

María del Rosío Barajas-Escamilla, Amir Kia  
and Maritza Sotomayor\*

# Concepts and Measurements of Economic Interdependence: The Case of the United States and Mexico

DOI 10.1515/gej-2015-0034

**Abstract:** We developed a theoretical model capable to analyze U.S. fiscal and monetary policy effects on Mexican exports in order to provide an alternative approach to the study of economic interdependence. The model was estimated for the sample period of 1980–2013. The existing literature evidences quantified interdependence through trade flows and ignores the role of the U.S. fiscal and monetary policies. This paper uses the concept of sensitivity, from the economic interdependence literature, to verify the long and short run relationships between the U.S. and Mexico in a context of trade integration. Our findings confirm Mexico's sensitivity to unanticipated shocks in particular coming from the U.S. monetary policy, the exchange rate and the world oil price.

**Keywords:** economic interdependence, sensitivity, fiscal and monetary policies, Mexico, NAFTA

**JEL Classification:** F140, F150, C32, E52

## 1 Introduction

Although the North American Free Trade Agreement (NAFTA) between Mexico, the United States and Canada came into effect in 1994, the impact of the agreement on Mexico has not been thoroughly studied in the context of economic interdependence. For Mexico, the treaty was seen as the natural result and deepening of a trade liberalization process that began in the mid-1980s, Moreno-Brid, Rivas-Valdivia, and Santamaría (2005). Thus far, the extent of economic interdependence between countries has been examined mainly through the trade flows, for example see

---

\*Corresponding author: **Maritza Sotomayor**, Finance and Economics Department, Utah Valley University, Orem, UT 84058–5999, USA, E-mail: [maritza.sotomayor@uvu.edu](mailto:maritza.sotomayor@uvu.edu)

**María del Rosío Barajas-Escamilla**, Social Studies Department, El Colegio de la Frontera Norte, Tijuana, BC 22560, Mexico, E-mail: [rbarajas@colef.mx](mailto:rbarajas@colef.mx)

**Amir Kia**, Finance and Economics Department, Utah Valley University, Orem, UT 84058–5999, USA, E-mail: [akia@uvu.edu](mailto:akia@uvu.edu)

Barbieri (1996), Nagayasu (2010) and Zhang (1995). The two main attributes of economic interdependence are sensitivity and vulnerability, which have been well-studied in the field of international relations, but not extensively in the field of applied economics. In the past, the economic interdependence between the U.S. and Mexico has been examined exclusively from either an international relations perspective, see, e. g., Ronfeldt and Sereseres (1983) and the Bilateral Commission on the Future of United States-Mexico Relations (1988) or by using economic integration theories, e. g., Cañas, Coronado, and Gilmer (2004), Castillo, Varela, and Ocegueda (2010), Hanson (2001) and Phillips and Cañas (2004).

This paper provides a review of the theoretical literature on economic interdependence and extends the analysis of the trade flows by developing a theoretical model which was estimated for the U.S. demand for Mexican exports in the context of economic interdependence and integration (e. g., NAFTA). In this manner, this study develops a more comprehensive view of economic interdependence in an economic integration context which the authors have not seen in previous empirical literature.

Two quantitative measures are offered in this paper. The Bilateral Trade Intensity Index (BTII) has been typically applied to examine economic interdependence, Zhang (1995). In this study we build an index for the 1970–2014 period, which allows us to analyze Mexican trade before the trade liberalization process and after NAFTA implementation, and to test significant changes in the U.S.-Mexican trade relation. An increase in the already high value of the BTII is found in particular after trade integration which reveals the significance of the U.S. market for Mexican products. Moreover, this high value makes imperative a deeper analysis of the U.S.-Mexican trade relation by providing an empirical estimation of the U.S. import demand for Mexican products to examine the degree of sensitivity. This estimation has been done through the cointegration and error correction model analysis. The results from this estimation confirm how changes in the U.S. monetary and fiscal policies have an impact on the U.S. import demand for Mexican products (sensitivity). The short-run dynamics confirm Mexico's sensitivity to unanticipated shocks in particular coming from the U.S. monetary policy, the exchange rate and the world oil price.

The rest of the paper is organized as follows. The second section presents a literature review of economic interdependence, emphasizing the two moments in the evolution of the meaning of economic interdependence as well as the previous empirical evidence on the U.S. demand for exports from Mexico. The third section shows a quantification of economic interdependence by the estimation of the BTII which establishes the significance of the U.S. economy for Mexican exports. Furthermore, contrary to the current existing literature, a model for the U.S. demand for exports from Mexico is developed. The fourth

section presents the data and empirical results. The final section is devoted to the main findings and final remarks.

## 2 Literature Review

Economic globalization gives rise to a high degree of economic integration and interdependence among countries. In this context, asymmetries become evident, as does the need to design public policies to reduce a country's vulnerability and sensitivity, which are both products of interdependence. See for example Gasiorowski (1986), Kirby (2006) and Kroll (1993).

Economic interdependence was originally developed in the context of international relations based on Hirschman's (1945) idea on the relationship between international trade and conflict.<sup>1</sup> Rosecrance et al. (1977) and Keohane and Nye (1989) suggest that in the new context of economic globalization, the political power of a country is determined by its significance in international trade, which translates into a specific type of economic interdependence. After the 1990s, the globalization process incorporated the developed and developing countries in broader economic interdependence as result of the increasing participation of most countries in international trade and the emergence of global production networks. The concept of global production networks has been significant in the design of industrial policies that look for an increasing bilateral trade, see for example Kim, Yangseon, and Chung (2006) for the case study of Korea and China.

In several studies, Keohane and Nye fully developed the concept of economic interdependence in the context of the world's changing geo-political configuration and increasing globalization, see Keohane (1988), Keohane and Nye (1989, 1998) and Nye and Keohane (1971). In this respect, a concept such as interdependence refers to a condition of mutual dependence among countries or actors of different countries.<sup>2</sup> Interdependence implies reciprocal costly effects of transactions (not always symmetrical), but has to be differentiated from interconnectedness, where

---

<sup>1</sup> According to this author, the wealth of a country has a direct relationship to the country's role in the world economy, where foreign trade can be used as an instrument of national power policy. In order to measure a country's wealth level, the author developed an index of international trade. Hirschman's theoretical ground work has served in the conceptualization of economic interdependence. Authors such as Wagner (1988) attribute to Hirschman the more developed theory of economic dependence and its political use as well as the idea of asymmetrical interdependence as a source of power.

<sup>2</sup> With the same idea, Rosecrance et al. (1977) define interdependence as "the direct and positive linkage of the interests of states such that when the position of one state changes, the position of others is affected, and in the same direction" (pp. 426–427).

interactions do not have significant costly effects, Keohane and Nye (1989, 1998). Since economic globalism involves long-distance flows of goods, services and capital as well as all the elements that compose market exchange, Keohane and Nye (2000) considered globalization as the primary factor that explains interdependence. In sum, international trade should be considered the main indicator of economic interdependence.

This work distinguishes two concepts related to the measurement of economic interdependence. First, sensitivity which is associated with the effects on each party/country involved in an interdependent relationship as a result of changes imposed from outside (such as international crisis). Second, vulnerability refers to whether a country has the ability to implement policies that minimize transaction costs imposed by external effects of economic policies resulting from outside such as boycotts, embargoes and other trade disruptions, Keohane and Nye (1989).<sup>3</sup> Likewise, public policy and regulations coming from trade partners are seen as instruments that define the nature of interdependence.

Other authors such as Gasiorowski (1986), Barbieri (1996), and Zhang (1995) developed several proposals to operationalize the concept of economic interdependence, in all cases related to the reduction of conflicts. Gasiorowski, based on his analysis of the work of Hirshman (1945) and Keohane and Nye (1989), examines the linkage between economic interdependence and international conflict. The author questions whether the climate of interdependence fosters a greater or lesser sense of conflict between countries involved in the relationship. In his work, he points out that economic interdependence can be seen as a good mechanism to prevent wars among countries or at least to prevent possible military conflicts. In some of these studies the operationalization of economic interdependence was assessed by calculating trade intensity indexes.

Several studies of empirical evidence on economic interdependence used the Asian region as their case study, for example Balasubramaniam, Pua, and Abu-Mansor (2012), Kim, Yangseon, and Chung (2006) and Nagayasu (2010) exemplify how increasing trade flows among these countries foster economic interdependence. While Kim, Yangseon, and Chung (2006) examined how China's export structure as well as South Korea's cross-border production networks changed with the intensification of their trade flows, Nagayasu (2010) and Balasubramaniam, Pua, and Abu-Mansor (2012) focused on business cycles. Nagayasu showed that differences in trade among the ten Asian countries revealed how their different strengths and weaknesses impact their position in the context of the Asian economies. Balasubramaniam, Pua, and Abu-Mansor

---

<sup>3</sup> Transaction costs are expressed in different degrees of sensitivity and vulnerability for the involved countries in an economic relationship.

(2012) studied the level of economic interdependence reached by five countries that took part in the Association of Southeast Asian Nations (ASEAN) integration process plus China. This business cycle is linked to the structure of the global production networks in which these countries participate, which Kim, Yangseon, and Chung (2006) consider as complementary in trade relationships among these countries. Their results showed China's increasing role in shaping the structure of the international trade of this association and how its business cycle determined the business cycle of the other Asian countries.

