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Impact of exchange rate adjustment on Mexican exports to the United States

Impacto del ajuste cambiario sobre las exportaciones mexicanas hacia a los Estados Unidos

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Abstract

Mexico's trade links with the United States and China have promoted an interesting and even unique trilateral relationship worldwide, both due to the scale and the connection that have emerged between imports from the Asian country and Mexican exports to the North American market. Thus, by estimating various vector autoregressive (VAR) models, the impact of the exchange rate adjustment and imported goods from China on exports to the United States was quantified. According to the results obtained, it was found that, on the one hand, the relationship between the exchange rate and said exports is positive throughout the period; although the conclusion is not definitive for different periods; and on the other hand, it was verified that imports from China simulate Mexican exports to the northern neighbor's market, providing empirical evidence in the context of Mexican trade

JEL Code: F13, F59, C32, C51, C52
Keywords: exchange rate; imports of Chinese origin; exports to the United States

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Resumen

Los vínculos comerciales de México con Estados Unidos y China han propiciado una relación trilateral interesante e incluso única a nivel mundial tanto por la escala como por la conexión que se han registrado entre las importaciones procedentes del país asiático y las exportaciones mexicanas hacia el mercado norteamericano. Por ello, mediante la estimación de diversos modelos de vectores autorregresivos (VAR) se cuantificó el impacto del ajuste cambiario y de los bienes importados procedentes de China sobre las exportaciones hacia Estados Unidos.
De acuerdo con los resultados, se encontró que, por un lado, la relación entre el tipo de cambio y las ventas mexicanas al mercado estadounidense es positiva en todo el periodo a pesar de que la conclusión no es definitiva para distintos lapsos; y, por otro lado, se reveló que las importaciones procedentes de China incentivan las exportaciones aztecas al mercado de su vecino del norte.

Código JEL: F13, F59, C32, C51, C52
Palabras clave: tipo de cambio; importaciones procedentes de China; exportaciones hacia Estados Unidos

Introduction

Since the mid-1990s, in the face of the massive implementation of trade liberalization measures, the Mexican economy has established important relations with the USA and China, two economies that, in addition to being the strongest in the world today, are Mexico's two main trading partners and have been engaged in a trade conflict since 2018.

Since the implementation of the North American Free Trade Agreement (NAFTA), the USA has been the main destination for Mexican exports, with figures that exceed 80% of the total. At the same time, products from China have become increasingly important in the Mexican market, particularly after 2001, when it joined the World Trade Organisation (WTO).[1] Accordingly, Mexico has implemented various sectoral promotion programs to avoid possible distortions of the tariff preferences agreed upon within the NAFTA framework.

Regardless of the diverse and controversial opinions in discussions on the consequences of China's increasingly active participation in trade exchanges with Mexico and the USA (Ley, 2012; Embassy of Mexico in China, 2015; Limas, 2019; Liu & Covarrubias, 2023), the growing strengthening of ties between the three countries has been evident. To a large extent, imports from China are destined not only for final consumption but also, for the most part, to be incorporated into the different links of the production plants installed in Mexico to export the final products to international markets.

[1]A detailed analysis of the effects of China's accession to the WTO on Mexican trade can be found in Liu (2022) and Covarrubias (2023)

Nevertheless, in analyzing this importance within the field of intentional trade, it is essential to include the exchange rate. It plays a crucial role in the main aspects derived from conventional economic theory. It is commonly recognized that a devaluation of the exchange rate implies an incentive for the growth of exports due to the cheapening of domestic goods compared to their foreign counterparts.

In this context, the quantitative estimation of the influence of exchange rate adjustment on exports is a factor that should not be excluded from this trilateral relation in terms of trade exchanges between the three nations, nor should its importance be underestimated. Therefore, this paper proposes a hypothesis in which, on the one hand, imports from the Chinese economy, particularly manufactured goods with high technological content[2], have a positive impact on the growth of Mexican exports to the US market as a fundamental part of the linkage of global value chains in the increasingly important participation of the Asian economy in Mexican exports. On the other hand, in contrast to what is established in conventional theory, exchange rate adjustment harms these exports in certain periods of low exchange rate stability. In general, an unexpected exchange rate movement is strongly linked to the risk of higher transport costs, and as a consequence, the gains from bilateral trade are reduced in terms of lower exports.

Given these elements, the research aims to show empirical evidence of the impact of the exchange rate adjustment in Mexico and the import of Chinese goods on exports to the USA. Several cointegration VAR models were estimated for different time lags based on these considerations.

