

# ANALYSIS OF HORIZONTAL PRICE TRANSMISSION: THE CASE OF MEXICO–UNITED STATES DRY BEAN TRADE

ANTONIO AGUILAR-LOPEZ<sup>1</sup>  
ALEŠ KUHAR<sup>2</sup>

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**ABSTRACT:** *Dry bean is the leading source of plant-based proteins in Mexico, yet the country's self-sufficiency shows an eroding tendency after the enforcement of NAFTA. During this period, the United States became Mexico's principal supplier of dry beans. The purpose of this paper is to analyse the price transmission for black and pinto dry beans in Mexico in the period between 2012 and 2019. The research results however reveal only a very limited relationship between the analysed prices in the two countries. It is established that price dynamics are predominantly governed by domestic market interactions rather than those transmitted across the border, hence the erosion of Mexico's self-sufficiency in dry bean cannot be entirely attributed to the trade liberalization..*

**Key words:** *horizontal price transmission, dry bean, United States–Mexico agricultural trade, vector auto-regression model*

**JEL classification:** E31; Q17

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## 1 BACKGROUND

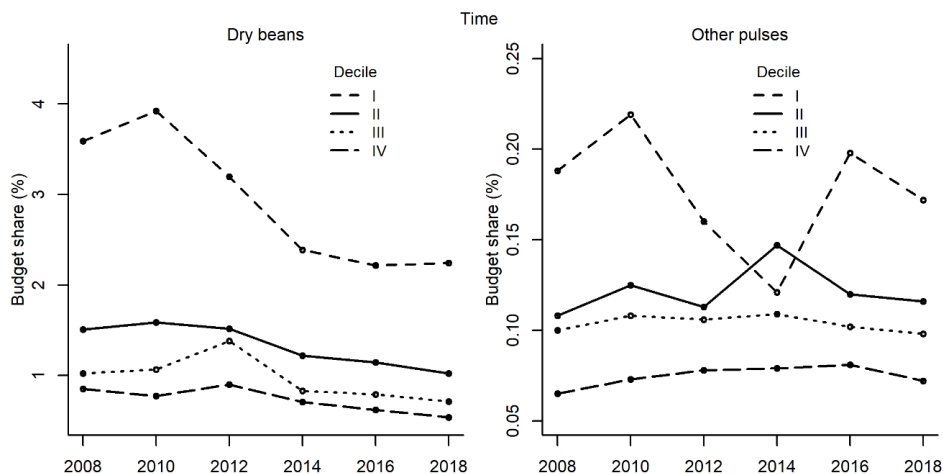
Dry bean plays a significant role in Mexico's economy since it is the leading source of low-cost plant-based proteins, particularly important for the considerable part of the country's population stricken by poverty and often still affected by undernourishment (Figure 1). Furthermore, it is also one of the main annual crops measured by the share of the cultivated agricultural land, however, most of the production takes place under rain-fed conditions and with low levels of productivity. Nonetheless, for many households in Mexico, dry bean is an important source of income and a determinant of welfare (Sangerman Jarquín et al., 2010). It is important to point out that, even though the growth of the per capita consumption of dry bean has slowed down during the last decades among Mexicans, data show that for households of the lower socioeconomic strata and those living in smaller communities, dry bean tends to account for a considerable share of their global spending on food (INEGI, 2019).

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1 Instituto Tecnológico Superior de Huichapan, División de Ingeniería en Gestión Empresarial, Huichapan, México

2 Corresponding author: University of Ljubljana, Biotechnical Faculty, Ljubljana, Slovenia, e-mail: ales.kuhar@bf.uni-lj.si

Figure 1: Average budget share for dry bean and other pulses (chickpeas, lentils, lima beans, and peas) for households of the lower income deciles (expenditure as a percentage of current quarterly income), 2008-2018

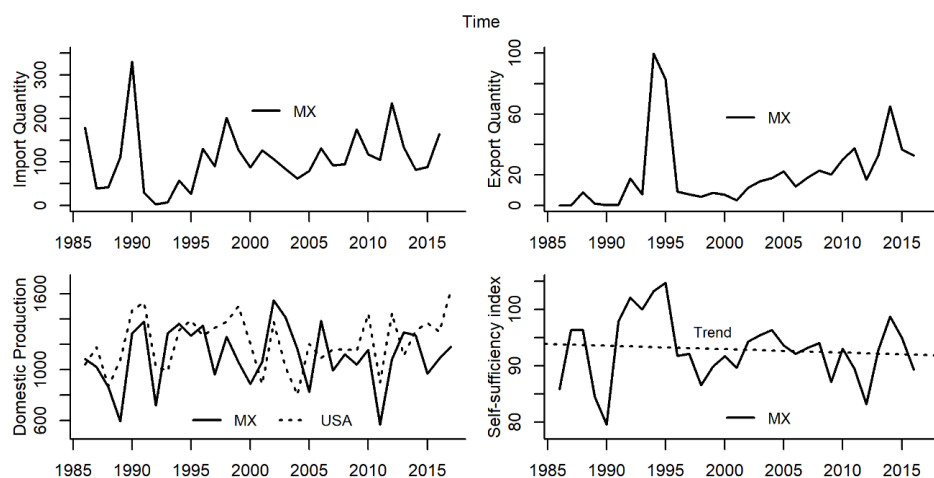


Source: own elaboration with data from INEGI 2019

Mexico still produces about 50 different varieties of beans which can be divided into four major groups. Black beans account for slightly less than a half of total Mexican bean consumption, Pinto beans represents one third and the remaining share is covered by pink and yellow varieties. Production is spatially concentrated and three regions are responsible for about 80% of the country's dry bean production, much whereof takes place under semi-arid conditions (Vallejo Díaz, 2010). On an aggregate level, Mexico's dry bean production has shown a notable variation in the last decade, but the overall trend has been relatively flat.