Empirical literature that approximates economic interdependence through the analysis of business cycles has been widely analyzed for the U.S.-Mexico relationship in particular after the signing of NAFTA. In this regard, an increase of economic interdependence has been understood as an increase in the synchronization of business cycles. Some of these works select the Mexican manufacturing employment and the U.S. economic indicators as the main variables of their analysis, e. g., Fragoso, Pastrana, and Castillo (2008) and Garces-Diaz (2008), while others concentrate on different macroeconomic variables, e. g., Castillo, Varela, and Ocegueda (2010), Cuevas, Messmacher, and Werner (2003), Herrera (2004) and Mejía, Gutiérrez, and Farías (2006). In particular, it is noted that the economic liberalization process pursued after the debt crisis of 1982 opened a new era in the economic relation between both countries with the gradual deregulation of the Mexican financial system.<sup>4</sup> Since trade flows have been highlighted as a significant source of economic interdependence it is noteworthy to mention the works of Chiquiar and Ramos-Francia (2005) as well as Torres and Vela (2003) who study the synchronization of business cycles between Mexico and the U.S. economy. While no conclusive consensus on the synchronization of both business cycles for these economies exists, most of the indicators reveal that this synchronization is evident after the NAFTA implementation, and that both economies were sharing common trends before the trade integration. However, Miles and Vijverberg (2011), using the Markov-switching model, point out, due to a better Mexican policy implementation, a greater synchronization occurs between business cycles for these two economies after NAFTA.<sup>5</sup>

---

<sup>4</sup> Relevant explanation about the Mexican economic liberalization process can be found in Huerta (1994) and Lustig (1998).

<sup>5</sup> From a regional perspective, Delajara (2012) studies the synchronization between business cycles of the U.S. and Mexico regions. The empirical estimation is through the use of regional coincident indexes. His work confirms the high co-movement of the Mexican northern region business cycle with the U.S. economy, which happens in a lesser degree with the center and south regions of Mexico. Phillips and Cañas (2004) measured the impact from the business cycle in four metropolitan border areas of Texas and Mexico. The business cycle index showed that

Another area of research related to economic interdependence between U.S. and Mexico is the analysis of bilateral trade flows, specifically the estimation of import and export functional forms, using mostly the cointegration analysis. These studies include Garces-Díaz (2008), Fullerton and Sprinkle (2005) and Cermeño, Jensen, and Rivera (2010). The main finding is the existence of a cointegration relationship between exports and imports. Romero (2010) estimated the Mexican demand for imports and found that monetary and fiscal policies in Mexico were not effective to control the demand for imports after the debt crisis. However, like previous studies, these authors concentrated on an ad-hoc model. Furthermore, the majority of these studies ignore the fact that there are strong asymmetries between the U.S. and Mexico by offering empirical evidence based on the overall measurement of international trade. Such shortcoming may create a biased result.

In order to fill the gap in the literature on economic interdependence, in this work we develop and estimate a theoretical model for the U.S. import demand for Mexican non-oil exports and verify how changes in the U.S. monetary and fiscal policies influence this trade. We will also show that Mexican exports are not just sensitive to the U.S. monetary and fiscal policies, but also to monetary policy and real exchange rate shocks. In this regard, we develop the empirical model in the following section.

### 3 Modelling Economic Interdependence Between the U.S. and Mexico

In order to test our hypothesis about the role of sensitivity as an element that defines the character of economic interdependence, in this section we use two quantitative measurements of the economic interdependence between the U.S. and Mexico. The first one is the Bilateral Trade Intensity Index for the 1970–2014 period. This index has been commonly applied to verify economic interdependence, Zhang (1995). The objective is to confirm the significance of the U.S. economy for Mexican products. The index will also serve as an introduction to our second quantitative measurement, a theoretical and empirical model of demand of imports of the U.S. from Mexico for the 1980–2013 period. In particular this work shows, based on Keohane and Nye's (1989) concept of sensitivity, how

---

changes in the border region were strongly correlated with changes in the state of Texas and with changes in the U.S. economy more generally.

Mexican exports are sensitive to the U.S. monetary and fiscal policies and the real exchange rate.

### 3.1 Bilateral Trade Intensity Index

An initial quantitative measurement of economic interdependence between two countries can be shown using a Bilateral Trade Intensity Index (BTII) which measures the relative significance of one country's trade in the total trade of its partner in relation with the rest of the world. This index has been applied to study the effects of regional integration, see Anderson and Norheim (1993) and Iapadre and Tironi (2009).<sup>6</sup> This paper follows the work of the former for the construction of this index:

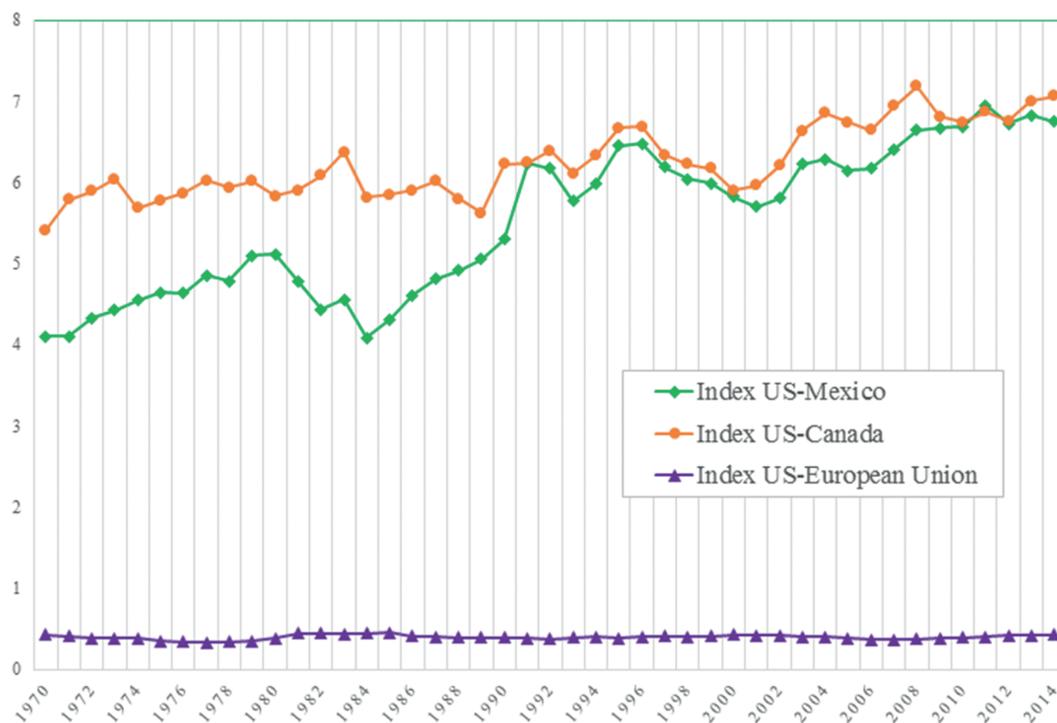
$$BTII_{ij} = \frac{\frac{TT_{ij}}{TT_{iw}}}{\frac{TT_{oj}}{TT_{ow}}}, \quad [1]$$

where  $TT_{ij}$  is the total trade (exports plus imports) from Mexico ( $i$ ) to the U.S. ( $j$ ),  $TT_{iw}$  is the total trade of Mexico with the world ( $w$ ),  $TT_{oj}$  is the total trade from the rest of the world (excluding Mexico) ( $o$ ) with the U.S. and  $TT_{ow}$  is the total trade from the rest of the world with the world. The BTII values range from zero, which indicates no bilateral trade between the U.S. and Mexico, to infinity, which indicates only bilateral trade. An index equal to one indicates a bilateral trade that is neutral, where the weight of trade between partners equals the weight of trade with the rest of the world. If  $BTII_{ij} > 1$  ( $BTII_{ij} < 1$ ), the proportion of exports of Mexico that are destined to the U.S. is greater (less) than what would correspond to the participation of U.S. in world import demand, i. e., that would exist in the absence of geographical bias.

Figure 1 shows the data for the U.S. and Mexico for the 1970–2014 period. With the purpose of highlighting the significance of the U.S. market for Mexican products, we also included the indexes of two other important partners for the U.S.: Canada and the European Union.

As can be seen in Figure 1, before the trade liberalization process (1986–1987) began in Mexico, the country's BTII showed a significant difference with Canada's index. However, the rapid increase occurred after Mexico put in place trade policies that opened its economy and since then both countries shared the same

<sup>6</sup> The index has its origins in the work of Leamer and Stern (1970) who related trade intensity indices with gravity models of international trade and the works of Balassa (1965) who proposed an index of revealed comparative advantage between regions to examine regional integration.



**Figure 1:** Bilateral intensity trade index 1970–2014 between the U.S. and Mexico, Canada and the European Union.

trend. It seems that NAFTA's implementation in 1994 did not have an impact on the index neither for Canada nor Mexico. Note that there is a high value of the index for NAFTA partners from the beginning of the 1990s until now in particular when comparing with the European Union. For Mexico and Canada, the U.S. market is by far the most important destination for exports, a trend that ranges back before trade integration, as indicated by the high value of the index. Different results are shown for the BTII of the European Union, which does not reach even 0.5 for the period under analysis. Nevertheless, it is expected that the BTII will be higher for individual countries such as England or Germany. Since this is an aggregate index, it does not take into account the weight of individual countries of the European Union but the total trade for the economic region.

Figure 1 shows clearly that trade intensity increased from 1970 to 2014 and reveals the economic interdependence between the U.S. and Mexico. As it was mentioned in the previous sections, the BTII has been commonly used to assess economic interdependence at the bilateral level. In our case, the index has helped to establish the significance of the U.S. economy for Mexican products and serves as the introduction for our theoretical search model for the U.S. import demand for Mexican exports.

The high value of BTII for the Mexican trade with the U.S. further justifies the development and estimation of a model for the U.S. import demand of Mexican exports and through the proposed estimation model we will verify how changes in the fiscal and monetary policies can impact the performance of Mexican exports.

### 3.2 The Model

As for a second quantitative measurement of economic interdependence in this paper, we will develop a model of the U.S. demand for the total Mexican non-oil exports. We will estimate the model in the next section. This model is an attempt to fill the gap with the existing literature on economic interdependence. As it was discussed in the previous sections, economic interdependence has been analyzed and quantified through the trade flows. The model offers a new approach in which fiscal and monetary policies can have an impact on the U.S. import demand for Mexican non-oil exports (Mexican exports hereafter) and where concepts such as sensitivity can be developed.