The results obtained in the regressions confirmed the main contributions of this study, namely that imports from the Asian country make up an important part of Mexico's productive and export dynamics toward the US market, making the importance of the expansion of the Chinese economy increasingly relevant; furthermore, the exchange rate is a relevant variable that is negatively related to the same flows of goods in periods of high volatility.

The explanation is that exchange rate volatility has negative implications for international trade due to the risk aversion of economic agents, which reduces the volume of exports from developing economies. Moreover, this is compounded by the dollarisation of liabilities of Mexican exporting companies with difficulties in financing themselves within the country and the inclusion of hidden costs in the exports of these companies (Mántey, 2013), two factors that are not mutually exclusive and constitute an uncertain environment.

It is also important to stress that this research is a first attempt to incorporate the trilateral trade factor between the three economies to assess the impacts of the exchange rate adjustment on Mexican exports to the US market.

[2] These types of goods are mainly concentrated in chapters 84, 85 and 87 of the Harmonized System.

Thus, its relevance revolves around the consideration of economic policymakers to analyze the dynamics of Mexico's trade with its main partners to help increase the effectiveness of bilateral trade in an environment of trade openness while at the same time seeking a more stable monetary policy concerning the volatility of the exchange rate.

In addition to this introduction, the paper is divided into three sections: the first section analyzes the evolution of the exchange rate as an instrument of monetary policy and reviews the debates on exchange rate volatility and its effect on international trade. In the second section, econometric estimation is carried out through different cointegration VAR models to describe the long-run behavior in the whole period and, subsequently, for specific periods with varying characteristics regarding exchange rate volatility. Finally, the conclusions are presented.

Exchange rate adjustment and its impact on foreign trade

The Mexican economy faces a double dilemma regarding monetary policy formulation and exchange rate management. On the one hand, it is argued that there is a conflict of objectives between inflation control and economic growth. An exchange rate appreciation is required to achieve the inflation target, which would contradict a competitive exchange rate to stimulate increased exports (García & Perrotini, 2014). On the other hand, within the adopted approach of inflation targeting in monetary policy, these authors argue that the exchange rate is competitively more efficient in controlling the price level than the interest rate since inflation is more sensitive to the exchange rate adjustment than the interest rate variation.

The use of the exchange rate in Mexico's economic policy framework

The monetary policy implemented in Mexico has focused on the priority objective of price stabilization and the exchange rate was used as a nominal anchor. Nonetheless, in the face of the 1994 financial collapse, the strategy was found to be unfeasible, so the floating exchange rate regime was adopted to initiate a transition process based on the New Macroeconomic Consensus (NCM) aimed at a monetary policy of inflation targets, which was formalized in 2001 accompanied by a strategy of export growth and which assumes competitive and efficient markets, where, in addition, the interest rate stabilizes the product and reduces inflation (Mántey, 2009; Heath & Acosta, 2019; Cerezo *et al.*, 2020).

Recently, the Bank of Mexico (Spanish: *Banco de México*) (2021) ratified its conduct through the inflation targeting regime to ensure the stability of the purchasing power of the national currency, which implies having inflation within an established and stable range by defining a target for the interbank

interest rate and thus influencing aggregate supply and demand, and in turn influencing inflation through different transmission channels, such as the exchange rate.

Theoretically, the monetary policy framework within the NCM is circumscribed by a flexible exchange rate regime and the inflation targeting model, with the interest rate used as a short-run instrument.

Accordingly, Mántey (2009) showed that free-floating is not permissible in Mexico because the priority is to achieve the established inflation targets, and it is used in coordination with the interest rate and sterilized intervention in the foreign exchange market so that the postulates of the theoretical model of NCM inflation targeting are not fulfilled. The author attributed this to the institutional differences and transmission mechanisms between developed and developing economies, in addition to the fact that the exchange rate constitutes the fastest monetary policy transmission channel through the variation of imported input costs and changes in external demand to achieve inflation targets.

The inflation targeting model cannot explain the exchange rate pass-through toward inflation, creating an opaque situation in which, for strategic reasons, the central bank does not disclose achieving inflation targets through unconventional channels such as sterilized intervention in the foreign exchange market (Archer, 2005).[3]

In general terms, Mexico optimizes a combination of instruments to conduct its policy: on the one hand, open market operations that regulate the behavior of the interest rate, and on the other, sterilized interventions to stabilize the exchange rate. This contradiction concerning the export growth model occurs because inflation control depends on exchange rate appreciation as a transmission mechanism.

