusions

In this paper the behavior of commodity prices and the real exchange rate have been econometrically studied adopting a system approach. This is a central issue to analyze for many developing countries whose economies have

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[12] It should be noted that this estimated coefficient remained constant when we recursively estimated the system, even though the trade balance of energy became negative during the last part of the sample.
[13] This effect which is observed only during the last part of the sample may not be captured by our estimates of the exchange rate's adjustment coefficient.

undergone deep transformations as a result of the last commodity boom. For those facing the positive (and unusually long-lasting) shock of high commodity prices, the resulting export growth of natural resources may have also had important consequences derived from the exchange rate appreciation. We study these transmission mechanisms for Argentina, a long term and significant commodity producer and exporter.

At the same time, for the commodity importers, the last commodity boom represented a terms of trade deterioration. This is the Argentina case as far as the economy became a net oil importer since 2011.

We apply Johansen's (1996) cointegration approach for two different systems. In the first system, we found two long run relationships which can be identified with the excess export supply function and the real exchange rate function under the assumption of a small country. We tested exogeneity, rather than assuming from the outset which variables are exogenous and which not. For the system as a whole, only commodity prices and domestic consumption were weakly exogenous (the pushing variables).

Our results indicate that commodity prices have a positive effect on both the exchange rate and exports. Thus, increasing commodity prices, like those observed over the last decades, raised the commodity-export volume and appreciate the real exchange rate, which in turn discourages growth in exports. This finding is in line with the hypothesis of the Dutch disease. However, we found this transmission effect in a sample period in which the aggregate expenditure has been another pushing variable of the exchange rate. The expansionary policies adopted by the government seemed to lead to a larger appreciation of the exchange rate.

In the second system, we found only one long run relationship which was identified as an oil import demand. Oil imports negatively depend on the international oil prices and the real exchange rate. We also found a significant positive effect of the economic activity on oil imports. However, no evidence about the effect of imported volumes on the real exchange is found. The appreciation of the exchange rate in real terms originated in the commodity boom could not be attenuated by the effect of energy imports over the sample period studied.

In a nutshell, after controlling by domestic variables, the estimated models have shown how commodity prices have been a key variable to understand

their relationships with exports, oil imports and in particular with the exchange rate, which represent a first link in the chain of the effects of commodity prices on the Argentine economy.

References

Ahumada, Hildegart (1996). "Exportaciones Argentinas: su comportamiento de largo plazo y su dinámica". Instituto Torcuato Di Tella.

Albrieu, Ramiro, Andrés López, and Guillermo Rozenwurcel (Coord. 2014). "Los recursos naturales en la era China: ¿Una oportunidad para América Latina?". Red Mercosur 24.

Alexeev, Michael, and Robert Conrad (2009). "The elusive curse of oil." *The Review of Economics and Statistics,* Vol. 91(3): 586-598.

Arize, Augustine (1990). "An econometric investigation of export behaviour in seven Asian developing countries." *Applied Economics,* Vol. 22(7): 891-904.

Brunnschweiler, Christa N., and Erwin H. Bulte (2008). "The resource curse revisited and revised: A tale of paradoxes and red herrings." *Journal of Environmental Economics and Management,* Vol. 55(3): 248-264.

Catão, Luis, and Elisabetta Falcetti (2002). "Determinants of Argentina's External Trade." *Journal of Applied Economics,* Vol. V: 19-57.

Chen, Yu-chin, and Kenneth S. Rogoff (2003). "Commodity currencies." *Journal of International Economics,* Vol. 60(1): 133-160.

Corden, Warner M. (1984). "Booming Sector and Dutch Disease Economics: Survey and Consolidation." *Oxford Economic Papers,* Vol. 36: 359-380.

Corden, Warner M., and J. Peter Neary (1982). "Booming sector and de-industrialisation in a small open economy." *The Economic Journal,* Vol. 92: 825-848.

De Gregorio, José, Alberto Giovannini, and Holger C. Wolf (1994). "International evidence on tradables and nontradables inflation." *European Economic Review,* Vol. 38(6): 1225-1244.

De Gregorio, José, and Holger C. Wolf (1994). "Terms of trade, productivity, and the real exchange rate." NBER Working Paper.