Let us consider an economy with a single consumer, representing a large number of identical consumers. The consumer maximizes the following utility function:

$$E \left\{ \sum_{t=0}^{\infty} \beta^t U(c_t, c_t^*, g_t, k_t m_t) \right\}, \quad [2]$$

where, following Kia (2013), the utility has an instantaneous function as:

$$U(c_t, c_t^*, g_t, k_t m_t) = (1 - \alpha)^{-1} (c_t^{\alpha_1} c_t^{*\alpha_2} g_t^{\alpha_3})^{1-\alpha} + \xi (1 - \eta)^{-1} [(k_t m_t)_{\eta_1}]^{1-\eta}, \quad [2']$$

and  $c_t$  and  $c_t^*$  are single, non-storable, real domestic and foreign consumption goods, respectively.  $m_t$  is the holdings of domestic real (M/p) cash balances.  $E$  is the expectation operator, and the discount factor satisfies  $0 < \beta < 1$ .  $g$  is the real government expenditure on goods and services and it is assumed to be a “good”. Furthermore,  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$ ,  $\alpha$ ,  $\eta_1$ ,  $\eta$  and  $\xi$  are positive parameters and  $0.5 < \alpha < 1$  and  $0.5 < \eta < 1$ . The latter assumption ( $0.5 < \alpha < 1$  and  $0.5 < \eta < 1$ ) is needed to ensure a standard demand for money. Since none of the following results is sensitive to the magnitude of  $\alpha_1$ ,  $\alpha_2$ ,  $\alpha_3$  and  $\eta_1$  for the sake of simplicity we assume these parameters are all equal to one. The utility function [2] is similar to what Kia (2006a) assumes in the specification of utility function [2']. For the sake of simplicity, following Cox (1983), Drazen and Helpman (1990), Hueng (1999) and Kia (2006a) among many others, we assume that the total output is exogenously given.<sup>7</sup>

<sup>7</sup> In other words, we assume labor is supplied inelastically. Note that none of the results will be affected if we relax this assumption.

Note that we are assuming that individuals benefit from government services in their consumption, e. g., clean and safe roads, foods that have been inspected, provide a higher utility to consumers. Following Kia (2006a) we can consider  $g$  as public demand for public goods. Furthermore, we assume services of money enter the utility function and we chose the units in such a way that the services of domestic money  $S [= m]$ , e. g., Sidrauski (1967).

Variable  $k_t$  summarizes risk associated to holding domestic money and it is a function of oil price over the long run and policy and political regime changes over the short run. Specifically, we postulate that over the long run:

$$\log(k_t) = k_0 \log(\text{oilprice}_t). \quad [3]$$

It is assumed that the short-run dynamics of the risk variable  $[\log(k)]$  is equal to a set of interventional dummies which account for economic crisis, innovations as well as policy regime changes which influence services of money. Variable  $\text{oilprice}$  is the world real oil price. We hypothesize constant coefficient  $k_0 > 0$  since as the price of oil goes up demand for the currency of a net oil-importing country (U.S.), everything else being constant, goes up.

The utility function is assumed to be increasing in all its arguments, except variable  $k$  that is decreasing, strictly concave and continuously differentiable. The demand for services of money  $S [= m]$ , following Sidrauski (1967), will always be positive if we assume  $\lim_{s \rightarrow 0} U_s = \infty$  for all  $c$ , where  $U_s = \partial U / \partial s$ . Given  $g$  and oil price, the consumer maximizes [2] subject to the following budget constraint:

$$\tau_t + y_t + (1 + \pi_t)^{-1} m_{t-1} + (1 + \pi_t)^{-1} (1 + R_{t-1}) d_{t-1} = c_t + q_t c_t^* + m_t + d_t, \quad [4]$$

where  $\tau_t$  is the real value of any lump-sum transfers/taxes received/paid by consumers,  $q_t$  is the real exchange rate, defined as  $E_t p_t^* / p_t$ ,  $E_t$  is the nominal exchange rate (domestic price of foreign currency),  $p_t^*$  and  $p_t$  are the foreign and domestic price levels of foreign and domestic goods, respectively,  $y_t$  is the current real endowment (income) received by the individual and  $d_t$  is the one-period real domestically financed government debt which pays  $R$  rate of return. Assume further that  $d_t$  is the only storable financial asset.

Maximizing the preferences with respect to  $m$ ,  $c$ ,  $c^*$  and  $d$ , and subject to budget constraint [4] for the given  $g$  will yield the following solution:<sup>8</sup>

$$c_t^* = (\alpha_2 / \alpha_1) c_t q_t^{-1}.$$

Since we assumed  $\alpha_2 / \alpha_1 = 1$  we will have:

<sup>8</sup> Detailed solutions of the model, for the sake of brevity, are not reported, but are available upon request.

$$\begin{aligned} c_t^* &= c_t q_t^{-1}, \text{ or} \\ \log(c_t) &= \log(c_t^*) + \log(q_t). \end{aligned} \quad [5]$$

Using the assumption  $\alpha_1 = \alpha_2 = \alpha_3 = \eta_1 = \eta_2 = 1$  we will have:

$$\begin{aligned} \log(\xi) - \log(k_t) - \eta \log(m_t) + \eta \log(k_t) &= \log(R_t/1 + R_t) + \log(c_t^*) + \log(g_t) \\ - \alpha \log(c_t) - \alpha \log(c_t^*) - \alpha \log(g_t) + \log(q_t). \end{aligned} \quad [6]$$

Substitute for  $c$  from (5) in (6) to get:

$$\log(c_t^*) = \beta_0 + \beta_1 \log(m_t) + \beta_2 \log(k_t) + \beta_3 \log i_t + \beta_4 \log(g_t) + \beta_5 \log(q_t), \quad [7]$$

where  $\beta_0 = (1/(1 + \alpha)) \log(\xi) > 0$ ,  $\beta_1 = -\eta (1/(1 + \alpha)) < 0$ ,  $\beta_2 = (\eta - 1) (1/(1 + \alpha)) < 0$ ,  $\beta_3 = (1/(1 + \alpha)) < 0$ ,  $\beta_4 = -((1 - \alpha)/(1 + \alpha)) < 0$ ,  $\beta_5 = -(\alpha/(1 + \alpha)) < 0$  and  $i_t = \log(R_t/1 + R_t)$ , using  $0.5 < \alpha < 1$  and  $0.5 < \eta < 1$ .

Let us assume the U.S. import ( $cm^*$ ) from Mexico is a constant proportion of its total imports, i. e.,  $cm^* = \epsilon c^* = mx$ , where  $\epsilon$  is a constant parameter and  $mx$  is the exports of Mexico to the U.S. which are equal to the U.S. imports from Mexico. Substitute  $mx$  and (3) in (7) to get:

$$\begin{aligned} \log(mx_t) = \log(\epsilon c_t^*) &= -\log(\epsilon) + \beta_0 + \beta_1 \log(m_t) + \beta_2 k_0 \log(\text{oilprice}_t) \\ &+ \beta_3 \log i_t + \beta_4 \log(g_t) + \beta_5 \log(q_t). \end{aligned} \quad [8]$$

Equation [8] can be written as:

$$\begin{aligned} \log(mx_t) &= x_0 + x_1 \log(m_t) + x_2 \log(\text{oilprice}_t) + x_3 \log i_t + x_4 \log(g_t) \\ &+ x_5 \log(q_t) + x_6 \text{trend}, \end{aligned} \quad [9]$$

where  $x_0 = -\log(\epsilon) + \beta_0 = ?$ ,  $x_1 = \beta_1 < 0$ ,  $x_2 = \beta_2 k_0 < 0$ ,  $x_3 = \beta_3 < 0$ ,  $x_4 = \beta_4 < 0$ ,  $x_5 = \beta_5 < 0$ ,  $x_6 > 0$ . To capture the change in technology we also added a time trend to eq. [9], where its coefficient is clearly positive.

Equation [9] is a long-run U.S. demand for Mexican exports. According to this relationship as the money supply in the U.S. goes up (i. e., higher services of money in the utility) demand for Mexican exports will fall. This implies that U.S. monetary policy can affect exports of Mexico (sensitivity). A higher interest rate can also affect negatively the Mexican current account. Interestingly, the net impact of the U.S. monetary policy on Mexican exports depends on the differences between  $x_1$  and  $x_3$  coefficients. An easy monetary policy in the U.S. reduces Mexican exports through a higher money supply, but improves this export through a lower interest rate.

---

**8** Detailed solutions of the model, for the sake of brevity, are not reported, but are available upon request.

A higher oil price increases the services of money (demand for money) in the U.S. and, therefore, reduces Mexican exports. The fiscal policy in the U.S. also negatively influences Mexican exports. Namely, as government expenditure on goods and services in the U.S. increases, demand for Mexican exports to the U.S. falls. According to this model, both the U.S. fiscal and monetary policies influence the Mexican economy (which is an evidence of Mexico's high level of sensitivity to the U.S. changes in its policies that impact international trade), while the net effect of these two policies is an empirical issue. Finally, the U.S. exchange rate policy also influences Mexican exports as the real exchange rate goes up imports from Mexico become more expensive and so demand for imports will fall. As can be seen from above, the concept of sensitivity is clearly determined by the model. We will empirically test the model over the long and short run in the next section. This will be the second quantitative measurement of economic interdependence in this paper. Namely, the study of the long-term relationship between the total Mexican non-oil exports with the U.S. demand for Mexican products.

## 4 Data and Empirical Results

The data used in this study includes quarterly series obtained from various sources such as the International Monetary Fund (IMF), the St. Louis Federal Reserve Bank (FRED), and the Instituto Nacional de Estadística, Geografía e Informática (INEGI) from Mexico. The sample period is 1980Q1–2013Q4 with a total of 132 observations. The choice of the period is based on the availability of the data. All data, when appropriate, are seasonally adjusted, or when they are available only in a non-seasonal form, they are seasonally adjusted. All variables, when appropriate, are in millions of dollars.

