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Intraindustry trade in the manufacturing sector and the transportation and electronics subsectors between Mexico and the United States

Comercio intraindustrial del sector manufacturero y de los subsectores de transporte y electrónicos entre México y los EUA

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Abstract

This paper analyzes the determinants of intraindustry trade in the manufacturing sector, the subsector of electronics and computers, and the subsector of transport equipment. An ARDL model is used to estimate the long- and short-term determinants. The results indicate that the evolution of intraindustry trade in the manufacturing sector between Mexico and the USA, in the short and long term, is positively impacted by lower wages paid in Mexico and FDI flows into Mexico, the impact of economic activity in both countries, and the level of trade openness. Finally, the impact of the economic downturn caused by the Covid-19 pandemic had an effect on the behavior of trade in the short term.

JEL Code: F14, F15, C22
Keywords: intraindustry trade; economic integration; manufacturing; economic recession

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Resumen

En este trabajo se analiza los determinantes del comercio intraindustrial del sector manufacturero, el subsector de electrónicos y computadoras y el subsector de equipo de transporte. Se utiliza un modelo ARDL para estimar los determinantes de largo y corto plazo. Los resultados indican que la evolución del comercio intraindustrial en el sector manufacturero entre México y los EUA, en el corto y largo plazo, es impactada positivamente por los salarios más bajos pagados en México y los flujos de IED hacia México, el impacto de la actividad económica de ambos países y el nivel de apertura comercial. Finalmente, el impacto de la caída económica ocasionada por la pandemia del Covid-19 tuvo un efecto en el comportamiento del comercio en el corto plazo.

Código JEL: F14, F15, C22
Palabras clave: comercio intraindustrial; integración económica; manufacturas; recesión económica

Introduction

The volume of foreign trade in similar manufacturing goods registered in the different classifications of trade activities has grown rapidly at the international level. This type of intraindustry trade can be explained not only by differences in comparative advantages but also by the expansion of economies of scale generated by large multinational companies, the reduction of transportation costs, the large size of export markets in developed countries, and the relatively low wages in developing countries, which contribute to making products more competitive in international markets.

In the case of the Mexican economy, intraindustry trade has been expanding for several decades as a result of the growing integration of the Mexican economy with the US economy, which is related to foreign investment flows from the United States and the increased specialization of production resulting from the establishment of manufacturing and maquiladora plants in Mexico. As a result, there has been increased participation of intraindustry trade in Mexico's foreign trade, particularly in the sector's leading manufacturing activities such as electronics and automotive.

Different studies on intraindustry trade between Mexico and the United States have found evidence of the growing importance of this type of trade (Esquivel, 1992), especially in the manufacturing sector (Buitelaar & Padilla, 1996). Since the establishment of the North American Free Trade Agreement (NAFTA), an acceleration of intraindustry trade has been observed (Clark, Fullerton Jr., & Burdorf, 2001; Montout, Mucchielli, & Zignago, 2002), which has continued to expand since 2000. Notwithstanding, increasing intraindustry trade between China and Mexico has been observed since 2014, while intraindustry trade between Mexico and the United States has maintained a stable trend (Mendoza, 2016).

In this context, the COVID-19 pandemic negatively affected the trade growth rate between Mexico and the United States. This paper aims to estimate the short- and long-run effect of this phenomenon on intraindustry trade in the manufacturing sector of both economies, as well as in the electronics and computer and transportation equipment sub-sectors of the Mexican economy. The study starts from the hypothesis that the pandemic has only had a short-run effect on the development of production chains and intraindustry trade between Mexico and the United States. To analyze the determinants of the behavior of intraindustry trade in the manufacturing sector, a regressive distributed lagged (RDL) model was established to help estimate these determinants in both the short- and long-run dynamics.

The paper is structured as follows: the theoretical approaches to intraindustry trade will be presented in the first section. The second section describes the trends and structure of trade between Mexico and the United States. The third section describes the evolution of intraindustry trade between the two countries. The fourth section presents the methodology and results obtained, and finally, the fifth section includes the conclusions of the research.

Theoretical aspects of US-Mexico intraindustry trade

Theoretical perspectives on intraindustry trade

This paper analyzes intraindustry trade between Mexico and the United States from the perspective of the new theory of international trade. From this approach, endogenous growth models have been established that emphasize that an important part of international trade is related to specialization in producing intermediate consumables (Romer, 1990). In addition, Grossman and Helpman (1991) and Krugman (1981) developed the "new theory of international trade" based on models of monopolistic competition and increasing returns. These theoretical approaches propose that an important part of international trade is based on economies of scale that encourage international specialization of the production of a small number of companies, which drives intraindustry trade.

Likewise, to understand intraindustry trade as an important component of international trade, it is necessary to address the concept of product differentiation that arises in markets with monopolistic competition. Initially, Lancaster (1979) modeled horizontal differentiation based on variety preferences. This theoretical approach was developed at the aggregate level by Krugman (1980), who demonstrated a correlation between preference diversity and increasing economies of scale. As a result, a view of international trade was established in which trade in differentiated products takes place mainly between economies with similar factor endowments.