According to the FAOSTAT data (FAO, 2019), in 2017 the quantities produced were 1.18 million tonnes, which is slightly above the ten year's average (1.10 million tonnes). Despite the relatively high production quantities in the last years, these are insufficient to cover the apparent national consumption of this commodity which is slightly increasing. Therefore, demand was met by increasing imports and consequently Mexico's self-sufficiency index for dry beans measured as the ratio of domestic production to apparent national consumption depicts a slightly eroding tendency (Figure 2).

Figure 2: Mexico's domestic production of dry beans, imports, exports, and self-sufficiency index (1986-2017), quantities in thousand metric tonnes. FAO, 2019



Source: Own elaboration.

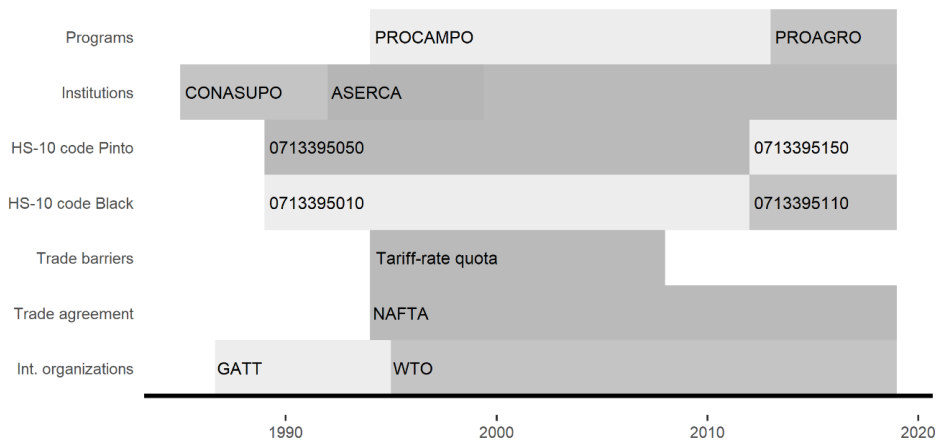
Mexico is a major participant in international agricultural trade and the United States (U.S.) is the country's largest agricultural trading partner, accounting for almost 90% of exports and 70% of imports of agro-food categories. The U.S. is also the principal foreign supplier of dry beans to Mexico as it has imported on average around 130 thousand tonnes of the commodity in the last decade. Since its share is more than 95%, the U.S. traditionally accounts for almost all of Mexico's dry beans imports. The figure Import Quantity reveals the total imported quantities of dry beans were generally fluctuating, nevertheless, with a slightly upward trend (Figure 2). The last available data for 2016 are 164 thousand tonnes, which is notably above the ten-year average. Pinto and black beans from the U.S. represented on average 46.16% of Mexican imports of dry beans during the 2012-2018 period (FAO, 2019).

Beans are one of the four agricultural commodities commonly known as sensitive products in Mexico, and consequently there is a long history of government protection and intervention on this market (Yunez-Naude, 2003). On the contrary, economic liberalism has been the framework for Mexico's general economic and agricultural policies during the last decades. The debt crisis of 1982 marked the end of the import substitution model for the country and ushered it into an era of exposure to international competition, as well as the liberalization of production and labour markets (Martínez, 2007). Thus, Mexico joined the General Agreement on Tariffs and Trade (GATT) in 1985 and then NAFTA<sup>3</sup> in 1994 (OECD, 2006). Mexico's agricultural sector was not a part of the liberalisation process, and prior to the agricultural policy reform in 1990 the government heavily

<sup>3</sup> North American Free Trade Agreement.

regulated the prices and marketed the output of beans. Consequently, international trade became insignificant and substantial policy induced distortions were present. Mexico continued the expensive policy system of market intervention with tariffs, import quotas and guaranteed or concerted agricultural commodity prices until the trade liberalisation under NAFTA, therefore maintaining its domestic bean prices above world prices (*producer price support*). Moreover, the system of consumer subsidies<sup>4</sup> for beans provided a considerable consumer price support (Baffes & Gardner, 2003). The trade policy for the dry bean sector, however, changed substantially with the inception of the NAFTA. The agreement included the tariff phase-out schedule which combined tariff-free quotas with declining tariff rates for over-quota imports for the four sensitive agricultural products, namely, maize, dry beans, milk and sugar. All the import barriers insulating the Mexican agricultural sector against trade with the U.S. and Canada were phased out in 2008. A common Most-Favoured-Nation tariff of 125.1% is applied by Mexico to imports of dry bean from third countries, though, as already mentioned, these imports are not significant in most of the years (OECD, 2006).

Figure 3: Policy structure for the black and pinto beans sector in Mexico (1980-2018)



Source: Own elaboration.

<sup>4</sup> Until 1999, the system of consumer subsidies was run by a parastatal organization “Compañía Nacional de Subsistencias Populares” (CONASUPO), which was in charge of the activities related to food security for beans, maize, feed products and milk powder.

The Mexican government also directed income transfers to producers of basic crops by means of institutions and programs such as ASERCA (1991), PROCAMPO (1993), and Alianza para el Campo (1995). The PROCAMPO program was expanded and then renamed to PROAGRO in 2012. These programs included agricultural diesel and energy subsidies, commodity storage support, investment support throughout the production process, marketing services and diversification support for uncompetitive bean farmers (Yunez-Naude & Barceinas Paredes, 2004). The development of the policy structure for Mexico's black and pinto beans sector is presented in Figure 3.