The proxy for total exports is the real Mexican non-oil exports. The variable  $m$  is the real M1 and  $i$  ( $= \log(R_t/1 + R_t)$ ), where  $R$  from 1980 up to 1996Q4 is the three-month commercial paper rate and after that it is the three-month AA non-financial commercial paper rate. Variables  $oilprice$ ,  $g$  and  $q$  are the real oil price in \$US, the real U.S. federal government expenditure on goods and services and the \$US/Peso real exchange rate, respectively.

### 4.1 Long-Run Relationships

We estimate the long-run cointegrating relationship (eq. [9]) of the U.S. demand for total Mexican non-oil exports, developed in the previous section. With respect to the previous empirical evidence on the cointegration analysis applied

to the study of the Mexican external sector, the income variable was found to be the most significant variable in the explanation of the trade sector (total exports and imports) for trade between the U.S. and Mexico. For example, see Cermeño, Jensen, and Rivera (2010), Cuevas (2010), Fullerton and Sprinkle (2005) and Ramírez (2005). To the best knowledge of the authors, no study in the existing literature has developed a theoretical model which is capable of analyzing how Mexican exports (level of sensitivity of the Mexican economy) are affected by the U.S. fiscal and monetary policies and at the same time providing a new approach to the study of economic interdependence (by including variables that represent fiscal and monetary policies). We are filling this gap in this paper.

To investigate the stationarity property of the variables, we used the Augmented Dickey-Fuller and non-parametric Phillips-Perron tests. Furthermore, to allow for the possibility of a break in intercept and slope, we also used the test developed by Zivot and Andrews (1992). According to the test results, all variables are integrated of degree one (non-stationary). See Table 1.

The long-run estimation results are given in Table 2. Johansen-Juselius Maximum Likelihood estimation results are reported in the first and second panels. It should be noted that constant models can have time-varying coefficients if a deeper set of constant parameters characterizes the data generation process. As Kia (2006b) shows the estimated long-run relationship can be biased when the appropriate policy regime changes and/or other exogenous shocks are not incorporated in the short-run dynamics of the system. During the sample period the exogenous shocks which could influence the short-run dynamics of the system include the Mexican debt crisis of 1982–1983 and the peso devaluation of December 1994, known later as the “tequila effect”. The effects of NAFTA have been introduced with two different dummies. The first one reflects a transitional period of the economic integration. Since the tariff elimination was gradual and took more than ten years, it is more appropriate to include a linear increasing dummy rather than a zero-one dummy.<sup>9</sup> The second dummy expresses the starting of NAFTA from the first quarter of 1994. It should be noted that the global financial crisis of 2007–2008 is introduced in two forms. A first dummy refers to the U.S. financial crisis and the second dummy refers to the period when Mexico is fully affected by this crisis.

The following dummy variables included in the short-run dynamics of the system are D1 for the NAFTA gradual tariffs reduction (value of zero before 1994Q1 and gradually increasing its value to 1 in 2008Q4 and hereafter), D2 for the Mexican debt crisis (equal to 1 from 1982Q2 to 1983Q4 and zero, otherwise), D3 for the peso crisis (equal to 1 from 1995Q1 to 1996Q1 and zero, otherwise), D4

---

<sup>9</sup> This work follows Kia (2006b) in the construction of a transitional dummy.

**Table 1:** Stationary tests: 1980 (Jan.)–2013 (Dec.) Absolute values\*.

Variables	Augmented Dickey-Fuller <i>t</i> -stat.	Phillips-Perron <i>t</i> -stat.	Zivot-Andrews <i>t</i> -stat.
<b>Levels:**</b>			
<b>log(mx)</b>	0.48	2.04	5.24 <sup>b</sup>
<b>log(m)</b>	2.24	0.97	2.86
<b>log (oilprice)</b>	1.88	1.70	3.13
<b>log(i)</b>	2.26	1.17	5.12 <sup>b</sup>
<b>log(g)</b>	1.44	1.55	2.40
<b>log(q)</b>	3.77 <sup>b</sup>	3.10	5.09 <sup>b</sup>
<b>Changes of:</b>			
<b>log(mx)</b>	5.77 <sup>a</sup>	10.52 <sup>a</sup>	6.60 <sup>a</sup>
<b>log(m)</b>	3.82 <sup>b</sup>	3.99 <sup>b</sup>	5.17 <sup>b</sup>
<b>log (oilprice)</b>	5.90 <sup>a</sup>	5.75 <sup>a</sup>	6.66 <sup>a</sup>
<b>log(i)</b>	3.38 <sup>c</sup>	3.53 <sup>b</sup>	5.00
<b>log(g)</b>	3.99 <sup>b</sup>	15.43 <sup>a</sup>	5.65 <sup>a</sup>
<b>log(q)</b>	5.15 <sup>a</sup>	11.64 <sup>a</sup>	5.54 <sup>b</sup>

Notes: \* All tests include constant and trend. The critical value for Augmented Dickey-Fuller *t* test (lag-length = 4) and for Phillips-Perron non-parametric Z test (window size = 4) is 3.42 at 5 % and 3.98 at 1 %, respectively. The critical value for Zivot-Andrews *t* test (lag length = 4) is -5.08 at 5 % and -5.57 at 1 %, respectively. The number of observations is 136.

\*\* **log(mx)** is the log of real non-oil Mexican exports; **log(m)** is the log of real monetary supply; **log(oilprice)** is the log of real oil prices; **log(i)** is the log  $i = \log(R_t/1 + R_t)$ , where  $R$  from 1980 up to 1996Q4 is the three-month commercial paper rate and after that it is the three-month AA non-financial commercial paper rate; **log(g)** is the log of real federal government consumption expenditures; **log(q)** is the log of the real exchange rate.

<sup>a</sup>Significant at 1 %.

<sup>b</sup>Significant at 5 %.

<sup>c</sup>Significant at 10 %

for the effects of the financial crisis of 2008 (equal to 1 from 2008Q4 to 2009Q4 and zero, otherwise), D5 for the implementation of NAFTA (equal to 1 from 1994Q1 and zero, otherwise) and finally, uscrisis for the U.S. financial crisis (equal to one for the period of 2007Q4 and 2009Q3 and zero, otherwise), in the short-run dynamics of the system.

Table 2: Long-run test results\*.

$H_0 = \rho$	0	1	2	3	4	5	Diagnostic tests**	p-value
Trace <sup>(1)</sup>	227.0	150.1	91.3 <sup>a</sup>	55.1	30.1	11.0	Autocorrelation LM(1) LM(2)	0.000
Trace 95 <sup>(2)</sup>	179.0	141.4	106.9	77.6	50.0	26.4		0.146
p-value	0.00	0.02	0.26	0.53	0.61	0.67	ARCH LM(1) LM(2) Normality	0.235 0.199 0.000
							Lag length = 6	

Johansen-Juselius Maximum Likelihood result for  $\rho = 2$ . Null: restrictions are accepted:  $\chi^2(1) = 1.494$ , p-value = 0.222

Normalized	log(mx)	log(m)	log(oilprice)	log(i)	log(g)	log(q)	1983:03	1991:04	trend
log(mx) (t-stat)	-	-0.82 (3.07)	-0.30 (6.44)	0.01 (0.51)	-0.29 (2.23)	0.18 (2.54)	restricted	0.49 (8.48)	0.04 (9.54)
log(q) (t-stat)	Restricted	-4.04 (2.17)	-3.14 (8.84)	0.61 (3.10)	6.00 (5.98)	-	-2.30 (5.39)	restricted	-0.13 (5.41)

#### Fully Modified Ordinary Least Squares (FMOLS) results\*\*\*

log(mx) (t-stat)	-0.49 (2.26)	-0.42 (7.98)	-0.86 (5.05)	0.08 (2.87)	0.42 (3.69)	0.02 (0.09)	0.07 (0.34)	0.04 (24.28)
---------------------	-----------------	-----------------	-----------------	----------------	----------------	----------------	----------------	-----------------

\* The sample period is 1980Q1–2013Q4. The model includes constant, trend and two structural breaks dummies. **log(mx)** is the log of real non-oil Mexican exports; **log(m)** is the log of real monetary supply; **log(oilprice)** is the log of real oil prices; **log(i)** is the log of real interest rates; **log(g)** is the log of real government consumption expenditures; **log(q)** is the log of the bilateral real effective exchange rate.

\*\* LM(1) and LM(2) are one and two-order Lagrangian Multiplier test, respectively (Godfrey 1978, 1988).

\*\*\* Results without restrictions. With restrictions we obtain similar results.

Notes: <sup>a</sup> means we cannot reject the null of  $\rho = 2$ .

<sup>(1)</sup>Using the Bartlett correction factor, the Trace test has been corrected for the small sample error; see Johansen (2000, 2002).

<sup>(2)</sup>The critical values of the Trace rank test were simulated. The critical values of the test statistics are calculated based on the length of the random walk of 400 with 2500 replications.

We use the multiple structural change test by Bai and Perron (2003) up to two maximum breaks. According to the test results, the breaks are 1983:3 and 1991:4 in the system. In fact, these breaks are associated with the Mexican debt crisis period as well as the liberalization of the Mexican financial system, respectively. Since dummy variables are included in the system we had to simulate the critical values of the Trace rank test. The critical values of the test statistics are calculated based on the length of the random walk of 400 with 2,500 replications and using the Bartlett correction factor, the Trace test has been corrected for the small sample error; see Johansen (2000, 2002). Based on the Trace test results, there are two cointegration relationships in space. According to the diagnostic test, the error is homoscedastic and there is no autocorrelation with the lag length of 6. However, the error is not normally distributed, but as Johansen (1995a) states, a departure from normality is not very serious in cointegration tests.