It should be noted that intraindustry trade can also occur between countries with differences in income levels and factor endowments. Thus, Stiglitz (1987) extended the analysis of intraindustry trade

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by considering that it is possible to separate this trade into its horizontal and vertical components. Considering the differences between the quality and unit costs of traded products, the author concludes that generating trade between developed and developing countries is possible based on vertical intraindustry trade. Recently, general equilibrium models have been developed with homogeneous and differentiated goods produced with increasing returns to scale, where the effect of trade openness generates an increase in trade of differentiated products with higher utility for consumers. Likewise, smaller economies could increase the share of exports in a context of trade with countries of different economic sizes (Cieślik & Wincenciak, 2018).

Trade between Mexico and the United States shows a significant importance of intraindustry trade, characterized by many goods differentiated by their final and intermediate destination, with different production costs. This is because Mexico tends to export manufactured products with low value-added content and consumables, while US exports are concentrated in exports of final goods with high value-added content (Albarrán & Mejía, 2020). In this context, it is important to analyze this trade's short- and long-run determinants that characterize the economic integration processes between the two countries.

Review of the literature on intraindustry trade between Mexico and the United States

The growing development of intraindustry trade between Mexico and the United States has generated several studies showing the importance of this activity in manufacturing trade. Esquivel (1992) analyzed manufacturing trade between the two countries for the period 1981-1990 and found evidence of an increase in intraindustry trade in some Mexican manufactured exports to the United States. Buitelaar and Padilla (1996) estimated Mexico's intraindustry trade with its main trading partners for the period 1990-1995 and found that more than 40% of trade was intraindustry trade. They also showed a reduction in non-manufacturing exports and an increase in manufacturing exports.

León and Dussel (1999) analyzed the 1995-1999 period and found that industries with intraindustry trade exhibited positive trade balances, while industries with interindustry trade showed negative trade balances. Clark, Fullerton Jr., and Burdorf (2001) examined intraindustry trade between the United States and Mexico during the first five years of NAFTA. The authors indicated an expansion of intraindustry trade and noted that the increase in intraindustry trade had not generated economic adjustment problems in Mexico's manufacturing activities. Montout, Mucchielli, and Zignago (2002) analyzed intraindustry trade in the automotive industry between Canada, the United States, and Mexico under NAFTA, noting that this type of trade intensified during the 1990s. The authors also established a gravity model and found that the distance and market size variables predominantly influenced this type of trade in the automotive industry.

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Sotomayor (2012) analyzed intraindustry trade between the United States and Mexico from 1994 to 2006. The author proposed an intraindustry trade index adjusted for maquiladora industry trade and differentiated by its vertical and horizontal nature. The econometric model results indicate that bilateral intraindustry trade is affected by foreign direct investment, product differentiation, and trade restrictions. Also, according to López, Rodil, and Valdés (2014), intraindustry trade continued to increase in Mexico during the 2000s to reach more than 50% of the value of exports. Mendoza (2016) estimated Mexico's intraindustry trade with the United States and China. The results indicate that this type of trade between Mexico and the United States is concentrated in the automotive and communications industries, with an increase in intraindustry trade from the signing of NAFTA until 2014 and then remaining relatively stable. The growing trade between Mexico and China in intraindustry trade in electronics is also observed due to the growing trade between both countries.

Characteristics of the expansion of trade between Mexico and the United States

The establishment of NAFTA gradually reduced the tariff structure and established rules of origin for the content of consumables in the North American region, as well as for the protection of foreign direct investment. As a result, trade relations between Mexico and the United States experienced accelerated growth (Figure 1). The size of both economies and the development of value chains, comparative advantages, and transportation costs have been important sources of regional economic and trade integration between both countries. The rapid growth of trade has been characterized by a comparatively faster increase in Mexican exports than in US exports. Thus, it is observed that between 1994 and 2006, which was the period of greatest expansion, the average annual growth rate of Mexican exports to the US market was 11.9%, while that of imports was 7.3%.

It is important to note that between 2009 and 2018, the pace of trade growth between Mexico and the United States slowed. The COVID-19 pandemic has negatively affected both countries' economic activity, further decreasing bilateral trade. In particular, Mexico's exports and imports have fallen at annual rates of 7.3% and 7.2%, respectively. During the first four months of 2020, this situation resulted in a drastic drop in trade, especially in April, when exports decreased by 51.2% and imports by 78.9% compared to the previous month[1].