The implications of the market liberalisation under NAFTA have been addressed in numerous studies. In the case of the agricultural sector, Yunez-Naude & Barceinas Paredes (2004) pointed to the following expected outcomes from the treaty, namely, 1) domestic prices would fulfil the Law of One Price (or LOP; in this case, they would mirror the U.S. prices), 2) prices of imported commodities would manifest reductions, and 3) exposure to international competition would increase productivity and/or reduce the domestic supply of importable commodities. Moreover, the dry bean sector alone has been the subject of several papers and reports. The study of García Salazar et al. (2006) evaluates the effects of import tariff reduction and the exchange rate changes by an inter-temporal and spatial equilibrium model. Following the same approach, Borja Bravo & García Salazar (2008) assess policy scenarios aimed at the reduction of imports. Ayala Garay et al. (2008) analyse the competitiveness and profitability of the sector in Mexico and the U.S., while Sangerman Jarquín et al. (2010) focus on the evolution of dry bean production in Mexico and the consequences of the trade agreement. Further, Zahniser et al. (2010) provide a comprehensive report of the dry bean sectors of Mexico and the U.S. Although some of the above-mentioned contributions include brief comments related to the expected implications of the trade liberalisation on prices of agricultural commodities, they focus mainly on the competitiveness of the Mexican producers.

There is nevertheless no comprehensive and focused study which analyses the evolution of prices and how the international prices of dry beans are transmitted to the Mexican market. Thus, a decade of an entire exposition of the Mexico's dry bean market to the international dynamics calls for a detailed assessment of the issue, using recent data and contemporary time series econometrics methods. Considering the foregoing, the authors aim at analysing the horizontal price transmission of the world prices (*namely the U.S. export prices*) to the Mexican market of Pinto and Black beans exclusively. Therefore, the central objective of the paper is to evaluate the level of integration in the markets mentioned above, providing a detailed insight into the dynamics of prices of the two most relevant varieties of dry beans using the vector auto-regression models (VAR). Understanding the price co-movements across the markets is often a central focus when one tries to evaluate the level of market integration and market efficiency. For that reason, the horizontal price transmission analysis attracts notable academic attention and the paper tries to expand the available methodological and empirical applications. Contributions from less developed countries that rely heavily on food imports, from the post-communist economies interested in the functioning of the re-established market mechanism and from those subject to economic

policy reforms geared towards the liberalization of their domestic markets, keep growing. The rationale driving this interest is that an appropriate level of price transmission may predict efficient arbitrage and serve as a measure of market efficiency.

The presented analysis also corresponds with another important trade agreement to be implemented, namely the United States–Mexico–Canada Agreement (USMCA) which has been signed but not yet ratified<sup>5</sup>. The issue of the sensitivity of the dry bean market and the corresponding prices has often been mentioned by the Mexico’s policy makers and reported by the media. The results might therefore help to achieve more effective agricultural policy governance and to support the actual implementation of the USMCA.

The remainder of the paper is organized as follows. After starting with the “Methodological approach” section which presents the methodology with the arguments for the selection of the models, the “Data” section in the continuation provides a description of the data used, whereas the empirical results are presented in the “Results and discussion” section. Finally, the remarks and policy recommendations are included in the section “Conclusions”.

## 2 METHODOLOGICAL APPROACH

Two horizontally related markets are expected to have a virtually same price, recognizing that the actual differences might be due to factors such as transaction costs (implied by the arbitrage), market power, economies of scale, and product differentiation, among others (Abidoye & Labuschagne, 2014). Conventionally, when analysing the horizontal price transmission, the law of one price constitutes the fundamental elements of the underlying theoretical framework. This law states that in the case of international trade where there are no hindrances for the movement of commodities and the transport costs are assumed to be zero, the spatial arbitrage condition and spatial market efficiency ensure the prices of homogeneous commodities traded in different countries are equated when expressed in the same currency (Ardeni, 1989).

A modified version of the LOP with transport costs would be:

$$P_t^d = er_t P_t^f + C_t^{fd} \quad (1)$$

where  $P_t^d$  is the domestic price,  $P_t^f$  is the foreign price,  $C_t^{fd}$  are the transaction costs of spatial arbitrage from  $f$  to  $d$ , while  $er_t$  is the exchange rate in time  $t$ . If a relationship such as (1) holds at each  $t$ , the international and domestic markets are said to be integrated (Rapsomanikis et al., 2003).

In the paper at hand, four variants of price transmissions are ascertained. The first two are the horizontal cross-commodity transmissions based on the argument that the commodities involved are imperfect substitutes, and the systematic differences in the prices analysed render the homogeneity assumption not tenable, i.e. the imported dry beans tend to be more expensive than the domestic alternatives. What is more, there is evidence of bidirectional trade found in the U.S. and Mexico dry bean market during the period of the study. The second two price transmissions are comprised of the two stages of a cross-border supply chain and hence cannot be regarded as purely horizontal. Although the homogeneity assumption was disregarded in the case of the horizontal price transmission, the prices involved may still co-move to some extent, however the transmission will be imperfect (Minot, 2011).