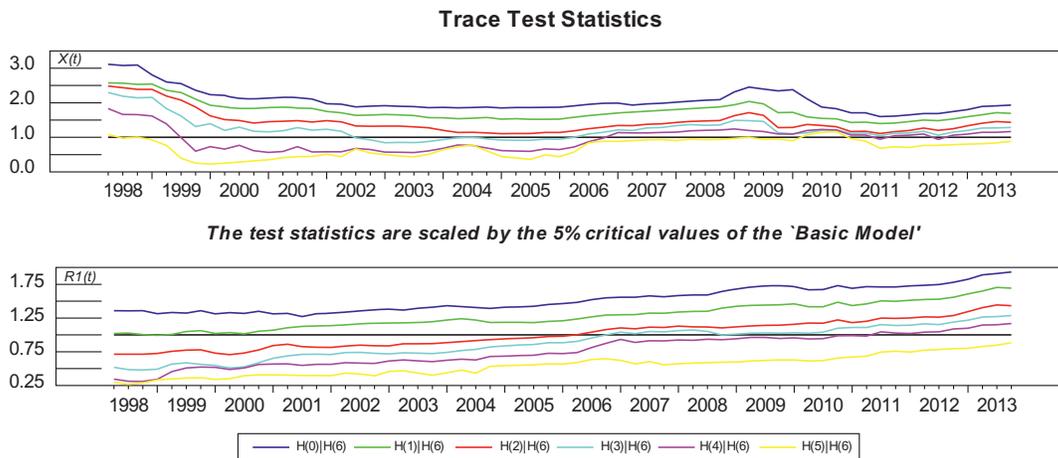
Since there are more than one cointegration relationship in space, identifying restrictions must be imposed to ensure the uniqueness of both short- and long-run parameters in the relationships. Following, e. g., Johansen and Juselius (1994) and Johansen (1995b), we can test to verify if the estimated coefficients of cointegrating equations are, in fact, economically meaningful. Many different identification restrictions were imposed. The final identified equations are reported in the second panel of Table 2. According to Chi-squared result, the restrictions cannot be rejected. Furthermore, generic identification (which is related to the linear statistical model and requires the rank condition) is satisfied. Moreover, both empirical and economic identifications are satisfied.<sup>10</sup>

As Figures 2–7 show all tests and coefficients are stable. Note that all recursive tests are normalized by the 5% critical value implying that calculated statistics that exceed unity suggest unstable cointegrating vector results. In Figures 2 and 3, the curve  $X(t)$  plots the actual disequilibrium as a function of all short-run dynamics including the dummy variable, while the  $R1(t)$  curve plots the “clean” disequilibrium that corrects for short-run effects. The first 18 years were held up for the initial estimation. As these figures show, all test statistics appear stable over the long run and the LR tests are also stable when the models are corrected for short-run effects. As Figures 4–7 show, all coefficients are stable.

Having established that both tests and coefficients are stable we will interpret the identified equations. The first equation resembles eq. [9]. Except interest rate all coefficients are statistically significant and except the coefficients of

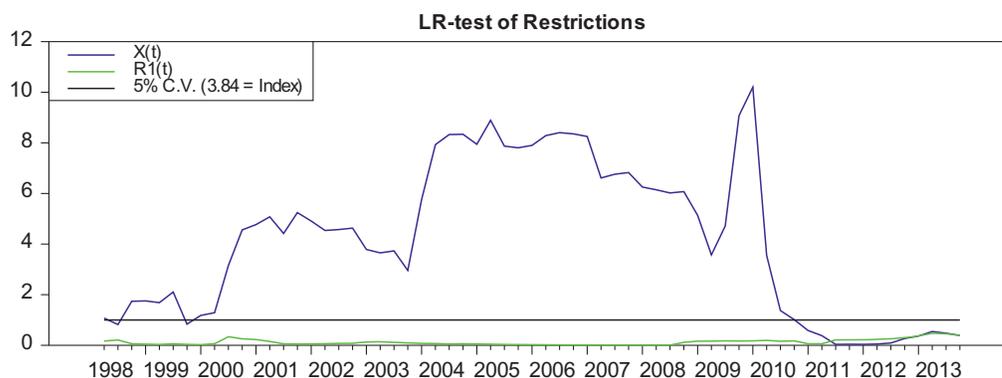
---

<sup>10</sup> The empirical identification is related to the estimated parameters values and the economic identification is related to the economic interpretability of the estimated coefficients of an empirically identified structure, Johansen and Juselius (1994).



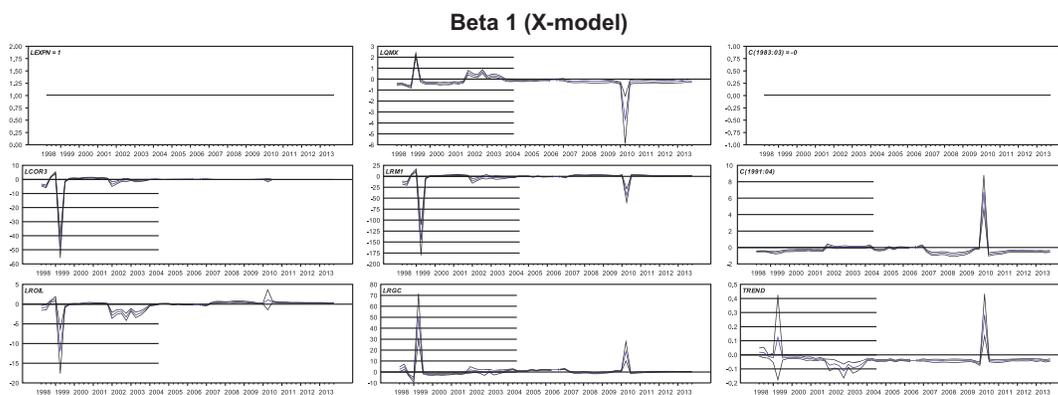
**Figure 2:** Trace test\*.

Notes: \*  $X(t)$  = the actual disequilibrium as a function of all short-run dynamics and the dummy variable.  $R1(t)$  = the “clean” disequilibrium that corrects for short-run effects.



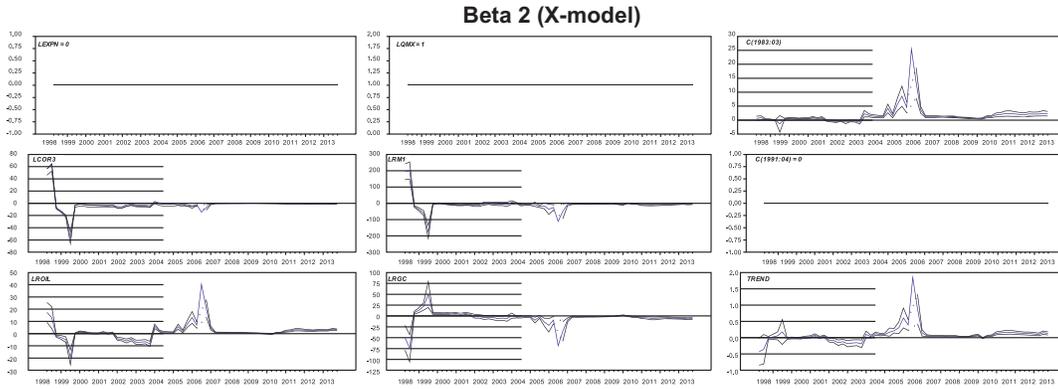
**Figure 3:** Recursive likelihood ratio tests\*.

Notes: \*  $X(t)$  = the actual disequilibrium as a function of all short-run dynamics and the dummy variable.  $R1(t)$  = the “clean” disequilibrium that corrects for short-run effects.



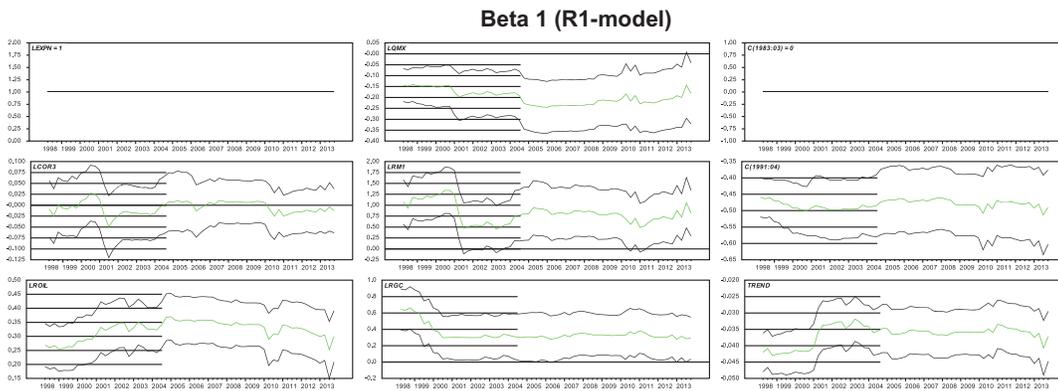
**Figure 4:** Test for constancy of the parameters of the identified Mexican to the U.S. export model\*.

Note: \*In X-model we re-estimate all parameters in each step.



**Figure 5:** Test for constancy of the parameters of the identified Mexican \$US/Peso Real exchange rate model\*.

Note: \* In X-model we re-estimate all parameters in each step.

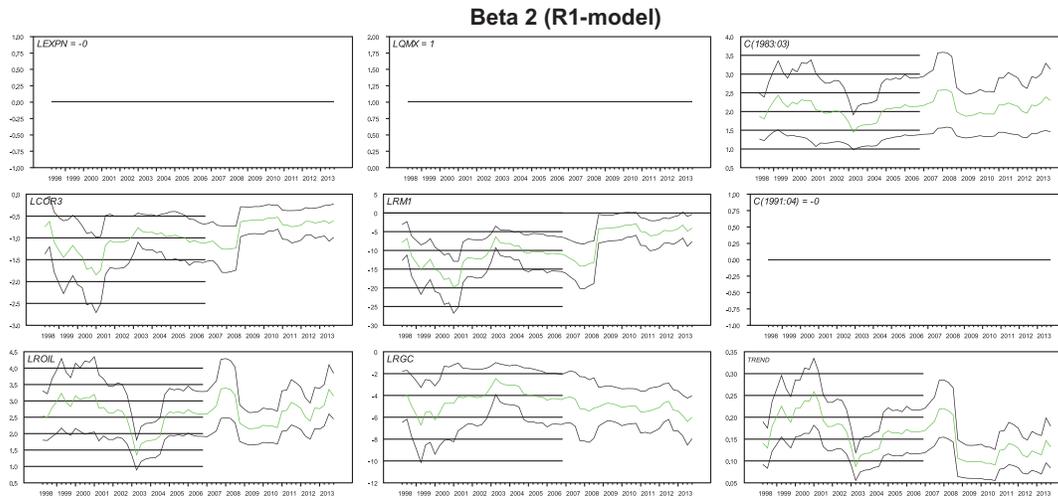


**Figure 6:** Test for constancy of the parameters of the identified Mexican to the U.S. export model\*.

Note: \* In R1-model we re-estimate only the long-run parameters Alfa and Beta, concentrating out the short-term dynamics using the full sample estimate of the parameters.

interest rate and exchange rate all coefficients have the correct sign. For the sake of robustness we also used Phillips and Hansen’s (1990) Fully Modified Least Squares (FMOLS). The results of this test are reported in the bottom panel of Table 2. According to the estimated result of the FMOLS test for eq. [9], all estimated coefficients confirm the Johansen-Juselius Maximum Likelihood Procedure test result. But all estimated coefficients now are statistically significant.