[1]Estimates by the author based on information from The US Census Bureau: Economic Indicators Division USA Trade Online

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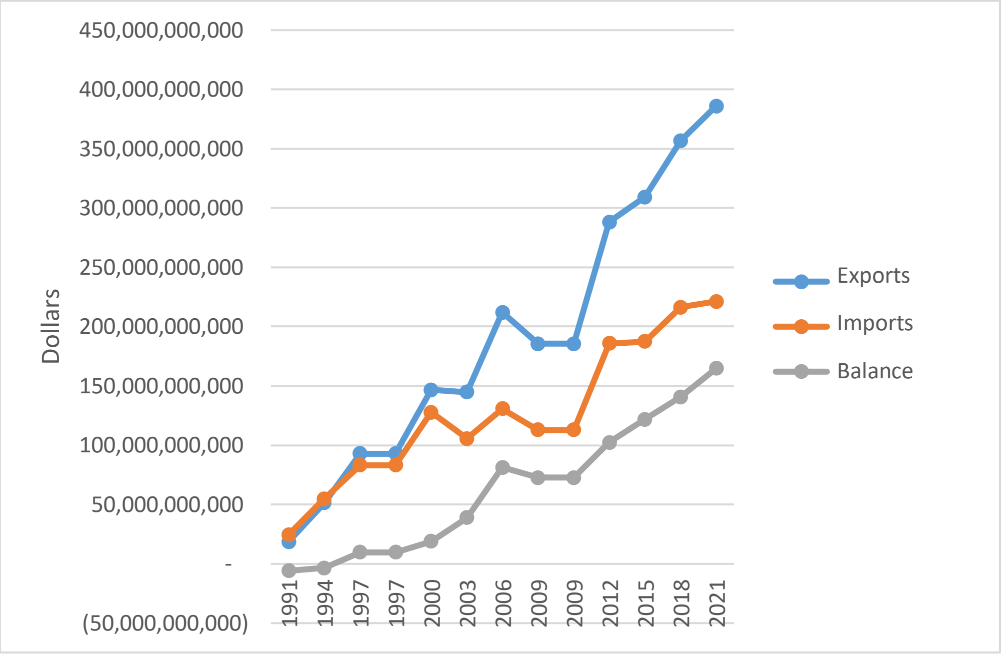

Figure 1. Mexico-United States Trade Trends, 1991-2021
Source: created by the author with data from the United Nations Comtrade database—Harmonized classification.

A central aspect of the increase in trade between Mexico and the United States has been the growing importance of manufacturing production and trade. Thus, it can be seen that manufacturing accounted for the largest percentage of Mexico's total exports. Likewise, the importance of manufacturing trade has increased recently, from 83.7% in 2008 to 92.6% of total trade. Specifically, the dynamics of Mexico's manufacturing exports have been directly related to trade growth in transportation, computer, electronic, and telecommunications equipment. Notably, in 2008, the computer and electronics subsector represented 20.7% and the transportation equipment subsector 20.4%. Nevertheless, in 2021, the transportation equipment subsector increased its share, moving to first place in manufacturing exports and reaching 30.9%, while the computer and electronics subsector fell to 18.4%. Thus, these two manufacturing subsectors have been fundamental to the growth of Mexico's manufacturing exports.

In particular, the export of automobiles, auto parts, televisions, computers, and electronic consumables, such as semiconductors, has been decisive in the export boom of Mexico's economy. Nonetheless, it should be noted that the development of these activities has not been exempt from impacts derived from the 2009 recession and the COVID-19 pandemic. Thus, after a rapid growth of these manufacturing exports in the period following the signing of NAFTA and the impact of the 2009 recession, a deceleration of these manufacturing exports is observed as of 2019, which deepened with the impact of the COVID-19 pandemic.

On the other hand, the value of exports of the computer and electronics subsector for the period shows moderate growth with a significant drop in March 2020, and then increases and subsequently shows a tendency to stagnate. From May 2020 onwards, monthly growth rates showed significant oscillations, with dips between September and November and an increase between March and May 2021. Thus, the volume of exports of the subsector has not had substantial increases, as in May 2021 they were USD 5 481 million, while in November 2021, they had a slight increase reaching USD 6 541 million. Finally, the transportation equipment subsector was more severely affected, falling 78.5% and then recovering and remaining stagnant from July 2020 to November 2021[2].

Recent intraindustry trade developments between Mexico and the United States

Intraindustry trade trends in the computer and electronics and transportation subsectors

One of the characteristics of the Mexican manufacturing industry is that an important part of its activities are carried out in maquiladora export plants. Thus, a substantial part of manufacturing exports are produced in assembly plants that use intermediate consumables from abroad to add value and produce goods that are exported to the United States. As a result, a significant portion of trade between both countries is carried out in chains of vertical and horizontal integration, where consumables from the United States are transformed in Mexico and re-exported to the United States. Since 2004, there has been a slowdown in the growth of the intraindustry trade index, although the total volume of trade has continued to increase. This is due, among other factors, to increasing competition from Southeast Asian countries in the international trade of parts, components, and assembly of automobiles, computers, and televisions, among others.

Estimates of the intraindustry trade index for the 2008-2021 period show differentiated results using the North American Industrial Classification System (NAICS) at three and four digits for the computer and electronics and transportation equipment subsectors and their most representative branches. Concerning the first subsector, the intraindustry trade index remained stable, rising from 0.71 to 0.74 between 2008 and 2021 (Figure 2), with a moderate average growth of 3.5% in exports and 4.2% in

[2]Estimates by the author based on information from The US Census Bureau: Economic Indicators Division USA Trade Online

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imports. Nonetheless, there was a significant drop in the intraindustry trade index of the computer branch from 0.90 to 0.62. This is due to a higher growth of exports compared to imports, which affected the intraindustry trade structure of the branch. On the other hand, the communication equipment branch showed a slight increase in the intraindustry trade index from 0.45 to 0.55. Nevertheless, this branch experienced a drop in both imports and exports during the period. Finally, the intraindustry trade index of the semiconductor industry fell from 0.60 to 0.54, with higher growth in imports of consumables than in exports of electronic components.