Doornik, Jurgen A. (1998). "Approximations to the asymptotic distribution of cointegration tests." *Journal of Economic Surveys,* Vol. 12(5): 573-593.

Fanelli, José M., and Ramiro Albrieu (2013). "Recursos naturales, políticas y desempeño macroeconómico en la Argentina 2003-2012." *Boletín Informativo Techint,* Vol. 340: 17-44.

Frankel, Jeffrey, and Andrew Rose (1995). "Empirical Research on Nominal Exchange Rates." In *Handbook of International Economics*, ed. G. M. Grossman, and K. S. Rogoff, Vol. 3: 1689-1729. Amsterdam: Elsevier Science Publishers.

Frenkel, R., and Martín Rapetti (2012). "External Fragility or Deindustrialization: What is the Main Threat to Latin American Countries in the 2010s?". *World Economic Review*, Vol. 1: 37-57.

Froot, Kenneth A., and Kenneth S. Rogoff. (1995). "Perspectives on PPP and long-run real exchange rates." In *Handbook of International Economics*, ed. G. M. Grossman and K. S. Rogoff, Vol. 3: 1647-1688. Amsterdam: Elsevier Science Publishers.

Garegnani, M. Lorena (2008). "Enfoques alternativos para la modelación econométrica del consumo en Argentina". La Plata: Editorial de la Universidad Nacional de La Plata.

Johansen, Soren (1992). "Testing weak exogeneity and the order of cointegration in UK money demand data." *Journal of Policy Modeling,* Vol. 14(3): 313-334.

Johansen, Soren (1996). "Likelihood-based Inference in Cointegrated Vector Autoregressive Models". Oxford: Oxford University Press.

Johansen, Soren, Rocco Mosconi, and Bent Nielsen (2000). "Cointegration analysis in the presence of structural breaks in the deterministic trend." *The Econometrics Journal*, Vol. 3(2): 216-249.

Juselius, Katarina (2006). "The Cointegrated VAR Model. Methodology and Applications". Oxford: Oxford University Press.

Mariscal, Rodrigo, and Andrew Powell (2014). "Commodity Price Booms and Breaks: Detection, Magnitude and Implications for Developing Countries." Inter-American Development Bank, Research Department.

Navajas, Fernando (2011). "Energía, maldición de recursos y enfermedad holandesa." *Boletín Informativo Techint,* Vol. 336: 85-100.

Nielsen, Bent (1997). "Bartlett correction of the unit root test in autoregressive models." *Biometrika,* Vol. 84(2): 500-504.

Nielsen, Bent, and Anders Rahbek (2000). "Similarity issues in cointegration analysis." *Oxford Bulletin of Economics and Statistics,* Vol. 62(1): 5-22.

Reinhart, Carmen M. (1995). "Devaluation, relative prices, and international trade: evidence from developing countries." *IMF Staff Papers,* Vol. 42: 290-312.

Rogoff, Kenneth S. (1992). "Traded goods consumption smoothing and the random walk behavior of the real exchange rate." NBER Working Paper.

Urbain, Jean-Pierre (1992). "On weak exogeneity in error correction models." *Oxford Bulletin of Economics and Statistics,* Vol. 54: 187-207.

van der Ploeg, Frederick, and Steven Poelhekke (2009). "Volatility and the natural resource curse." *Oxford Economic Papers,* Vol. 61: 727-760.

Appendix A. Sources and definitions

The index of commodity prices (p^x), the real peso/dollar exchange rate (e) were obtained from the Central Bank of Argentina (both average quarterly). The index of commodity prices (IPMP) developed by the Central Bank of Argentina includes the prices of the most representative commodities for Argentine exports, updating the weights every year to reflect the product share in Argentine trade.

The gross domestic product (y), agricultural sector GDP (y_agri), and the domestic consumption (d), calculated as the sum of public and private expenditures (at constant prices), as well as the raw material export volume index (x) and oil imports of Argentina (m) measured as imported fuels and lubricants[14] were obtained from the Argentine National Institute of Statistics. The agricultural sector GDP was the only seasonally-adjusted series, by X12-ARIMA, as it showed a marked stochastic seasonal pattern.

Up to 2006Q4 we used official data from the described sources, but from 2007Q1 we used our own elaborated statistics for the real exchange rate, agricultural sector GDP and the domestic consumption based on private estimations.