Discussions on exchange rate volatility and its effect on exports

Some studies focus on the existence of a minimal quantitative negative effect of exchange rate volatility on trade (IMF, 2004). Others show varying changing effects: insignificant, of little significance, null, limited, and weak relation (Ozturk, 2006). In general, there are heterogeneous opinions regarding the existence of a relation between exchange rate instability and trade, where the impossibility of generalized statements is evident since the empirical evidence mainly suggests results associated with the choice of the study period, the specification of the empirical model, and the countries considered in the study, whether developed or developing (Ibidem, Coric, & Pugh, 2010).

[3]The use of this element has been the subject of debates by various authors including Rosas (2011), Mántey (2009, 2011), Mántey and Rosas (2014), Girón (2015) and Rodríguez (2015).

Theoretically, a nominal exchange rate devaluation has favorable effects on aggregate demand and economic growth, specifically by increasing competitiveness, since such an exchange rate movement would imply a restriction on imports and an incentive to increase exports. There are numerous studies in favor of making the nominal exchange rate more flexible, mainly of a structuralist nature, that propose a competitive and stable real exchange rate, such as Bresser-Pereyra (2006), Frenkel (2008), and Galindo and Ros (2008).

In contrast, the empirical works of Berman and Berthou (2009) and Mántey (2013) provide the elements to assert that a devaluation has negative effects on exports of emerging economies such as Mexico, due to the imperfections in financial markets that affect exporting companies in emerging economies with greater intensity. Furthermore, the oligopolistic structure of international trade, where competitive advantages do not depend only on relative labor costs but, to a greater degree, on technological progress and the positive externalities companies receive from their governments, also harms exports.

Research shows that the reason for this negative relation lies in the dollarization of the liabilities of Mexican exporting companies with difficulties in financing themselves within the country and in the inclusion of hidden costs in the exports of these companies (Mántey, 2013; Lane & Shambaugh, 2010).

In this regard, Lobo and Mosquera (2021) show a negative relation between exchange rate volatility and exports for the case of Colombia with eleven of its trading partners using a panel model and a gravity model. They thus show that, in the face of anticipation of risk, an increase in volatility would suggest an expected marginal profit for exports and, therefore, an increase in exports. Nevertheless, this does not always occur. In situations of uncertainty, economic agents choose the option that represents a lower risk for them. Therefore, volatility creates uncertainty in the international market, so producers decide to place their goods in the domestic market.

In addition to the above, if the exchange rate variation becomes unpredictable, it could create even greater uncertainty in terms of benefits and costs and reduce international trade.

Similar relations were found in Xie and Baek (2020), although they conclude that it is impossible to fully determine whether exchange rate volatility positively or negatively affects exports.

Finally, Crookes *et al.* (2022) also agree, in a case study of the United Kingdom, that there are different conclusions on exchange rate volatility. Nonetheless, they consider that exchange rate adjustment and exports have to do with the reduced sensitivity of global linkages and the capacity of large companies to absorb exchange rate movements in their margins.

Empirical estimation of the effects of the exchange rate on the export dynamics of Mexico with its main trading partner

As hypothetically stipulated, a large part of the merchandise from China is linked to the Mexican production and export sector, particularly that directed toward the US market. In addition, the exchange rate has diverse effects on these dynamics, so both variables are considered in the estimation presented here.

To this end, estimates were made following a deductive method; that is, the first estimation was that of a cointegration VAR model that includes imports from China and exports to the USA, as well as the nominal exchange rate in the study period from January 1995 to February 2020. It was found that there is a dependence between the bilateral relations that Mexico has with its two main partners and that exchange rate fluctuations have a positive effect on exports to the USA, even though the conclusion is not definitive and the relations change in the different estimation periods.

The conventional theory does not consider a negative relation between Mexican exports to the USA and the exchange rate. Nonetheless, based on the described association, a model was estimated for three selected periods based on the volatility of the exchange rate for a more in-depth analysis.

Methodology; VAR cointegration models as a tool in analysis

This research aims to characterize the simultaneous interactions between exports to the USA, imports of Chinese origin, and the nominal exchange rate using monthly data from 1995 to 2020.[4]

This was achieved by estimating a cointegration VAR model by applying the methodology proposed by Johansen (1988). To this end, a system of simultaneous equations was defined, where each variable is expressed in its reduced form: distributed lag equations. In other words, the values at time t of each variable do not represent explanatory variables but the respective lags of each involved in the model.