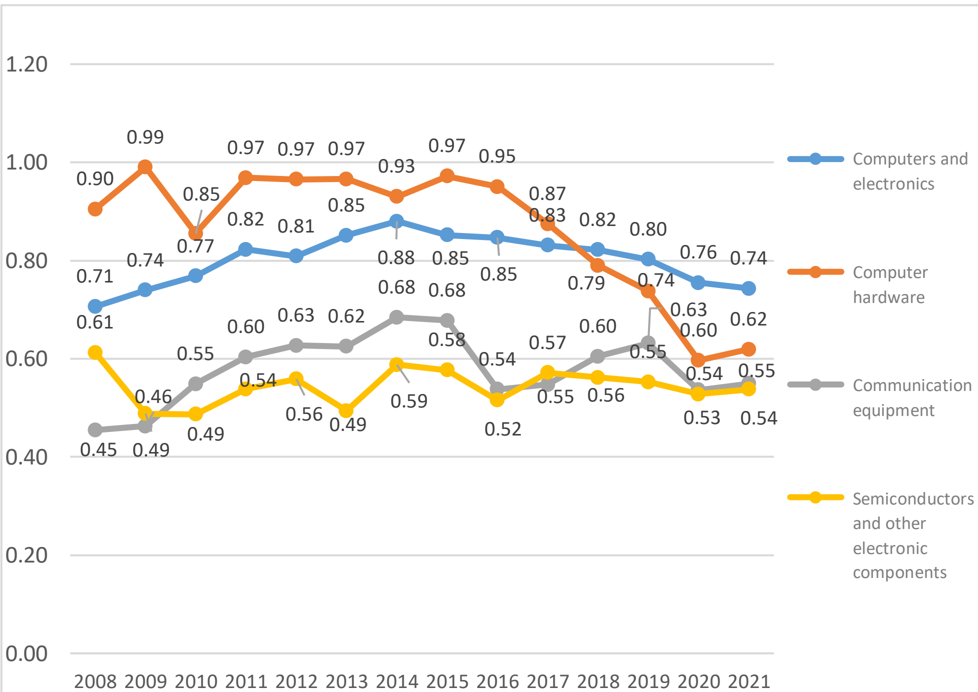

Figure 2. Mexico: trends in intraindustry trade in the computer and electronics subsector
Source: created by the author with data from the US Census Bureau: Economic Indicators Division USA Trade Online.

The transportation equipment subsector showed a drop in the index from 0.58 in 2008 to 0.39 in 2021, suggesting no intraindustry trade in this subsector. This trend reflects the impact of the COVID-19 pandemic and the lower average growth of imports (3.6%) compared to exports (7.7%) in the period (Figure 3). Nevertheless, within the subsector, it is noteworthy that the automotive branch shows a high intraindustry trade index, which increased from 0.70 in 2008 to 0.92 in 2021. The growth of the index was related to accelerated and similar average annual growth rates between imports and exports, which maintained a ratio between the value of exports and imports. In contrast, the vehicle engines and auto parts sectors experienced declines in the intraindustry trade index, indicating little intraindustry trade activity in these activities.

Thus, the intraindustry trade scenario of the most important subsectors of Mexico's manufacturing trade has shown a relative stagnation in the computer and electronics subsector and a drop in the transportation equipment subsector. Concerning the former manufacturing activity, there was a drop in total trade and intraindustry trade in the communications branch. In the latter subsector, only the automobile branch shows intense intraindustry trade, while the auto parts and engine branches do not have significant intraindustry trade, probably due to the penetration of imports in these activities from China and other countries.