Thus, one long run representation for the cross-commodity price transmission is given by:

$$p_t^d = \alpha + \beta p_t^w + \varepsilon_t; \text{ with: } p_t^w = \ln(P_t^w) = \ln(er_t P_t^f) \quad (2)$$

where  $p_t^d$  is the natural log of  $P_t^d$  (i.e. domestic price),  $p_t^w$  is the world price (or benchmark price, but in this study the prices of beans imported from the U.S.), and  $\alpha$  represents the shifters contributing to the price differentials which are assumed to be a constant proportion of the prices. In the case of cross-commodity price transmission,  $\beta$  is expected to be close to 1 under perfect substitutability (Listorti & Esposti, 2012). Finally, if  $p_t^d$  and  $p_t^w$  are non-stationary series, i.e. their order of integration is 1 or  $I(1)$ , and if equation (2) holds in the long run, then  $\varepsilon_t$  represents stationary deviations [ $I(0)$ ] from the equilibrium value at each time. In that case, the two prices are said to be co-integrated. It is observed that spatial arbitrage activities do not occur immediately but involve time delays. Moreover, the nature of the data prompts the use of time series methods, the rationale being that shocks affecting regional trade could be persistent (Fackler & Goodwin, 2001).

Following the use of the dynamic regression models, Rapsomanikis et al. (2003) argue for the evaluation of the notional components of the transmission between prices such as 1) asymmetry, 2) co-movement and completeness, 3) dynamics and speed, as an approach to ascertain the extent of the studied price transmissions. To ascertain the dynamic relationships between the prices, this analysis follows a version of the price transmission testing framework advanced by Rapsomanikis et al. (2003), which entails the use of time series techniques.

The first step within the framework of this research is to analyse the degree of integration of the time series involved in the analysis. The series must be organized in pairs, i.e. the first one is the price causing the shock and the second one the price out of which a response is expected. Three alternatives emerge from the results, namely, 1) when the degrees of integration are different, then it is said that the series are not co-integrated, 2) when the degrees are 0 [ $I(0)$ ], then it is possible to estimate a Vector Auto-regressive (VAR) model in levels, and 3) when the degrees are 1 [ $I(1)$ ], then a test on the null hypothesis of co-

integration must be performed. Here, two possible results emerge, either a) acceptance or b) rejection. In the first case, the suggestion is to estimate a VAR in first differences, while in the second case it is to estimate a Vector Error Correction Model (VECM) (Rosa et al., 2014). In each of the three alternatives, it is advised to perform the Granger-causality tests (Rapsomanikis et al., 2003). The degree of integration of the series in the research was ascertained using the Augmented Dickey-Fuller test (ADF) (Dickey & Fuller, 1979), which examines the null hypothesis of  $I(1)$  versus the alternative of  $I(0)$ . The question of the Granger-causality between the variables was addressed using the Toda & Yamamoto (TY) (1995) approach. The Granger-causality test is used to ascertain whether the past values of one variable help in explaining the current values of another variable in conjunction with the past values of the second variable. The TY approach comes in handy when the order of integration of the variables is not the same and may be performed independently of the co-integration test. Within the research, the co-integration test was performed with the Engle & Granger (EG) (1987) procedure. Co-integration occurs when two or more  $I(1)$  series are trending together or co-moving so that they reveal a long run equilibrium relationship. The production levels of dry bean in Mexico and the U.S. have been comparable during the last decades and are positively correlated in the 1986-2017 period (Pearson's correlation coefficient = 0.36, test value > 5% critical value). Finally, since the two markets under the study are expected to be integrated, Mexico might represent a large buyer to the U.S. during shortage periods, which raises the question of endogeneity. To mitigate the issue, VAR models were set up with the prices under study whenever co-integration was not found.



### 3 DATA

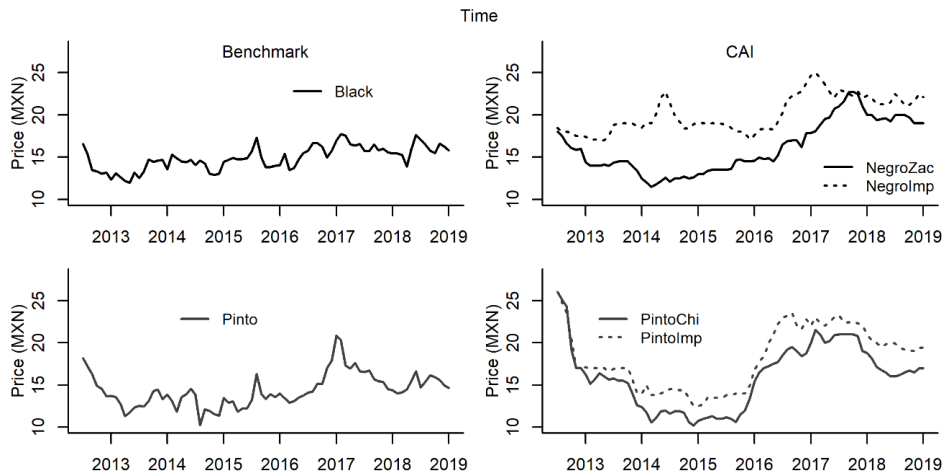
The required data for the analysis were extracted from the official Mexican national sources (e.g. SNIIM) and the United States Department of Agriculture (USDA) database. The analysis was carried out using nine monthly series, ranging from July 2012 through January 2019 (Table 1).