It is worth noting that, being unrestricted models, the main advantage is that there will be no specification errors in the empirical estimation. In addition, the long-run cointegration solution is exempted from spuriousness or nonsense regressions, as defined by Granger and Newbold (1974) based on the initial idea of Yule (1926).

VAR models provide better estimation of forecasts than static models, so in this case, the results are analyzed dynamically and structurally, where the importance of a shock of one variable on the others becomes evident.

A cointegration VAR model for the entire study period

[4]The available data can be found on the websites of the Ministry of Economy for imports and Banco de México for the nominal exchange rate.

In recent years, trade flows between China, Mexico, and the USA have intensified substantially so that Mexican imports from the Asian economy form part of the linkage of global value chains in production since Chinese expansion has been a decisive factor in the analysis. For this reason, special emphasis was placed on the quantitative estimation of the trilateral relation since few studies currently focus on it quantitatively.

This model was estimated monthly and covers the period from January 1995 to February 2020. The natural logarithms of Mexico's exports to the USA (LXEU), the nominal exchange rate (LTC), and imports from China (LMCH) were used as explanatory components.

To properly apply the methodology, the series involved in the model must be integrated into the same order. Therefore, the Augmented Dickey-Fuller and Phillips-Perron tests were estimated to corroborate the series' stationarity with 95% confidence (Tables 3 and 4 in the Appendix).

As shown in Figure 1, the series were stationary in first order.

According to the criteria established in the E-views software, it was decided to use eleven lags for the first model, which showed stability within the unit circle.

It is important to note that Liu *et al*. (2020) estimated a model with similar characteristics and showed the effects measured by exchange rate and import elasticities with both parameters positive. Nevertheless, this paper examines the impact of the exchange rate on US exports in more detail. For this reason, Granger causality was estimated within the VAR model (Table 5 in the Appendix). The authors focused on the set of explanatory variables that affect Mexican exports to the USA, which is confirmed by the estimation of the model.

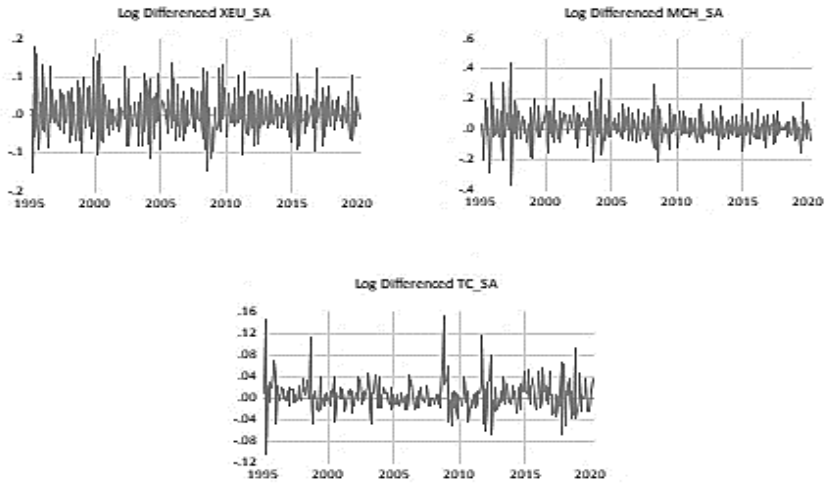

Figure 1. Mexican exports to the USA, imports from China, and nominal exchange rate (variables differentiated in natural logarithms) with monthly frequency from January 1995 to February 2020
Source: created by the authors with data from BANXICO (2020) and SE (2021)

The long-run cointegrating relation using Johansen cointegration is shown in Equation 1 with standard errors in parentheses:

$$LXEU = \underset{(0.0237)}{0.1575}LMCH + \underset{(0.1353)}{0.2788}LTC \quad (1)$$

It shows that in terms of elasticities, Mexican exports to the USA are positively related in the long run to imports from China and to the nominal exchange rate throughout the study period since the estimated coefficients are statistically significant.

In general, for the whole period, it can be observed that a nominal exchange rate impulse harms exports to the USA, an impact that is reversed after the third lag. In contrast, the impact of a boost in Chinese imports has a positive trend for the whole period but changes constantly, as shown in Figure 2.