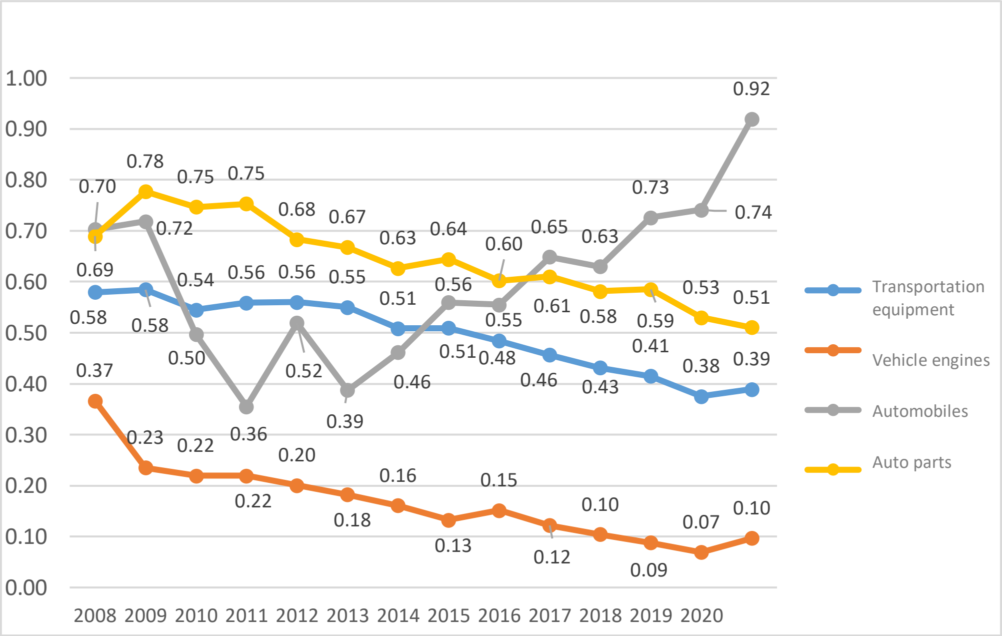

Figure 3. Mexico: intraindustry trends in the transportation equipment sector
Source: created by the author with data from the US Census Bureau: Economic Indicators Division USA Trade Online.

Foreign direct investment and wages in the computer and electronics and transportation equipment sub-sectors

The expansion of manufacturing exports and imports between Mexico and the United States has been largely related to the increase in foreign direct investment (FDI), particularly by US companies operating in Mexico. According to the different world trade classification systems, trade in goods of multinational companies belonging to the same sector or subsector is considered part of intraindustry trade (IIT).

FDI is a driver of IIT because it promotes the expansion of multinational companies' international activities and production. Helpman and Krugman (1987) emphasized that the composition of factor endowments between countries promotes exports and imports of intermediate and final goods in the same economic activity. In general, it is considered that the greatest dynamic of IIT growth is currently taking place between developed and developing countries, which is explained by the fragmentation of production expressed in vertical intraindustry trade.

In the case of the Mexican economy, the importance of trade in the computer, electronics, and transportation equipment subsectors is related to the IIT and FDI operations of multinational companies located in those subsectors. Notably, the share of FDI in the computer and electronics subsector represented 8.7% of total FDI in the manufacturing sector in 2008, increasing to 17.9% in 2009 and decreasing to 7.4% in 2019 (Table 1). Thus, this subsector showed significant increases in its share of total investment in manufacturing. Nonetheless, in 2020, a sharp drop in the share was observed. The electronic components branch, in which semiconductor production is a central part, stands out; the share of that branch in the manufacturing sector was 4.1% in 2008, decreasing to 3.3%, which reduced its share in total FDI in the manufacturing sector by an annual average of 0.6%.

The transportation equipment subsector received 21.6% of total FDI in the manufacturing sector in 2008, rising to 42.3%b in 2020, with an annual growth rate of 6.7%. The figures show that this subsector has benefited substantially from FDI, which has promoted its trade growth. Within the subsector, the automobile and truck manufacturing and auto parts branches stand out; the former exhibited an average annual growth rate of 18.1%, while the latter showed a negative average growth of -0.2.

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Table 1
Evolution of foreign direct investment in the manufacturing sector and the percentages of the computer and electronics and transportation equipment sub-sectors

By sector, sub-sector, and branch	31-33 Manufacturing industries (millions of dollars)	334 Computer equipment and electronic accessories	3344 Electronic components	336 Transportation equipment	3361 Automobiles and trucks	3363 Parts for motor vehicles
2008	9 213.40	8.70%	4.10%	21.60%	3.40%	14.40%
2010	14 446.70	12.10%	1.50%	21.70%	5.80%	13.00%
2012	9 730.69	11.80%	2.60%	33.30%	11.90%	20.10%
2014	18 914.87	3.80%	0.40%	32.50%	14.80%	15.60%
2016	17 938.08	8.10%	2.10%	31.30%	15.10%	15.20%
2018	15 610.76	9.70%	2.60%	43.80%	21.30%	21.00%
2020	10 693.47	7.40%	3.30%	41.30%	25.90%	12.10%
AAGR	1.20%	0.00%	-0.60%	6.70%	18.10%	-0.20%

Source: created by the author with data from the Ministry of Economy, Statistical Information on Foreign Direct Investment.
AAGR: average annual growth rate.

Wage differentials as a determinant of intraindustry trade

The expansion of intraindustry trade reflects, to a large extent, the fragmentation and internationalization of production processes. The search for cost reduction has led multinational companies to settle in countries with a low-skilled labor force and low wages, and on the other hand, to seek technological innovations to replace the labor force and increase capital intensity. This has resulted in increased trade in intermediate goods, the displacement of industries, and changes in the demand for labor.

Thus, an important part of intraindustry trade is characterized by its vertical component of a differentiated nature, where the factor endowment between countries determines the exchange of goods. It has been pointed out that countries with a greater abundance of capital will export goods of higher technological content and quality, while countries abundant in the labor factor will export goods of low technological content and quality (Falvey & Kierzkowski, 1987). It should be noted that differences in factor endowments are reflected in the relative difference in factor prices, affecting Mexican manufacturers' comparative advantages.