Table 1: *Variable description, units of measure and source (monthly series)*

Variable	Description	Units	Source
NegroZac	Frequent average price for bola Zacatecas black bean, at CAI	MXN/Kg	Sistema Nacional de Información e Integración de Mercados (SNIIM)
PintoChi	Frequent average price for Chihuahua pinto bean, at CAI	MXN/Kg	Sistema Nacional de Información e Integración de Mercados (SNIIM)
NegroIm	Frequent average price for black bean, traded as 'imported' at CAI	MXN/Kg	Sistema Nacional de Información e Integración de Mercados (SNIIM)
PintoIm	Frequent average price for pinto bean, traded as 'imported' at CAI		Sistema Nacional de Información e Integración de Mercados (SNIIM)
B-5110	Price of black beans obtained as the ratio of value to quantity of imports from the U.S., code: 0713395110	USD/Kg	Global Agricultural Trade System (GATS), FAS-USDA
B-5150	Price of pinto beans obtained as the ratio of value to quantity of imports from the U.S., code: 0713395150	USD/Kg	Global Agricultural Trade System (GATS), FAS-USDA
Er	Average exchange rate	MXN/USD	OECD Statistics
Black	Benchmark price for black beans (obtained as B-5110*Er)	MXN/Kg	Own elaboration
Pinto	Benchmark price for pinto beans (obtained as B-51-50*Er)	MXN/Kg	Own elaboration

In choosing the time frame, the availability of continuous observations was considered. Among the series, there are two domestic prices for dry bean, namely, 1) black bola Zacatecas (NegroZac) and 2) pinto Chihuahua (PintoChi) traded at the Central de Abasto de Iztapalapa (CAI), which is Mexico City's biggest wholesale market. Other series are 3) benchmark price for black beans imported by Mexico under the code 0713395110 (Black), 4) benchmark price for pinto beans imported by Mexico under the code 713395150 (Pinto), 5) price of black bean traded under the label 'imported' at CAI (NegroIm), and 6) price of pinto bean traded under the label 'imported' at CAI (PintoIm) (Figure 4).

Figure 4: Benchmark prices and prices for black bean and pinto bean traded at CAI



Source: Own elaboration

It is worth mentioning that although prices in the U.S. for the beans considered in this study (i.e. foreign price) displayed a downward trend in the period analysed, when expressed in the Mexican currency (i.e. world price or benchmark) this tendency was reversed due to the depreciation of the Peso against the U.S. dollar. The prices of the domestic alternatives, on the other hand, dropped manifestly during the years from 2013 to 2015, accompanying the above-average harvests in the years from 2012 to 2014. Under a complete exchange rate pass through (ERPT), a change in the farm price measured in a domestic currency will be fully transmitted to the retail price measured in a foreign currency (see reviews by Menon, 1995; Goldberg & Knetter, 1997).

#### 4 RESULTS AND DISCUSSION

The proper use of the terms *integration* and *efficiency* in the context of international agricultural markets has been pointed out in the existing literature (Barrett, 2001). Based on the latter, an early result is that the Mexico and the United States market for black and pinto dry beans has been integrated during the period under study, as evidenced by the continuous and unhindered trade (USDA - FAS, 2019). In the following sections, the results regarding research efficiency are reported, with all procedures carried out using the log transformation of the prices involved in the analysis.

#### 4.1 Unit root test

The ADF tests the null hypothesis of a unit root presence or that the series is  $I(1)$ , i.e.  $H_0: \delta = 0$  against the one-sided alternative  $H_1: \delta < 0$  in the equation:

$$\Delta Y_t = \alpha + \beta t + \delta Y_{t-1} + \theta_1 \Delta Y_{t-1} + \dots + \theta_p \Delta Y_{t-p} + u_t \quad (3)$$

where  $t$  represents the trend and  $\alpha$  is the intercept. Three specifications were evaluated, including the 1) model with time trend and intercept (Trend), 2) model with intercept only (Drift), and 3) model with none of the above (None). The results for the series in levels are displayed in Table 2.

Table 2: ADF test results for the series in levels

Variable	Type test	Lag (p)	$\delta$	Test value	CV* 10%	CV 5%	CV 1%
NegroZac	None	1	0.0002	0.1687	-1.61	-1.95	-2.60
NegroIm	None	2	0.0005	0.4604	-1.61	-1.95	-2.60
Black	None	6	0.0019	0.8095	-1.61	-1.95	-2.60
PintoChi	None	3	0.0002	0.1013	-1.61	-1.95	-2.60
PintoIm	None	1	-0.0007	-0.4467	-1.61	-1.95	-2.60
Pinto	None	0	-0.0015	-0.4576	-1.61	-1.95	-2.60
NegroZac	Drift	1	-0.0168	-0.8430	-2.58	-2.89	-3.51
NegroIm	Drift	2	-0.0519	-1.7015	-2.58	-2.89	-3.51
Black	Drift	6	-0.1862	-2.3541	-2.58	-2.89	-3.51
PintoChi	Drift	3	-0.0293	-1.4971	-2.58	-2.89	-3.51
PintoIm	Drift	1	-0.0441	-1.9191	-2.58	-2.89	-3.51
Pinto	Drift	0	-0.1855	-2.9808	-2.58	-2.89	-3.51
NegroZac	Trend	1	-0.0795	-2.8132	-3.15	-3.45	-4.04
NegroIm	Trend	1	-0.1246	-2.9401	-3.15	-3.45	-4.04
Black	Trend	6	-0.5392	-3.5236	-3.15	-3.45	-4.04
PintoChi	Trend	3	-0.0398	-1.7842	-3.15	-3.45	-4.04
PintoIm	Trend	1	-0.0760	-2.9625	-3.15	-3.45	-4.04
Pinto	Trend	0	-0.2537	-3.7725	-3.15	-3.45	-4.04

\*CV = Critical Value

The lag lengths were chosen based on the Akaike Information Criterion (AIC). The null hypothesis was rejected (test value > 5% critical value) in the case of the Pinto series, under the Drift and Trend specifications. From this result, we conclude there is not any co-integration between Pinto and PintoChi, nor is there any between Pinto and PintoIm.