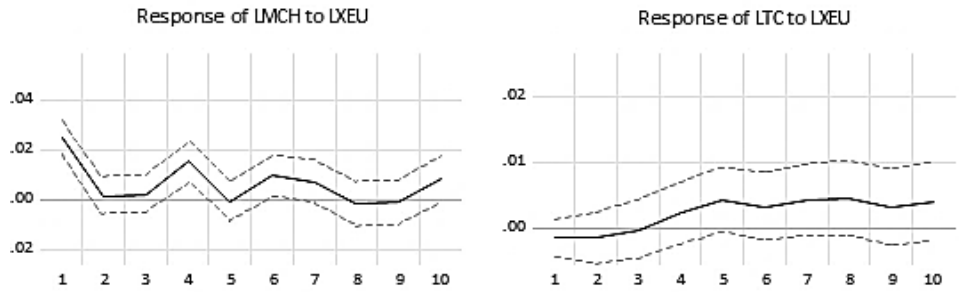

Figure 2. Impact of nominal exchange rate and imports from China on Mexican exports to the USA
Source: created by the authors in E-views

The model errors proved homoscedasticity and the absence of first-order and higher-order autocorrelation up to the ninth lag (Tables 6 and 7 in the Appendix). Being a model with 291 observations, despite not fulfilling the Cholesky normality test (Table 8 in the Appendix), asymptotic normality is assumed due to the law of large numbers, as explained by Wooldridge (2010). It should be noted that, in this type of model, when estimated with monthly data, the sample is very large; nonetheless, the assumptions are hardly fulfilled, in addition to the fact that many other factors determine international trade. To this end, an effort was made to adjust the model by using six dummy variables: D97 in April 1997, D98 in August 1998, D00 in February 2000, D04 in March 2004; D06 in January 2006, and D08 in the period that marks the beginning of the global financial crisis from September 2008 to February 2009.

Cointegration analysis in different periods

Throughout the entire study period, the exchange rate is characterized by different stages according to its degree of volatility. Figure 3 shows the behavior of the nominal exchange rate growth rate segmented into three periods and the behavior in levels of the same variable on axes 1 and 2, respectively.

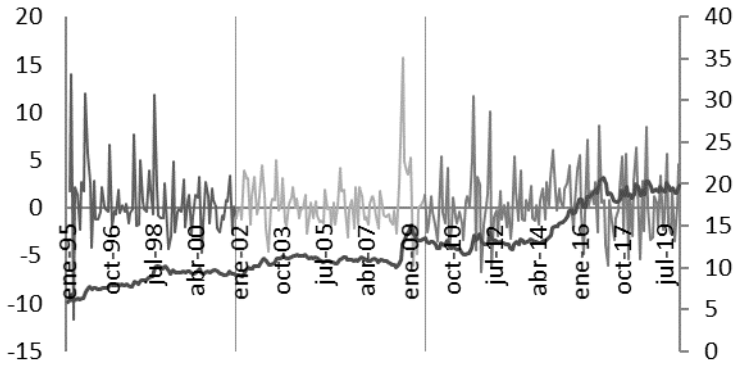

Figure 3. Main axis: Nominal exchange rate growth rate, divided into three periods. On the secondary axis: Nominal exchange rate in levels
Source: created by the authors with data from Banxico (2020)

High volatility (measured by variance) can be observed in the first period (January 1995-December 2001); apparent stability, where the trend is almost horizontal, in the second (January 2002-September 2009); and moderate volatility, between small periods of stability, in the third period (October 2009-February 2020), as shown in Table 1.

Table 1
Variance of the growth rate of the nominal exchange rate

Period 1	12.56
Period 2	7.56
Period 3	11.07

Source: created by the authors

In general terms, the first period began in January 1995, one year after NAFTA came into effect, and ended in December 2001 when China joined the WTO, in addition to the formalization in Mexico of the export growth strategy, which assumed competitive and efficient markets. The period was characterized by high exchange rate volatility, a systematically decreasing trend, and a very low share of Chinese imports in Mexican trade. By January 2002, a second period began with relative exchange rate stability that ended in September 2009, with the growing participation of imports from China as a significant factor. The third period is described as the beginning of the world crisis, in addition to different events that temporarily affected the currency's stability, so the corresponding monetary authorities contained volatility. The analysis period ends just before the global crisis caused by COVID-19.

Therefore, there are three different periods in which the relation between the real exchange rate and exports to the USA had different nuances, in agreement with the assertion of Ozturk (*op. cit.*) and

Coric and Pugh (*op. cit.*) that this relation can have different results that depend, in this case, on the characteristics of the selected study periods.