The third row of the second panel in Table 2 reports the second identified equation which may resemble a long-run estimation of the \$US/peso real exchange rate. We needed to restrict the Mexican exports and the 1991Q4 break to get an identified system. According to the estimation result both U.S. monetary and fiscal policies have influence the \$US/peso real exchange rate. A higher U.S. government expenditure also results in a higher value for \$US per



**Figure 7:** Test for constancy of the parameters of the identified Mexican \$US/Peso real exchange rate model\*.

Note: \* In R1-model we re-estimate only the long-run parameters Alfa and Beta, concentrating out the short-term dynamics using the full sample estimate of the parameters.

peso, everything else being constant. In sum, fiscal and monetary policies influence Mexican exports to the U.S. both directly and indirectly through its \$US/peso real exchange rate. Since the model confirms how sensitive Mexican exports are to the U.S. fiscal and monetary policies, we consider these findings are filling the gap in the analysis of economic interdependence of the U.S. and Mexico.

## 4.2 Short-Run Dynamic Model

Table 3 reports the parsimonious estimation of the final Error Correction Model (ECM) that is implied by the cointegrating vector on the basis of Hendry's General-to-Specific approach. To obtain the optimum lag length of variables Akaike and Schwarz information criterions for a maximum lag of eight quarters were used. The optimum lag profile was six quarters which were used at the original ECM. It should be noted that if small equilibrium errors can be ignored, while reacting substantially to large ones, the error correcting equation is non-linear, Granger (1986). Consequently, squared, cubed and fourth powered of the equilibrium errors (with statistically significant coefficients) as well as the products of those significant equilibrium errors were incorporated.

Assuming oil price is exogenous over the short run, we will have two endogenous variables in the system. But for the sake of brevity, the ECM of the U.S. demand

**Table 3:** Error-correction model (dependent variable =  $\Delta \log mx_t$ )\*.

Variable	Coefficient	Standard error	Hansen's stability $L_i$ test (5 % critical value = 0.05)
Constant	-0.08	0.14	0.73
$\Delta \log mx_{t-3}$	-0.19	0.04	0.71
$\Delta \log mx_{t-4}$	0.56	0.04	0.08
$\Delta \log m_{t-6}$	0.88	0.25	0.89
$\Delta \log oilprice_{t-4}$	-0.04	0.02	0.09
$\Delta \log oilprice_{t-5}$	0.07	0.02	0.35
$\Delta \log oilprice_{t-6}$	0.10	0.02	0.07
$\Delta \log q_{t-3}$	-0.15	0.05	0.03
$EC_{t-1}$	-0.09	0.03	0.76
Trend	-0.001	0.0002	0.75
D5	0.08	0.02	0.73
D19822	-0.13	0.05	Before the stability test $\Delta \log mx$ was adjusted for these dummy variables to avoid non-invertible matrix.
D19852	-0.15	0.05	
D19864	0.13	0.05	
D19912	0.25	0.05	
D19913	0.18	0.05	
D19914	0.16	0.05	
D19921	0.28	0.05	
D19922	-0.17	0.05	
Hansen's (1992) stability $L_i$ test on the variance = 0.29	$p$ -value = 0.15		
Joint (coefficients and the error variance) Hansen's (1992) stability $L_c$ test = 2.78	$p$ -value = 0.08		
Normality, Jarque-Bera = 1.24	$p$ -value = 0.54		

Notes: \* The sample period is 1980Q1–2013Q4. Mean of dependent variable = 0.03.  $\Delta$  means the first difference; D5 is a dummy variable to account for NAFTA starting 1994Q1. Dummy variables D19822, D19852, D19864, D19912, D19913, D19914, D19921 and D19922 are equal to one for 1982Q2, 1985Q2, 1986Q4, 1991Q2, 1991Q3, 1991Q4, 1992Q1 and 1992Q2 respectively and zero otherwise. These dummy variables are included in order to eliminate the outliers in the residuals.

EC is the error correction term which is defined as  $EC_t = \log(mx) - 0.013 \cdot \log(i) + 0.30 \cdot \log(oilprice) - 0.181 \cdot \log(q) + 0.817 \cdot \log(m) + 0.292 \cdot \log(g) - 0.490 \cdot d19914 - 0.037 \cdot \text{Trend}$ .

*Specification Tests:*  $\bar{R}^2 = 0.79$ ,  $\sigma = 0.04$ ,  $DW = 2.10$ ,  $\text{Godfrey}(6) = 1.96$  (significance level = 0.08),  $\text{White} = 87.22$  (significance level = 1.00),  $\text{ARCH}(5) = 3.78$  (significance level = 0.58), and  $\text{RESET}(3) = 0.51$  (significance level = 0.68). Note that  $\bar{R}^2$  and  $DW$ , respectively, denote the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin Watson statistic. White is White's (1980) general test for heteroskedasticity, ARCH is five-order Engle's (1982) test, Godfrey is five-order Godfrey's (1978) test, RESET is Ramsey's (1969) misspecification test, Normality is Jarque and Bera's (1987) normality statistics,  $L_i$  is Hansen's (1992) stability test for the null hypothesis that the estimated coefficient or variance of the error term is constant and  $L_c$  is Hansen's (1992) stability test for the null hypothesis that the estimated coefficients as well as the error variance are jointly constant.

for Mexican exports was only reported. However, the full estimation results of all these ECMs will be used to analyze the unanticipated shocks in endogenous variables using impulse response functions. In Table 3,  $\Delta$  denotes a first difference operator and EC,  $\bar{R}^2$ ,  $\sigma$  and DW, respectively, denote the error correction term from the long-run equation for the U.S. demand for Mexican exports, the adjusted squared multiple correlation coefficient, the residual standard deviation and the Durbin-Watson statistics, respectively. White is White's (1980) general test for heteroskedasticity, ARCH is the five-order Engle's (1982) test, Godfrey is the five-order Godfrey's (1978) test, RESET is Ramsey's (1969) misspecification test, Normality is Jarque-Bera's (1987) normality statistics,  $L_i$  is Hansen's (1992) stability test for the null hypothesis that the estimated  $i$ th coefficient or variance of the error term is constant and  $L_c$  is Hansen's stability test for the null hypothesis that the estimated coefficients as well as the error variance are jointly constant.

Dummy variables D19822, D19852, D19864, D19912, D19913, D19914, D19921 and D19922 are equal to one for 1982Q2, 1985Q2, 1986Q4, 1991Q2, 1991Q3, 1991Q4, 1992Q1 and 1992Q2 respectively, and zero otherwise. These dummy variables are included in order to eliminate the outliers in the residuals.<sup>11</sup> According to the diagnostic tests the error term is white noise. None of the diagnostic checks is significant. Therefore, the estimation method is the Ordinary Least Squared. Based on Hansen's stability test results, all of the coefficients individually are stable. The estimated coefficient of the change in real exchange rate is weakly stable, but as we can see all the coefficients are jointly stable.

We also included *uscrisis* and D1 to D5 (defined previously), but, with the exception of D5, none of these variables was statistically significant and so they were dropped in the parsimonious estimation result reported in Table 3. According to this estimation result, the estimated coefficient of the error-correction term is negative and statistically significant.

According to the estimation result in Table 3, over the short run the exports of Mexico to the U.S. are not affected by the fiscal policy in the U.S. The oil price after four quarters has a negative effect on these exports as the model predicts. But it affects positively Mexican exports implying that as oil price goes up first the U.S. demand for Mexican goods goes down, but later the change encourages imports from Mexico over the short run. This is also true for the real exchange rate. As we would expect demand for Mexican exports went up after NAFTA as the coefficient of dummy variable D5 indicates.

---

<sup>11</sup> These outliers may be due to the following events: the Mexican debt crisis (D1982:2), the gradual changing in the economic policy due to the debt crisis (D1985:2), the period of trade liberalization process (D1986:4), the openness period of the Mexican financial system (D1991:2 through D1992:2).