The remaining series involved in the analysis have the same order of integration, namely I(1). On the other hand, the first differences of the series are all stationary (Table 3).

Table 3: ADF test results for the first differences of the series

Variable	Type test	Lag (p)	$\delta$	Test value	CV* 10%	CV 5%	CV 1%
$\Delta$ NegroZac	None	0	-0.7353	-6.6726	-1.61	-1.95	-2.60
$\Delta$ NegroIm	None	1	-0.6903	-5.6535	-1.61	-1.95	-2.60
$\Delta$ Black	None	5	-1.6259	-4.1121	-1.61	-1.95	-2.60
$\Delta$ PintoChi	None	2	-0.4670	-4.2872	-1.61	-1.95	-2.60
$\Delta$ PintoIm	None	0	-0.5548	-5.4483	-1.61	-1.95	-2.60
$\Delta$ Pinto	None	1	-1.2557	-7.4028	-1.61	-1.95	-2.60
$\Delta$ NegroZac	Drift	0	-0.7358	-6.6341	-2.58	-2.89	-3.51
$\Delta$ NegroIm	Drift	1	-0.6965	-5.6492	-2.58	-2.89	-3.51
$\Delta$ Black	Drift	5	-1.6709	-4.1834	-2.58	-2.89	-3.51
$\Delta$ PintoChi	Drift	2	-0.4637	-4.1914	-2.58	-2.89	-3.51
$\Delta$ PintoIm	Drift	0	-0.5575	-5.4233	-2.58	-2.89	-3.51
$\Delta$ Pinto	Drift	1	-1.2570	-7.3576	-2.58	-2.89	-3.51
$\Delta$ NegroZac	Trend	0	-0.7671	-6.7868	-3.15	-3.45	-4.04
$\Delta$ NegroIm	Trend	1	-0.6963	-5.6095	-3.15	-3.45	-4.04
$\Delta$ Black	Trend	5	-1.6541	-4.1219	-3.15	-3.45	-4.04
$\Delta$ PintoChi	Trend	2	-0.4692	-3.9743	-3.15	-3.45	-4.04
$\Delta$ PintoIm	Trend	0	-0.5841	-5.5372	-3.15	-3.45	-4.04
$\Delta$ Pinto	Trend	1	-1.2713	-7.3505	-3.15	-3.45	-4.04

\*CV = Critical Value

## 4.2 Granger-causality test

The test was performed following the TY approach which is useful even when the series do not have the same order of integration, and what is more, is independent of the co-integration test. Thus, six systems of VAR equations with an intercept ( $\alpha$ ) and a time trend ( $tt$ ) were set up, using the variables in Table 1, in a pair-wise fashion: NegroZac-Black, NegroIm-Black, PintoChi-Pinto, PintoIm-Pinto, and NegroZac-PintoChi.

Each system was specified as follows:

$$\begin{aligned} Y_t &= \alpha_1 + tt_1 + \theta_1 Y_{t-1} + \dots + \theta_p Y_{t-p} + \gamma_1 X_{t-1} + \gamma_p X_{t-p} + u_t \\ X_t &= \alpha_2 + tt_2 + \varphi_1 X_{t-1} + \dots + \varphi_p X_{t-p} + \lambda_1 X_{t-1} + \lambda_p X_{t-p} + u_t \end{aligned} \quad (4).$$

Table 4: Lag lengths at which the VAR systems produced non-correlated residuals

VAR equation	Chi-square	Df	P. value	Lag length (p)
NegroZac-Black	45.942	44	0.392	1
NegroIm-Black	35.220	40	0.685	2
NegroIm-NegroZac	32.787	40	0.784	2
PintoChi-Pinto	23.995	32	0.845	4
PintoIm-Pinto	34.697	40	0.707	2
PintoIm-PintoChi	36.211	40	0.642	2
NegroZac-PintoChi	35.567	40	0.670	2

The lag lengths (p) of the systems were determined by the AIC criterion. When necessary, more lags were added to each system up to the point where the residuals were no longer serially correlated, and all the roots of the characteristic polynomial lied within the unitary circle. Table 4 presents the final lag lengths of each system based on the results of the Portmanteau test applied for serially correlated errors, where 12 lags were used for the Portmanteau statistics.

Since the maximum order of integration of the variables in each pair was 1, a lag was added to each system (i.e.  $p + 1$ ) according to the TY approach. Afterwards, the systems were re-estimated, followed by testing the null hypothesis  $H_0: \gamma_1 = \gamma_2 = \dots = \gamma_p = 0$  on the first p lags of the re-estimated systems against  $H_1: \gamma_1 \neq \gamma_2 \neq \dots \neq \gamma_p \neq 0$ . This is equivalent to testing whether X Granger-causes Y. Likewise, testing the null  $H_0: \lambda_1 = \lambda_2 = \dots = \lambda_p = 0$  against  $H_1: \lambda_1 \neq \lambda_2 \neq \dots \neq \lambda_p \neq 0$  is equivalent to testing whether Y Granger-causes X.