Period 1; january 1995 to december 2001

To determine the growth of exports to the USA as a function of the nominal exchange rate and imports of Chinese origin, a VAR model was estimated for the period, assuming that the series are integrated of the first order. Similarly, the criteria for determining the length of the model were estimated.

The following equation was obtained from the estimated model with two lags through Johansen's cointegration.

$$\underset{}{LXEU} = \underset{(0.6944)}{4.59LMCH} \underset{(6.0387)}{-29.11LTC} \tag{2}$$

As in the previous model, the inverse roots of the autoregressive characteristic polynomial were estimated to check the stability of the model. As can be seen, following the hypothesis proposed, within an environment of high exchange rate volatility, the coefficients were statistically significant and are interpreted as the elasticity of exports to the USA relative to imports from China and the nominal exchange rate. Thus, a change in the latter is associated with a change in exports of 4.59 and -29.11, respectively.

The model errors met the assumptions of normality, homoscedasticity, and absence of first-order and higher-order autocorrelation. The corresponding tests are shown in Tables 9-11 in the Appendix. For this purpose, it was necessary to include four dummy variables: D95 in April 1995; D99 in January, May, and July 1999; D00 in February 2000; and D01 in July 2001.

Period 2; october 2002 to september 2009

As shown in Figure 3, the second period is characterized by stable behavior and low exchange rate volatility, in contrast to the first period.

A key factor in this effect is undoubtedly the growing behavior of exports to the USA, despite two drops in export levels in the last quarter of 2006 and the last quarter of 2007. Total exports to the USA grew at a higher rate than in the previous study period, despite the slow overall growth associated with the financial crisis, which did not manage to push foreign trade to the US market into negative territory, as it showed a growing trend as in previous years.

In a model that proved stability within the unit circle, Johansen's cointegration tests were applied to obtain the equation:

$$LXEU = \underset{CH(0.009}{0.3814LM9)} - \underset{C(0.0661)}{1.10LT}$$

(3)

It can be observed that the positive relation between exports to the USA and imports of Chinese origin persisted, with a significant decrease. Likewise, in contrast to the previous period, the negative relation with the nominal exchange rate decreased considerably within an environment of greater stability.

The coefficients obtained were statistically significant; consequently, the elasticity of exports to the USA regarding imports of Chinese origin and the nominal exchange rate was 0.38 and -1.10, respectively.

Similarly, the model's errors proved normality, homoscedasticity, and absence of first-order and higher-order autocorrelation (Tables 12-14 of the Appendix). It should be noted that it was necessary to include three dummy variables, namely D02 in April 2002, D06 in March 2006, and D08 in October 2008.

Period 3; october 2009 to february 2020

Under the pressure of the 2008 financial crisis in the United States, the repercussions in Mexico were stronger in the second half of 2009, when exports of goods and services were partially reduced due to the decline in US demand, as well as a decreasing trend in remittance revenue, and employment levels with negative annualized growth rates (Banxico, 2009).

In this context and under the Mexican monetary policy guided by the interest rate to seek price stability, adjustments were made in the foreign exchange market. Different studies confirm that the exchange rate still serves as a secondary instrument for achieving the inflationary objective through the monetary authority's interventions in the foreign exchange market (Ampudia 2007; Mántey 2009), and therefore, its impact on international trade is questionable.

The study period was concluded in February 2020 because a health emergency was declared in March of that year due to the COVID-19 pandemic. Consequently, a strong structural change began outside the period of analysis of this work.

Without loss of generality, the model presented stability within the unit circle, and when Johansen cointegration was applied, the following was obtained:

$$XEU = \underset{(0.0376)}{0.7739MCH} - \underset{(0.0458)}{0.1690TC} \quad (4)$$

These data confirm the highly significant increase in imports from China and Mexican exports to the USA, underscoring the importance of developing global value chains in the production process to further boost Mexico's export dynamics to its northern neighbor.

Nevertheless, it is important to mention two relevant points in this last period: on the one hand, the elasticity of exports relative to imports increased to 0.77, and the exchange rate decreased, although the negative sign prevailed with a value of 0. 16, both statistically significant coefficients; and on the other hand, although three dummy variables were included, namely, D11, in September 2011; D12, in April 2012, and D17 in August 2017, the normality and homoscedasticity tests were proven (Tables 15 and 16 of the Appendix, respectively). For the case of the absence of autocorrelation, it was proven only for lags 2 and 4 (Table 17 in the Appendix).