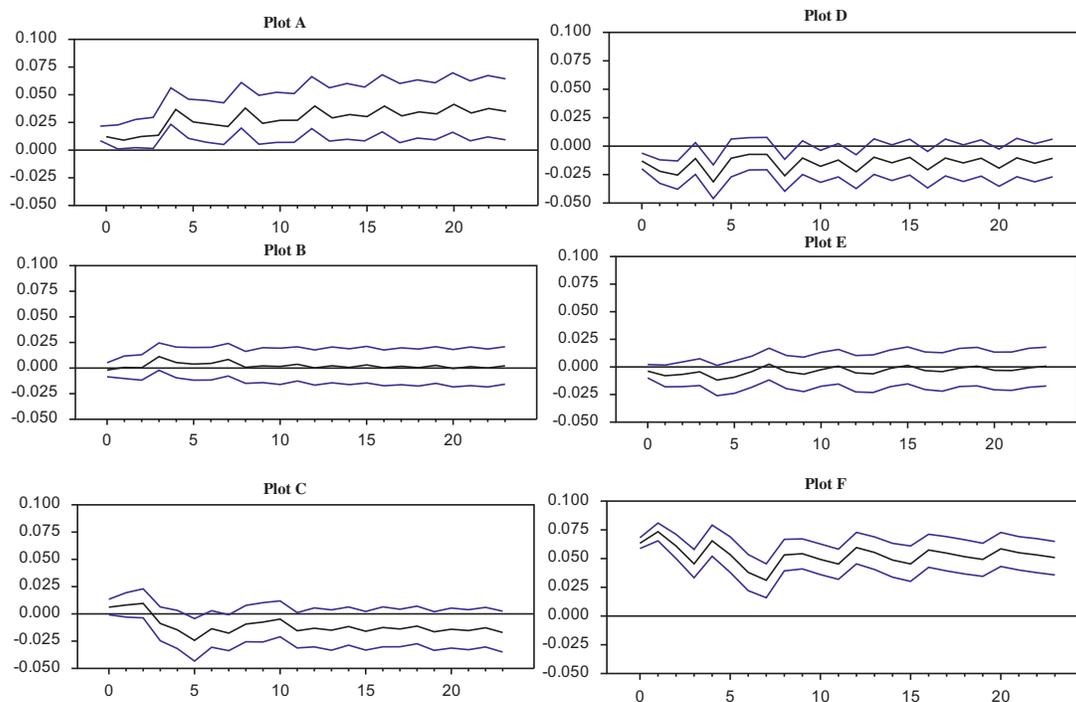
### 4.3 Unanticipated Shocks

The estimated coefficients of all ECMs were used to analyze the impact of unanticipated shocks (impulse responses) in the variables on the Mexican exports to the U.S. The Choleski factor is used to normalize the system so that the transformed innovation covariance matrix is diagonal. This allows us to consider experiments in which any variable is independently shocked. The conclusions are potentially sensitive to the ordering (or normalization) of the variables. As one would expect, part of a shock in the money supply is contemporaneously correlated to a shock in interest rate, real exchange rate and the oil price (in \$US) which by themselves are correlated to a shock in the government expenditure and the demand for the Mexican products (Mexican exports). Consequently, let us propose the ordering of money supply, interest rate, real exchange rate, oil price, government expenditure and Mexican exports. By ordering the Mexican exports last, the identifying restriction is that the other variables do not respond contemporaneously to a shock to the Mexican exports level. Note that this ordering is not critical in the analysis as no particular theory or empirical evidence conflicts with the logic of the proposed ordering.

We will run the VAR, with six lags (the lag length of the cointegration equations, see Table 2), in the error-correction form. The impulse response functions reflect the implied response of the levels. The deterministic variables (dummy variables) which account for exogenous shocks are included as exogenous variables. Let us follow Lütkepohl and Reimers (1992) and assume a one-time impulse on a variable is transitory if the variable returns to its previous equilibrium value after some periods. If it settles at a different equilibrium value, the effect is called permanent. Since neither the coefficients of VAR are known with certainty nor their responses to shocks, in computing confidence bands, the Monte Carlo simulation is used. The number of Monte Carlo draws is 1000.

In Figure 8, plots A to F depict the impulse responses of the level of Mexican exports to the U.S. to a shock in the money supply, interest rate, real exchange rate, oil price, government expenditure, as well as Mexican exports to the U.S., respectively. These figures show the normalized responses of a shock. The normalization has been done by dividing the response by its innovation variance. This allows all the responses to a shock to be plotted on a single scale. As we can see all responses are within the confidence band.

According to plots A, C and D one standard deviation shock to money supply in the U.S., the \$US/peso real exchange rate and the oil price, respectively, has a permanent effect on the Mexican exports to the U.S. One standard deviation shock to the U.S. interest rate and government expenditure has a temporary effect on the Mexican exports to the U.S., see plots B and E,



**Figure 8:** Impulse responses of the Mexican exports to the United States to a shock to variables. Plot A: Responses to the U.S. real money supply. Plot B: Responses to the U.S. interest rate. Plot C: Responses to the \$US/Peso real exchange rate. Plot D: Responses to the oil price. Plot E: Responses to the U.S. real government expenditure. Plot F: Responses to the Mexican exports to the U.S.

respectively. Finally, as Plot F shows, one standard deviation shock to Mexican exports to the U.S. has a permanent effect on itself. Consequently, Mexican exports to the U.S. are permanently sensitive to the shocks of money supply, exchange rate and oil price. However, it is temporarily sensitive to the shocks coming from the interest rate and government expenditures in the U.S.

We analyze variance decompositions for various time horizons in order to investigate whether U.S. monetary and fiscal policies as well as other shocks have played much of a role in accounting for Mexican exports to the United States. Table 4 reports variance decompositions for various time horizons. Each row shows the fraction of the  $t$ -step ahead of forecast error variance for the Mexican exports to the United States that is attributed to shocks to the column variables. The first column is the standard error of forecast for this variable in the model. Note that since the model assumes the coefficients are known, they are lower than the true uncertainty when the model has estimated coefficients.

The remaining columns provide the decomposition of the forecast errors. In each row, they add up to 100%. For instance, 91.62% of the variance of the one-step forecast error is due to the innovation in Mexican exports to the United States itself.

**Table 4:** Mexican exports to the United States variance decomposition.

Period (Quarters)	Shock to (Innovation in):						
	Standard error	Money supply	Interest rate	Real exchange rate	Oil price	Real government expenditure	Mexican exports
1	0.05	3.30	0.07	0.82	3.80	0.39	91.62
4	0.11	3.10	0.73	1.48	7.88	0.90	85.91
12	0.18	13.61	0.70	4.10	7.90	1.09	72.60
20	0.23	17.43	0.47	4.09	6.84	0.82	70.36
24	0.25	18.44	0.40	4.10	6.44	0.70	69.92

However, the more interesting information is that at the longer steps the interactions among the variables start to be more noticeable. We have truncated this table to 24 steps, i. e., six years, to make the interpretation more manageable.

According to these results, the four principal factors driving Mexican exports are itself, U.S. money supply, real exchange rate and oil price, which make clear the existence of high level of sensitivity of Mexican exports to the U.S. The importance of money supply shock (monetary policy) is increasing from 3.30 % in one quarter to 13.61 % of the Mexican exports forecast error variance after three years and to 18.44 % in six years. Since this variable was first in the ordering, it is not clear (from examining just this one ordering) whether this is an artifact of the ordering.

Real exchange rate accounts for the Mexican exports forecast error from 1.48 % after a year to 4.10 % in six years. However, this forecast error variance remains the same after three years. Furthermore, after a quarter, oil price shock accounts for 3.80 % of the Mexican exports forecast error variance, but increases to 7.90 % in three years and falls to 6.44 in six years. The impact of the monetary policy through interest rate shock accounts for only 0.70 % of the Mexican exports forecast error variance in three years and then it falls. So the U.S. monetary policy shock on the exports of Mexico, if any, is mostly through the shock in the money supply. Finally, the U.S. fiscal policy shock does not have any significant effect on this export forecast error variance.

## 5 Final Remarks

This paper aims to complement the existing literature by examining the theoretical and empirical literature on economic interdependence. The critical review

of such interdependence distinguishes two schools of thought: international relations and economic integration. The existing literature completely ignores the sensitivity impacts of the U.S. monetary and fiscal policies in the analysis of Mexican exports to the U.S. To deal with this shortcoming this paper develops a model capable of analyzing sensitivity impacts of the changes in the U.S. fiscal and monetary policies on Mexican exports. Before estimating the model we calculated a BTII to verify economic interdependence and it shows the significance of the U.S. market for Mexican products.

According to the estimation result Mexican exports to the U.S. are highly sensitive to fiscal and monetary policies over the long run. Furthermore, shocks coming from the money supply, real exchange rate as well as oil prices are permanent, while shocks from interest rate and government expenditures are transitory.

It is also clear that the point of departure of growing economic interdependence between both countries started with the Mexican economic liberalization (1986–1987) and became consolidated in 1994 with the signature of NAFTA. This economic interdependence also has meant that the Mexican economy has developed a high level of sensitivity from the U.S. economy (based on fiscal and monetary policies from the U.S.). Consequently, the policy implications of our findings are twofold: first Mexico should concentrate more on other international markets and second, the only way for Mexico to reduce complex interdependence from the U.S. is through the creation of economic tools to reduce a negative economic influence from the U.S. economic shocks and avoid strong changes in the business cycles.

## References

- Anderson, K., and H. Norheim. 1993. "From Imperial to Regional Trade Preferences: Its Effect on Europe's Intra- and Extra-Regional Trade." *Weltwirtschaftliches Archiv* 129 (1):78–102.
- Bai, J., and P. Perron. 2003. "Computation and Analysis of Multiple Structural Change Models." *Journal of Applied Econometrics* 18 (1):1–22.
- Balassa, B. 1965. "Trade Liberalization and Revealed Comparative Advantage." *Manchester School of Economic and Social Studies* 33 (2):99–123.
- Balasubramaniam, A., C.-H. Pua, and S. Abu-Mansor. 2012. "Economic Interdependence: Evidence From China and ASEAN-5 Countries." *Modern Economy* 3:122–5.
- Barbieri, K. 1996. "Economic Interdependence: A Path to Peace or a Source of Interstate Conflict?." *Journal of Peace Research* 33:29–49.
- Bilateral Commission of the Future of United States-Mexico Relations. 1988. "El Desafío de la Interdependencia: México y Estados Unidos: Informe." University of Texas: Fondo de Cultura Económica.
- Cañas, J., R. Coronado, and R. W. Gilmer. 2004. "Maquiladora Downturn: Structural Change or Cyclical Factors?." *International Business & Economics Research Journal* 3 (8):27–46.