Table 5: Granger-causality test results of pair-wise VAR systems (with constant and trend)

VAR equation (Y-X)	Null: X does not Granger-cause Y			Null: Y does not Granger-cause X		
	Chi-square	Df	p. value	Chi-square	DF	p. value
NegroZac-Black	0.193	1	0.661	0.001	1	0.974
NegroIm-Black	0.229	2	0.892	7.449	2	0.024
NegroIm-NegroZac	0.292	2	0.864	0.375	2	0.829
PintoChi_Pinto	0.995	4	0.911	2.280	4	0.684
PintoIm-Pinto	2.802	2	0.246	0.631	2	0.729
PintoIm-PintoChi	19.428	2	0.000	3.218	2	0.200
NegroZac-PintoChi	0.278	2	0.870	1.486	2	0.476

Table 5 displays the acceptance of two alternative hypotheses for the Granger-causality test, namely, that the price of NegroIm Granger-Causes Black and that the price of PintoChi Granger-Causes PintoIm with p. value < 0.05 and p. value < 0.01, respectively. In this case, the rejection of the null indicates that the price of Black can be better predicted using the past values of Black and NegroIm than using the past values of Black alone.

### 4.3 Co-integration test

The co-integration tests were carried out using the EG approach. Thus,  $p_t^d$  was regressed on  $p_t^w$  and the residuals saved as  $\varepsilon_t$ . Then, we regressed  $\Delta\varepsilon_t$  on  $\varepsilon_{t-1}$  in an equation as is (3), with drift. Lags of the dependent variable were added when necessary, according to the AIC. The results reveal co-integration is present when the coefficient of  $\varepsilon_{t-1}$  is statistically significant.

Table 6: *Co-integration test results*

Equation	Type test	Lag (p)	$\delta$	Test value	CV* 10%	CV 5%	CV 1%
NegroZac-Black	Drift	6	-0.1193	-2.0555	-3.04	-3.34	-3.90
NegroZac-PintoChi	Drift	0	-0.0559	-1.6132	-3.04	-3.34	-3.90
NegroIm-Black	Drift	0	-0.2963	-3.9162	-3.04	-3.34	-3.90
PintoChi-PintoIm	Drift	1	-0.2515	-3.4657	-3.04	-3.34	-3.90

\*CV = Critical Value. Values taken from Davidson & MacKinnon (1993).

The results of the EG test are shown in Table 6. There are two co-integrating relationships in the systems analysed, namely, between NegroIm and Black (which we take as being the same commodity in two stages of its marketing chain), and between PintoChi-PintoIm with p. value < 0.01 and p. value < 0.05, respectively. For the two other two systems, the conclusion is the prices are not co-moving in the long run, therefore leaving their dynamics limited to short-run responses.

### 4.4 VEC and VAR models

In the case of the systems where co-integration was found, the price transmission was ascertained by means of an equation as is:

$$\Delta p_t = \mu + \Pi p_{t-1} + \Gamma_1 \Delta p_{t-1} + \dots + \Gamma_p \Delta p_{t-p} + \varepsilon_t \quad (5).$$

Table 7: VECM estimates for the systems NegroIm-Black and PintoIm-PintoChi (Maximum likelihood)

Response	Variable	Estimate	Std. Error	Test value	p. value	AIC
NegroIm	ECT <sub>t-1</sub>	0.0206	0.0211	0.9742	0.3333	-994.6014
	Intercept	0.1262	0.1278	0.9874	0.3268	
	NegroIm <sub>t-1</sub>	0.4773	0.1192	4.0039	0.0002***	
	Black <sub>t-1</sub>	0.0770	0.0664	1.1591	0.2503	
	NegroIm <sub>t-2</sub>	-0.2406	0.1205	-1.9966	0.0498**	
	Black <sub>t-2</sub>	0.0826	0.0618	1.3371	0.1855	
Black	ECT <sub>t-1</sub>	0.1644	0.0376	4.3726	0.0000***	
	Intercept	0.9955	0.2275	4.3753	0.0000***	
	NegroIm <sub>t-1</sub>	0.2433	0.2122	1.1467	0.2554	
	Black <sub>t-1</sub>	0.1305	0.1182	1.1037	0.2735	
	NegroIm <sub>t-2</sub>	0.1348	0.2145	0.6283	0.5319	
	Black <sub>t-2</sub>	-0.0388	0.1100	-0.3525	0.7255	
	Variable		NegroIm	Black	Trend	
	Co-integrating vector		1.0000	-3.4624	0.0075	
Response	Variable	Estimate	Std. Error	Test value	p. value	AIC
PintoIm	ECT <sub>t-1</sub>	-0.2740	0.1254	-2.1842	0.0323**	-996.7971
	Intercept	0.1836	0.0843	2.177	0.0329**	
	PintoIm <sub>t-1</sub>	0.2391	0.1566	1.527	0.1313	
	PintoChi <sub>t-1</sub>	0.3793	0.1228	3.0898	0.0029***	
	PintoIm <sub>t-2</sub>	0.2042	0.1483	1.3768	0.173	
	PintoChi <sub>t-2</sub>	-0.2623	0.1338	-1.9604	0.0539*	
PintoChi	ECT <sub>t-1</sub>	0.1289	0.1613	0.7991	0.4269	
	Intercept	-0.0891	0.1085	-0.8215	0.4142	
	PintoIm <sub>t-1</sub>	-0.0582	0.2014	-0.289	0.7734	
	PintoChi <sub>t-1</sub>	0.5940	0.1579	3.7618	0.0003***	
	PintoIm <sub>t-2</sub>	0.2826	0.1907	1.4818	0.1429	
	PintoChi <sub>t-2</sub>	-0.3095	0.1721	-1.7984	0.0764*	
	Variable		PintoIm	PintoChi	Trend	
	Co-integrating vector		1.0000	-0.7856	-0.0014	

\*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$ 

Equation (5) is a long run specification of the VECM formed with the  $p_t$  vector of the prices (2x1) in each system and  $\Gamma_t$  as matrices (2x2) of the short-run responses to shocks. The lag-length specification of the models was selected using the AIC, the estimates of which are displayed in Table 7. The coefficient ECT is called an adjustment coefficient and

it indicates that in the system NegroIm-Black, Black does error correct and will return to equilibrium after  $1/0.1644 \sim 6$  steps, *ceteris paribus*.