Thus, in the case of manufacturing trade between Mexico and the United States, there is a large difference in the relative wage price of workers in the sector between the two countries. The average compensation during the 2008-2011 period in the manufacturing sector in Mexico was 705 dollars per

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month, while in the United States, it was 4 082.8 dollars per month (Table 2). The percentage share of average wages in Mexico was 17.4% of those in the United States. Mexico's comparative labor cost advantage has been a determining factor for the location of foreign companies in Mexico.

Table 2
Share of Mexico's manufacturing compensation in US manufacturing compensation (in USD)

Period	Mexico			United States			Mexico/United States		
	Total manufacturing	Computers and electronics	Transportation equipment	Total manufacturing	Computers and electronics	Transportation equipment	Total manufacturing	Computers and electronics	Transportation equipment
2008/0 1	761.6	736.1	835.2	3 499.2	4 750.1	4 414.0	21.8%	15.5%	18.9%
2010/01	707.9	738.3	765.3	3 693.9	5 178.2	4 768.1	19.2%	14.3%	16.1%
2012/01	724.4	751.7	756.6	3 891.3	5 361.9	4 904.1	18.6%	14.0%	15.4%
2014/01	751.6	828.0	760.9	4 033.2	5 398.5	5 081.9	18.6%	15.3%	15.0%
2016/01	616.8	697.0	631.4	4 183.6	5 577.9	5 218.9	14.7%	12.5%	12.1%
2018/01	684.0	774.0	703.5	4 397.3	5 862.7	5 394.3	15.6%	13.2%	13.0%
2021/01	771.7	867.3	759.9	4 718.4	5 999.1	5 712.7	16.4%	14.5%	13.3%
Average for the period	705.0	764.4	729.1	4 082.8	5 472.5	5 098.9	17.4%	14.0%	14.4%

Source: created by the author with data from the Economic Information Bank (BIE; Spanish: Banco de Información Económica)—a service provided by the National Institute of Statistics and Geography (INEGI; Spanish: Instituto Nacional de Estadística y Geografía)—and from the Bureau of Labor Statistics (BLS).

Concerning the computer and electronics and transportation equipment subsectors, average wages during the period were slightly higher than the manufacturing average. Thus, the computer and electronics subsector had an average monthly compensation of 764.4 dollars, while the transportation equipment subsector had an average monthly compensation of 729.1 dollars. It is worth noting that although the salaries of these subsectors are higher than the manufacturing average in Mexico, when considering the shares of these salaries in the salaries of these subsectors in the United States, it is observed that they are lower than the manufacturing average. Thus, the remunerations of the computer and electronics subsector only represented 14% of the remunerations in the United States, which averaged 5 472.1 dollars per month, and 14.4% of the transportation equipment subsector, which showed average monthly remunerations of 5 098.9 dollars. Therefore, the difference in the relative prices of the labor factor in the manufacturing sector in Mexico and the United States continues to be a determining factor in intraindustry trade, driving companies to continue localizing and producing for export from Mexico.

Methodology and databases

In order to analyze the determinants of intraindustry trade, an autoregressive distributed lagged model (ARDL) was applied. In the long-run analysis, empirical research has found that the means and variances

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do not depend on time, so it is necessary to use cointegration techniques, as is the case of ARDL models. This methodology makes it possible to check whether the combination of the variables used is integrated and, if necessary, to establish an error correction model that provides short- and long-run information on the variables used. The methodology was developed by Pesaran and Shin (1999) and Pesaran et al. (2001), who proposed the ARDL to estimate cointegration with a bounded procedure for a long-run relation, regardless if the order of the underlying variables is of order I(0), I(1), or a combination of both.

This method makes it possible to identify cointegrating vectors with underlying equations for each model variable, which generates an error correction vector to estimate the short-run and long-run dynamics. The estimation of the autoregressive distributed lag autoregressive model consists of including unrestricted lags of the regressors in a regression function. This estimation methodology is useful when variables are integrated in different orders or in combination of several orders. To perform the cointegration test of the ARDL equation, the maximum number of lags is determined if the error term has a normal distribution and if there is heteroscedasticity and autocorrelation. For this purpose, the Akaike information model order selection criterion (AIC), the Schwarz Bayesian criterion (SBC), and the Hannan-Quinn criterion (HQC) are used.

Some aspects that could be considered disadvantages of the ARDL model are that it requires absence of autocorrelation and heteroscedasticity, and that the series must have a normal distribution and be stationary in levels or in first differences. Also, the estimation model is valid as long as the error correction model is significant to avoid the variables on the right-hand side of the equation being weakly exogenous.