A summary of the results is shown in Table 2.

Table 2
Summary of results

Period	LXEU	LMCH	LTC
1995.01-2020.02	1.0000	0.1575	0.2788
1995.01-2001.12	1.0000	4.5944	-29.1155
2002.01-2009.09	1.0000	0.3814	-1.1000
2009.10-2020.02	1.0000	0.7739	-0.1690

Source: created by the authors

Some final remarks on model estimation

Initially, when estimating the models presented here, the aim was to show structural changes rather than forecasts. In other words, for forecasting purposes, it is a necessary condition that the model assumptions regarding errors are met: a normal distribution, constant variance and absence of autocorrelation. To this end, it was considered that, for the estimation with monthly data in the long run, there is a large number of observations, and therefore, it is very difficult for the assumptions to be fulfilled since there are several fluctuations in the stochastic processes that make it impossible to obtain a favorable result for the fulfillment of the assumptions.

In this regard, Covarrubias and Liu (2023) present a generalization of the resolution of VAR models for i variables with j lags, where the basis of the study lies in structural analysis. In general terms, asymptotic normality is assumed, given the law of large numbers, due to the size of the sample, and in

terms of homoscedasticity and autocorrelation, the results obtained are still the best linearly unbiased estimators (MELI) for forecasting purposes (Wooldridge, 2010; Gujarati, 2010), where it is confirmed that the results are reliable in terms of structural analysis.

Finally, the models presented here were rethought, and the assumptions were satisfactorily met by including dummy variables explained in the respective sections. The Appendix provides a complete summary of the tests performed.

Conclusions

In all four estimations, imports from China were a statistically significant variable explaining exports, highlighting the importance of Chinese products in Mexico's trade with the USA.

It should be noted that in the first period, although the elasticity is 4.5944 and statistically relevant, it should not be considered important because of the reduced participation of Chinese imports in Mexico's total imports and the significant increase in exports toward its northern neighbor's market due to the implementation of NAFTA.

Subsequently, after 2002, the elasticity went from 0.3714 to 0.7739 in the last period, indicating a growth in the same direction.

Regarding the exchange rate, although throughout the study period the elasticity of exports for this important variable was positive, at 0.2788, it has been shown that in specific periods it has a negative sign, with magnitudes of 29.1155, 1.10, and 0.1690, respectively. Thus, exchange rate volatility and the risk it entails lead to increases in transaction costs and, consequently, reductions in profits obtained from international trade, given the sensitivity of the links in the global value chains and the capacity of large companies to absorb exchange rate movements in their margins.

The estimated models also showed evidence of the strong impact that the Sino-Mexican trade relation has on Mexico's production and export dynamics with its main trading partner; thus, the impact of imports from China on exports to the US market should not be underestimated. Therefore, it is hoped that this study will enrich and contribute to research on the subject.

Finally, the results of this research are particularly relevant if the aim is to evaluate the impact of exchange rate volatility on international trade and to understand better Mexico's trade pattern with its two main trading partners, as well as the exchange rate effects on exports in an uncertain and highly volatile environment, Mexico must identify potentials and future scenarios in the trilateral relation with China and the USA, so that the authorities can create mechanisms capable of reframing trade policy and incentives to increase the country's competitiveness.

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Annex

Table 3
Augmented Dickey-Fuller Test

Statistic t	Level 5%	Probability
0.503943	-2.869750	0.9867
0.341902	-2.869775	0.9801
-1.377274	-2.869396	0.5938
-5.937203	-2.869750	0.0000

-4.465258	-2.869775	0.0003
-18.64024	-2.869419	0.0000

Source: created with data from Banxico (2020) and SE (2021)

Table 4
Phillips-Perron test

Variable	Statistic t	Level 5%	Probability
XEU	-1.160195	-2.869396	0.6925
MCH	0.042322	-2.869396	0.9608
TC	-1.320335	-2.869396	0.6211
D(XEU)	-59.33358	-2.869419	0.0001
D(MCH)	-28.10031	-2.869419	0.0000
D(TC)	-18.93058	-2.869419	0.0000

Source: created with data from Banxico (2020) and SE (2021)

Table 5
Granger Causality

Dependent Variable: XEU			
Excluded	Chi-sq	df	Probability
LMCH	44.13863	11	0.0000
LTC	14.22493	11	0.2208
All	58.67820	22	0.0000