- Castillo, R., R. Varela, and J. Ocegueda. 2010. "Synchronization of Economic Activity Between Mexico and the US: What Are the Causes?." *Revista De Análisis Económico* 25 (1):15–48.
- Cermeño, R., B. Jensen, and H. Rivera. 2010. "Trade Flows and Volatility of their Fundamentals: Some Evidence from Mexico." *Documentos de Trabajo del CIDE*, No. 496.
- Chiquiar, D., and M. Ramos-Francia. 2005. "Trade and Business-Cycle Synchronization: Evidence From Mexican and U.S. Manufacturing Industries." *The North American Journal of Economics and Finance* 16 (2):187–216.
- Cox, M. W. 1983. "Government Revenue From Deficit Finance." *Canadian Journal of Economics* XVI (2):264–74.
- Cuevas, A., M. Messmacher, and A. Werner. 2003. "Sincronización Macroeconómica entre México y sus Socios Comerciales del TLCAN." *BANXICO Documentos de Trabajo*, No. 2003–01.
- Cuevas, V. 2010. "The Dynamics of Mexican Manufacturing Exports." *CEPAL Review* 102:151–71.
- Delajara, M. 2012. "Sincronización entre los Ciclos Económicos de México y Estados Unidos. Nuevos Resultados con Base en el Análisis de los Índices Coincidentes Regionales de México." *BANXICO Documentos de Trabajo*, No. 2012–01.
- Drazen, A., and E. Helpman. 1990. "Inflationary Consequences of Anticipated Policies." *The Review of Economic Studies* 57 (1):147–64.
- Engle, R. F. 1982. "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation." *Econometrica* 50 (4):987–1007.
- Fragoso, E., J. Pastrana, and R. Castillo. 2008. "Sincronización Del Empleo Manufacturero En México Y Estados Unidos." *Economía Mexicana Nueva Época* XVII (1):5–47.
- Fullerton Jr., T., and R. L. Sprinkle. 2005. "An Error Correction Analysis of U.S.-Mexico Trade Flows." *International Trade Journal* XIX (2):179–92.
- Garces-Diaz, D. 2008. "An Empirical Analysis of the Economic Integration Between Mexico and the United States and Its Connection with Real Exchange Rate Fluctuations (1980–2000)." *The International Trade Journal* XXII (4):484–513.
- Gasiorowski, M. J. 1986. "Economic Interdependence and International Conflict: Some Cross-National Evidence." *International Studies Quarterly* 30 (1):23–38.
- Godfrey, L. G. 1978. "Testing Against General Autoregressive and Moving Average Error Models When the Regressors Include Lagged Dependent Variables." *Econometrica* 46 (6):1293–301.
- Godfrey, L. G. 1988. *Misspecification Test in Econometrics*. Cambridge: Cambridge University Press.
- Granger, C. W. J. 1986. "Developments in the Study of Cointegrated Economic Variables." *Oxford Bulletin of Economics and Statistics* 48 (3):213–18.
- Hansen, B. E. 1992. "Testing for Parameter Instability in Linear Models." *Journal of Policy Modeling* 14 (4):517–33.
- Hanson, G. H. 2001. "Mexico Integration and Regional Economies: Evidence From Border-City Pair." *Journal of Urban Economics* 50 (2):259–87.
- Herrera, J. 2004. "Business Cycles in Mexico and the United States: Do They Share Common Movements?." *Journal of Applied Economics* VII (2):303–23.
- Hirschman, A. O. 1945. *National Power and the Structure of Foreign Trade*. Berkeley, CA: University of California Press.
- Hueng, C. J. 1999. "Money Demand in an Open-Economy Shopping-Time Model: An Out-of-Sample-Prediction Application to Canada." *Journal of Economics and Business* 51 (6):489–503.
- Huerta, A. 1994. *La Política Neoliberal De Estabilización Económica en México*, Límites y Alternativas. Mexico: Editorial Diana.
- Iapadre, L., and F. Tironi. 2009. "Measuring Trade Regionalism: The Case of Asia." *UNU-CRIS Working Paper* 2009.

- Jarque, C. M., and A. K. Bera. 1987. "A Test for Normality of Observations and Regression Residuals." *International Statistical Review* 55 (2):163–72.
- Johansen, S. 1995a. *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford: Oxford University Press.
- Johansen, S. 1995b. "Identifying Restrictions of Linear Equations with Applications to Simulations Equations and Cointegration." *Journal of Econometrics* 69 (1):111–32.
- Johansen, S. 2000. "A Bartlett Correction Factor for Test on the Cointegration Relations." *Econometric Theory* 16 (5):740–78.
- Johansen, S. 2002. "A Small Sample Correction of the Test for Cointegrating Rank in the Vector Autoregressive Model." *Econometrica* 70 (5):1929–61.
- Johansen, S., and K. Juselius. 1994. "Identification of the Long-Run and the Short-Run Structure an Application to the ISLM Model." *Journal of Econometrics* 63 (1):7–36.
- Keohane, R. 1988. "International Institutions: Two Approaches." *International Studies Quarterly* 32 (4):379–96.
- Keohane, R., and J. S. Nye. 1989. *Power and Interdependence*, 2nd ed. Glenview, IL: Scott Foresman Little Brown.
- Keohane, R., and J. S. Nye. 1998. "Power and Interdependence in the Information Age." *Foreign Policy* 77 (5):81–94.
- Keohane, R., and J. S. Nye. 2000. "Globalization: What's New? What's Not? (and so What?)." *Foreign Policy* 118 (1):104–19.
- Kia, A. 2006a. "Deficits, Debt Financing, Monetary Policy and Inflation in Developing Countries: Internal or External Shocks?." *Journal of Asian Economics* 17:879–903.
- Kia, A. 2006b. "Economic Policies and Demand for Money: Evidence From Canada." *Applied Economics* 38 (12):1389–407.
- Kia, A. 2013. "Determinants of the Real Exchange Rate in a Small Open Economy: Evidence From Canada." *Journal of International Financial Markets, Institutions & Money* 23:163–78.
- Kim, J.-K., K. Yangseon, and H. L. Chung. 2006. "Trade, Investment and Economic Interdependence Between South Korea and China." *Asian Economic Journal* 20 (4):379–92.
- Kirby, P. 2006. "Theorizing Globalization's Social Impact: Proposing the Concept of Vulnerability." *Review of International Political Economy* 13 (4):632–55.
- Kroll, J. A. 1993. "The Complexity of Interdependency." *International Studies Quarterly* 37 (3):321–47.
- Leamer, E., and R. M. Robert Mitchell Stern. 1970. *Quantitative International Economics*. Chicago, IL: Aldine.
- Lustig, N. 1998. *Mexico: The Remaking of an Economy*, 2nd ed. Washington, DC: Brookings Institution.
- Lütkepohl, H., and H. E. Reimers. 1992. "Impulse-Response Analysis of Cointegrated Systems." *Journal of Dynamics and Control* 16 (1):53–78.
- Mejía, P., E. Gutiérrez, and C. Farías. 2006. "La Sincronización de Los Ciclos Económicos de México y Estados Unidos." *Investigación Económica* LXV (258):15–45.
- Miles, W., and C. Vijverberg. 2011. "Mexico's Business Cycles and Synchronization with the USA in the Post-NAFTA Years." *Review of Development Economics* 15 (4):638–50.
- Moreno-Brid, J. C., J. C. Rivas-Valdivia, and J. Santamaría. 2005. *Mexico: Economic Growth Exports and Industrial Performance After NAFTA*, No. 42. México: CEPAL.
- Nagayasu, J. 2010. "Macroeconomic Interdependence in East Asia." *Japan and the World Economy* 22:219–27.
- Nye, J. S., and R. Keohane. 1971. "Transnational Relations and World Politics: An Introduction." *International Organization* 25 (3):329–49.

- Phillips, K. R., and J. Cañas. 2004. *Business Cycle Coordination Along the Texas-Mexico Border*. Dallas, TX: Federal Reserve Bank of Dallas.
- Phillips, P. C. B., and B. Hansen. 1990. "Statistical Inference in Instrumental Variables Regression with I(1) Processes." *Review of Economic Studies* 57 (1):99–125.
- Ramírez, J. 2005. "La Economía Mexicana y El Sector Externo: Tendencias y Cointegración." *Desarrollo Internacional* 5 (2):5–16.
- Ramsey, J. B. 1969. "Tests for Specification Errors in Classical Linear Least-Squares Regression Analysis." *Journal of Royal Statistical Society, Series B* 31 (2):350–71.
- Romero, J. 2010. "Evolución de la Demanda de Importaciones de México: 1940–2009." *Centro de Estudios Económicos. Series documentos de trabajo El COLMEX*. Num. III-2010.
- Ronfeldt, D., and C. Sereseres. 1983. "The Management of U.S.-Mexico Interdependence: Drift Toward Failure?." In *Mexican-U.S. Relations: Conflict and Convergence*, edited by C. Vásquez and M. García y Griego, 43–107. Los Angeles: UCLA Chicano Studies Research Center Publications.
- Rosecrance, R., A. Alexandroff, W. Koehler, J. Kroll, and J. Stocker. 1977. "Whiter Interdependence." *International Organization* 31 (3):425–71.
- Sidrauski, M. 1967. "Rational Choice and Patterns of Growth in a Monetary Economy." *The American Economic Review* 57 (2):534–44.
- Torres, A., and O. Vela. 2003. "Trade Integration and Synchronization Between the Business Cycles of Mexico and the United States." *The North American Journal of Economics and Finance* 14 (3):319–42.
- Wagner, R. H. 1988. "Economic Interdependence, Bargaining Power and Political Influence." *International Organization* 42 (3):461–83.
- White, H. 1980. "A Heteroskedasticity-Consistent Covariance Matrix Estimator and a Direct Test for Heteroskedasticity." *Econometrica* 48 (4):817–37.
- Zhang, M. 1995. *Major Powers at a Crossroads: Economic Interdependence and an Asia Pacific Security Community*. Boulder, CO: Lynne Rienner Publishers.
- Zivot, E., and D. W. K. Andrews. 1992. "Further Evidence on the Great Crash, the Oil Price Shock, and the Unit-Root Hypothesis." *Journal of Business and Economic Statistics* 10 (3):251–70.