The estimations of the model yield short-run results through the differentiation of the non-stationary variables and the lag of the variables, which determine the cointegration process and, finally, the error correction model provides the long-run information. It should be noted that the advantages of this methodology are as follows: the low probability of an endogeneity problem as all variables are presented in one equation and are endogenous; the model can distinguish between explanatory and independent variables in the long run (Nkoro & Uko, 2016); it assumes a single reduced-form equation (Pesaran, Smith, & Shin, 2001); it can identify the cointegrating vectors; and, finally, the ARDL methodology serves to derive the error correction model. Thus, these models are relevant to the extent that they allow the analysis of economic situations where macroeconomic variables affect others in a distributed manner in future periods. Likewise, this methodology helps to estimate the short-run and long-run dynamics of the model's explanatory variables. In this study, three ARDL models are established to estimate the impact of the explanatory variables on the evolution of intraindustry trade between Mexico and the United States. Formally, the models are specified as follows:

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$$\Delta lnIIT_i = \alpha_{0i} + \sum_{i=1}^{k} \alpha_1 \Delta lnIIT_{i,t-1} + \sum_{i=1}^{k} \alpha_2 \Delta lnIED_{i,t-1} + \sum_{i=1}^{k} \alpha_3 \Delta lnRUM_{i,t-1} + \sum_{i=1}^{k} \alpha_4 \Delta lnPUS_{i,t-1} + \sum_{i=1}^{k} \alpha_5 \Delta lnPM_{i,t-1} + \sum_{i=1}^{k} \alpha_6 \Delta lnTPIB_{i,t-1} + \sum_{i=1}^{k} \alpha_7 \Delta lnTMAN_{i,t-1} + \sum_{i=1}^{k} \alpha_8 \Delta lnUMT_{i,t-1} + \delta_1 \, lnIIT_{i,t-1} + \delta_2 \, lnIED_{i,t-1} + \delta_3 \, lnRUM_{i,t-1} + \delta_4 \, lnPUS_{i,t-1} + \delta_5 \, lnPM_{i,t-1} + \delta_6 \, lnTPIB_{i,t-1} + \delta_7 \, lnTMAN_{i,t-1} + \delta_8 \, lnUMT_{i,t-1} + u_{1t} \tag{1}$$

where:

Δ = first difference

IIT = intraindustry trade index in period t in the sector and subsectors i

IED = direct investment from the United States (FDI)

RUM = ratio of average wages in Mexico to average wages in the United States

PUS = GDP per capita in the United States

PM = GDP per capita of Mexico

TPIB = share of trade in Mexico's GDP

UMT = percentage of US-Mexico trade with respect to Mexico and world trade

TMAN= US-Mexico trade

Quarterly data were used for the period 2008-2018. The intraindustry trade index for the manufacturing sector and the electronics and transportation equipment subsectors and calculations of trade between the two countries were based on data from the USA Trade Online of the United States Census Bureau. Information for calculating GDP per capita for the United States was obtained from the Bureau of Economic Analysis, the US Department of Commerce, and the Population Projections data sets of the United States Census Bureau. Mexico's GDP per capita was constructed with information from the National Accounts obtained from INEGI's Economic Information Bank and the Population Projections for Mexico and the Federal States, 2016-2050, from the National Population Council. Estimates for wages paid in the manufacturing sector in the United States were obtained from the Bureau of Labor Statistics (BLS), and for wages paid in the manufacturing sector in Mexico, data from the Economic Information Bank converted to dollars were used.

Estimates results

Unit root tests show that some of the series of the variables considered were stationary in first differences and others in levels, according to the Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Augmented Dickey-Fuller, and Phillips-Perron tests (Table 3). The intraindustry trade variables of the manufacturing sector, and of the electronics and computers subsector, as well as the foreign direct investment variables in the manufacturing sector and the subsectors analyzed were stationary in levels for the three tests indicated. On the other hand, the variables related to the transportation subsector, the GDP per capita of Mexico and the United States, and the manufacturing trade and electronics and transportation equipment subsectors were stationary in first differences. These results make it more appropriate to use the ARDL model, which better fits the series that can be estimated when the variables are stationary both in levels and in first differences.

Table 3
Unit root panel test

Variable	Augmented Dickey-Fuller	Phillips-Perron	KPSS[1]	Variable	Augmented Dickey-Fuller	Phillips-Perron	KPSS[1]
IITMAN	-5.18	-5.2	0.2	DTMAN	-8.98	-3.64	0.23
	0.00*	0.00*			0.00*	0.00*	
ITT334	-5.19	-5.2	0.21	DTMAN34	-12.53	-9.23	0.37
	0.00*	0.00*			0.00*	0	
DIIT336	-12.33	-9.79	0.25	TMAN336	-4.45	-10.69	
	0.00*	0.00*			0.00*	0.00*	
PM			0.13	DTMAN336		-10.69	
				IEDMAN	-6.19	-7.36	0.24
DPM	-7.28	-7.4			0.00*	0.00*	0
	0.00*	0.00*		IED334	-5.92	-7.05	0.29
DPUS	-8.44	-8.46	0.17		0.00*	0.00*	
	0.00*	0.00*		IED336	-6.19	-6.29	0.24
DTPIB	-26.63	-10.72	0.22		0.00*	0.00*	
	0.00*	0.00*		DRUM	-7.59	-7.63	32
					0.00*	0.00*	
UMT	-7.63	-11.01	0.32	DRUM334	-8.2	-8.32	0.31
	0.00*	0.00*			0.00*	0.00*	
DUMT	-7.63	-11.01	0.32	DRUM336	-8.2	-6.83	0.37
	0.00*	0.00*			0.00*	0.00*	