Appendix B. Unit root tests

To analyze the degree of persistent behavior in the variables, univariate unit root tests are reported in Table B1. We used the ADF (Augmented Dickey-Fuller) test to examine the order of integration of the original variables and their changes. Results indicate that the (log) level of all the analyzed variables appear to be I(1).

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[14] This variable was deflated by the oil price (West Texas Intermediate, US$/barrel) obtained from the International Financial Statistics (IFS – IMF).

Table B.1. ADF statistics for testing unit root (quarterly data, 1993-2013)

Sample period 1993Q1-2013Q4

Variable	k	$t_{\mathrm{ADF}(k)}$	P	σ	t-prob	AIC	Constant	Trend	Seasonals
x	2	-3.724**	0.503	0.174	0.048	-3.407	Yes	Yes	Yes
x	2	-2.523	0.84	0.182	0.001	-3.325	Yes	No	Yes
e	1	-1.638	0.955	0.079	0.000	-5.039	Yes	Yes	No
e	1	-1.852	0.955	0.078	0.000	-5.065	Yes	No	No
d	1	-1.641	0.963	0.02	0.000	-7.783	Yes	Yes	Yes
d	1	0.159	1.002	0.02	0.000	-7.755	Yes	No	Yes
p^x	1	-2.422	0.909	0.072	0.002	-5.205	Yes	Yes	No
p^x	1	-1.604	0.95	0.073	0.002	-5.184	Yes	No	No
y_agri	3	-4.415**	0.418	0.067	0.038	-5.342	Yes	Yes	No
y_agri	1	-2.069	0.877	0.072	0.018	-5.228	Yes	No	No
m	2	-1.376	0.88	0.345	0.000	-2.069	Yes	Yes	No
m	3	0.07	1.005	0.307	0.000	-2.301	Yes	No	No
p^{oil}	1	-3.660*	0.767	0.126	0.001	-4.092	Yes	Yes	No
p^{oil}	2	-1.189	0.967	0.13	0.019	-4.034	Yes	No	No
y	1	-1.663	0.953	0.023	0.006	-7.451	Yes	Yes	Yes
y	1	0.035	1.001	0.234	0.009	-7.428	Yes	No	Yes
Δx	2	-8.306***	-1.02	0.184	0.037	-3.29	Yes	Yes	Yes
Δx	1	-10.16***	-0.608	0.188	0.000	-3.265	Yes	No	Yes
Δe	1	-5.646***	0.312	0.078	0.095	-5.042	Yes	Yes	No
Δe	1	-5.557***	0.334	0.079	0.113	-5.054	Yes	No	No
Δd	3	-2.895*	0.552	0.02	0.096	-7.743	Yes	Yes	Yes
Δd	3	-2.769*	0.585	0.02	0.081	-7.757	Yes	No	Yes
Δp^x	1	-6.437***	0.149	0.073	0.041	-5.186	Yes	Yes	No
Δp^x	1	-6.412***	0.162	0.073	0.046	-5.204	Yes	No	No
Δy_agri	3	-5.528***	-0.624	0.074	0.101	-5.142	Yes	Yes	No
Δy_agri	3	-5.387***	-0.606	0.075	0.098	-5.083	Yes	No	No
Δm	3	-5.779***	-1.098	0.292	0.010	-2.388	Yes	Yes	No
Δm	3	-5.683***	-1.057	0.293	0.008	-2.396	Yes	No	No

Δp^{oil}	1	-7.224***	0.026	0.131	0.011	-4.015	Yes	Yes	No
Δp^{oil}	1	-7.279***	0.026	0.13	0.010	-4.04	Yes	No	No
Δy	3	-3.078*	0.467	0.023	0.065	-7.424	Yes	Yes	Yes
Δy	3	-3.013**	0.489	0.023	0.056	-7.443	Yes	No	Yes

Notes: the columns report the name of the variable examined, the selected lag length (k) the Akaike Information Criterion (AIC), the ADF statistic ($t_{ADF(k)}$), the estimated coefficient on the lagged level that is being tested for a unit value (ρ), the regression's residual standard error (σ), the tail probability of the t-statistic on the longest lag of the final regression (t-prob), the AIC and the columns indicating the included deterministic components. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.