Source: created by the authors in E-Views with data from Banxico (2020) and SE (2021)

Table 6
Joint Heteroscedasticity Test

Chi-sq	df	Probability
478.1867	432	0.0617

Source: created by the authors in E-views

Table 7
LM test for serial correlation in the VAR residuals

Null hypothesis: There is no serial correlation in the lag h						
Lag	LRE* stat	df	Probability	Rao F-stat	df	Probability
1	15.76871	9	0.0719	1.764899	(9, 598.8)	0.0719
2	15.02099	9	0.0904	1.680163	(9, 598.8)	0.0904
3	10.07416	9	0.3445	1.122205	(9, 598.8)	0.3445
4	11.23048	9	0.2602	1.252218	(9, 598.8)	0.2603
5	15.51901	9	0.0776	1.736590	(9, 598.8)	0.0776
6	5.979189	9	0.7420	0.663783	(9, 598.8)	0.7420
7	10.07491	9	0.3445	1.122290	(9, 598.8)	0.3445
8	3.867129	9	0.9199	0.428558	(9, 598.8)	0.9199
9	16.42326	9	0.0586	1.839162	(9, 598.8)	0.0586
10	17.35827	9	0.0434	1.945386	(9, 598.8)	0.0434
11	17.19892	9	0.0457	1.927271	(9, 598.8)	0.0457
12	18.98255	9	0.0253	2.130307	(9, 598.8)	0.0253

Source: created by the authors in E-views

Table 8
Cholesky Normality Test

Component	Jarque-Bera	df	Probability
1	0.363961	2	0.8336
2	15.33550	2	0.0005
3	66.91535	2	0.0000
Jointly	82.61481	6	0.0000

Source: created by the authors with E-views

Table 9
Cholesky Normality Test

Component	Jarque-Bera	df	Probability
1	1.165728	2	0.5583
2	2.085204	2	0.3525
3	8.250565	2	0.0162
Jointly	11.50150	6	0.0741

Source: created by the authors in E-views

Table 10
Joint Heteroscedasticity Test

Chi-sq	df	Probability
95.54163	96	0.494

Source: created by the authors in E-views

Table 11
LM test for serial correlation in the VAR residuals

Null hypothesis: There is no serial correlation in the lag h						
Lag	LRE* stat	df	Probability	Rao F-stat	df	Probability
1	1.581559	9	0.9965	0.172815	(9, 160.8)	0.9965
2	11.55124	9	0.2398	1.301343	(9, 160.8)	0.2400
3	7.511782	9	0.5840	0.835824	(9, 160.8)	0.5841

Source: created by the authors in E-views

Table 12
Cholesky Normality Test

Component	Jarque-Bera	df	Probability
1	0.471870	2	0.7898
2	0.194753	2	0.9072
3	0.351100	2	0.8390
Jointly	1.017723	6	0.9849

Source: created by the authors with E-views

Table 13
Joint Heteroscedasticity Test

Chi-sq	df	Probability
109.911	90	0.0755

Source: created by the authors in E-views

Table 14
LM test for serial correlation in the VAR residuals

Null hypothesis: There is no serial correlation in the lag h						
Lag	LRE* stat	df	Probability	Rao F-stat	df	Probability
1	12.73131	9	0.1751	1.435724	(9, 190.0)	0.1753
2	27.34569	18	0.0727	1.558723	(18, 212.6)	0.0730
3	38.80555	27	0.0660	1.481794	(27, 210.9)	0.0667

Source: created by the authors in E-views

Table 15
Cholesky Normality Test

Component	Jarque-Bera	df	Probability
1	0.510070	2	0.7749
2	2.087207	2	0.3522
3	3.440336	2	0.1790
Jointly	6.037612	6	0.4190

Source: created by the authors with E-views

Table 16
Joint Heteroscedasticity Test

Chi-sq	df	Probability
139.3253	132	0.3143

Source: created by the authors in E-views

Table 17
LM test for serial correlation in the VAR residuals

Null hypothesis: There is no serial correlation in the lag h						
Lag	LRE* stat	df	Probability	Rao F-stat	df	Probability
1	28.07922	9	0.0009	3.249430	(9, 258.1)	0.0009
2	16.85856	9	0.0510	1.908958	(9, 258.1)	0.0510
3	40.96003	9	0.0000	4.860807	(9, 258.1)	0.0000
4	13.78375	9	0.1302	1.551552	(9, 258.1)	0.1303

Source: created by the authors in E-views