In the case of the systems where no co-integration relationship was found, their short run dynamics were ascertained through bivariate VAR models. Such models were set up with the variables in first differences, as Rapsomanikis et al. (2003) suggest. The lag length was selected using the AIC, moreover, differences in logs were applied to approximate percent changes when multiplied by 100. The results of the VAR models are reported in Table 8.

Table 8: VAR estimates for the systems NegroZac-NegroIm, NegroZac-PintoChi and NegroZac-Black (Ordinary Least Squares)

Response	Variable	Estimate	Std. Error	Test value	p. value	R-Squared
$\Delta$ NegroZac	$\Delta$ NegroZac <sub>t-1</sub>	0.2478	0.1141	2.1716	0.0330**	0.0751
	$\Delta$ NegroIm <sub>t-1</sub>	0.0767	0.1262	0.6077	0.5452	
$\Delta$ NegroIm	$\Delta$ NegroZac <sub>t-1</sub>	-0.0162	0.0972	-0.1668	0.8679	0.1801
	$\Delta$ NegroIm <sub>t-1</sub>	0.4275	0.1076	3.9738	0.0002***	
$\Delta$ NegroZac	$\Delta$ NegroZac <sub>t-1</sub>	0.2132	0.1220	1.7471	0.0847*	0.0825
	$\Delta$ PintoChi <sub>t-1</sub>	0.0744	0.0755	0.9849	0.3279	
$\Delta$ PintoChi	$\Delta$ NegroZac <sub>t-1</sub>	0.3297	0.1765	1.868	0.0657*	0.2658
	$\Delta$ PintoChi <sub>t-1</sub>	0.3924	0.1092	3.5925	0.0006***	
$\Delta$ NegroZac	$\Delta$ NegroZac <sub>t-1</sub>	0.1896	0.1137	1.6681	0.0996*	0.1328
	$\Delta$ Black <sub>t-1</sub>	0.0426	0.0634	0.6722	0.5036	
	$\Delta$ NegroZac <sub>t-2</sub>	0.0927	0.1127	0.8229	0.4133	
	$\Delta$ Black <sub>t-2</sub>	0.1287	0.0628	2.0473	0.0443**	
$\Delta$ Black	$\Delta$ NegroZac <sub>t-1</sub>	-0.0782	0.2015	-0.3882	0.6990	0.0543
	$\Delta$ Black <sub>t-1</sub>	-0.0762	0.1123	-0.6790	0.4993	
	$\Delta$ NegroZac <sub>t-2</sub>	0.1055	0.1997	0.5281	0.5991	
	$\Delta$ Black <sub>t-2</sub>	-0.2032	0.1114	-1.8246	0.0722*	

\*  $p < 0.1$ ; \*\*  $p < 0.05$ ; \*\*\*  $p < 0.01$

The short-run dynamics of the prices analysed in the VAR models indicate that in two cases a statistically significant transmission was found, namely, in the systems NegroZac-PintoChi and NegroZac-Black with p. value < 0.1 and p. value < 0.05, respectively. Based on the acquired results, the final interpretation is that when the price of Black changes by 1% with respect to the previous month, the price of NegroZac responds with a 0.13% change relative to the previous month, however, with the response taking place with a two-month delay.



## 5 CONCLUSIONS

This contribution is aimed at examining the co-movement of the prices of the Pinto and Black dry bean in Mexico and the United States during the post-NAFTA period. The key research question of this study is whether there is a possibility of co-integration between the benchmark international price for pinto beans and the corresponding commodities traded at CAI entirely dismissed based on the results of the unit root tests. It was therefore confirmed that the price dynamics in the analysed markets are governed by domestic conditions rather than those transmitted across the border. Furthermore, the results of the VECM indicate there is no short run transmission from Black to NegroIm (which are regarded as the same commodity), nevertheless, the two share a common trend in the long run. Whereas the results from the VAR model indicate there is a statistically significant short run transmission from Black to NegroZac, they however do not share a common trend. The Granger-causality tests point out that the past values in the price of NegroIm are helpful when explaining the future values of Black beans. Among the domestic prices, the past values of PintoChi are of use when explaining the future prices of PintoIm. The former result indicates that the information regarding the prices of black dry beans traded at CAI might be used to influence the prices in the exporting markets, sourcing the United States.

Dry bean remains a sensitive product in Mexico, sharing in the political discourse and the academic interest. Regarding the latter, what this analysis suggests is that, although an aggregated self-sufficiency measure reflects an eroding tendency for Mexico in the case of dry beans, pinto beans imports dropped during the period under study, whereas black bean imports remained relatively flat. On the other hand, the presence of the bidirectional trade indicates that the beans imported from the United States behave as differentiated commodities which fetch higher prices at CAI. Therefore, with imports consumers in Mexico City gain access to substitute goods, keeping the cheaper domestic alternatives. From the consumer's point of view, price spikes are to be expected from the variables governing domestic supply and from the factors causing the actual differences between the prices compared, rather than from imports from the United States.

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