Source: created by the author

D = first difference in the series, D2 = second difference in the series, IITMAN = intraindustry trade index, IIT334 = intraindustry trade index for the computers and electronics subsector, IIT336 = intraindustry trade index for the transportation equipment subsector, PM = GDP per capita of Mexico, PUS = GDP per capita of the United States, TPIB = share of trade in Mexico's GDP, UMT = percentage of US-Mexico trade with respect to Mexico and world trade, TMAN= US-Mexico manufacturing trade, TMAN334 = subsector 334 trade between Mexico and the United States, TMAN336 = US-Mexico subsector 336 trade between Mexico and the United States, IEDM = US direct investment in Mexico's manufacturing sector, IED334 = US direct investment in subsector 334, IED336 = US direct investment in subsector 336, RUM = ratio of Mexico's average wages to those of the United States in the manufacturing sector, RUM334 = ratio of Mexico's average wages to those of the United States in subsector 334, RUM336 = ratio of Mexico's average wages to those of the United States in subsector 336.

* Null hypothesis of non-stationarity: Augmented Dickey-Fuller and Phillips-Perron were rejected. Hypothesis of non-stationarity: KPSS was rejected with a statistical significance of 1%.

Estimates of the short-run and long-run effects of the determinants of industrial trade between Mexico and the United States have been made based on an ARDL model. The analysis comprises three models: the first applied to the total manufacturing trade between the two economies, the second to the electronics and computer subsector, and the third to the transportation equipment subsector. To achieve this task, the order of lag selection for the three models was estimated, and four lags were selected according to the Akaike information criterion (AIC). Table 4 presents the corresponding LM, ARCH, and Breusch-Pagan-Godfrey tests, which rejected serial correlation and heteroscedasticity null hypotheses. The CUSUM and Jarque Bera tests showed that the models are stable, and the null hypothesis of normality was not rejected.

In addition, the Ramsey test was included to validate the specification of the equations, and the results contrasted with the F test considered the estimated models adequate. Finally, the WALD test rejected the null hypothesis, implying that the coefficients of the independent variables jointly affect the dependent variable. Likewise, the short-run estimates of the three models are presented and based on the F-statistic, the long-run coefficients are determined, and the error correction model is presented.

In the first model, the estimated coefficients on first differences show that the model for intraindustry trade in the manufacturing sector between Mexico and the United States yields positive and statistically significant coefficients for the variables FDI from the United States in the manufacturing sector in Mexico, GDP per capita in Mexico, the share of manufacturing trade in Mexico's total trade, the share of trade in Mexico's GDP, and the share of trade between Mexico and the United States in Mexico's total trade. On the other hand, the coefficients of the dichotomous variable for the periods comprising the COVID-19 pandemic and of the share of Mexico's manufacturing sector's wages among those of the US manufacturing sector were negative but not statistically significant.

The value of the F-statistic in the bounds test was higher than the critical values, which rejected the null hypothesis of no cointegration. The long-run coefficients that showed statistical significance and a positive coefficient were foreign direct investment, Mexico's GDPpc, and the volume of manufacturing trade. On the other hand, the coefficient of the ratio of wages paid in Mexico's manufacturing sector compared to average wages in the US manufacturing sector was negative and statistically significant. Likewise, the dichotomous variable presented a negative sign suggesting a negative effect of the COVID-19 pandemic, although it was not statistically significant. The error correction model equation had a negative sign and was statistically significant, indicating a cointegration process with adjustment of the long-run estimates.

The estimation results for the manufacturing sector indicate that, in both the short and long run, the dynamics of trade between Mexico and the United States, Mexico's economic activity, and North American foreign direct investment in the manufacturing sector drive intraindustry trade. Moreover, in

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the long-run, the ratio of relative wages paid in the manufacturing sector is a determining factor, with an inverse behavior with respect to intraindustry trade. Therefore, the relatively lower wages in Mexico seem to foster an increase in intraindustry trade between both countries.

Table 4
Estimation of short-run coefficients of ARDL models

	Model 1 ARDL (3, 3, 2, 4, 4, 3,1)	Model 2 ARDL (3, 3, 3, 2, 2, 4,3)	Model 3 ARDL (3, 3, 1, 2,1,1,3)
Variable	Manufacturing	Computer-electronics subsector	Transportation subsector
D(LIEDT)	0.002 (4.3)*		
D(LIEDT334)		0 (-0.94)	
D(LIEDT336)			0.06 (13.24)*
D(LPUS)	-0.27 (-7.67)*	0.12 (2.16)*	(-0.57) (-2.78)*
D(LPM)	0.01 (1.88)**	0.3 (3.18)*	0.15 (2.93)*
DRUM	0.001 (-0.32)		
DRUM334		-0.15 (-3.35)*	
DRUM336			-0.74 (-4.69)
D(LTMAN)	0.03 (3.87)*		
D(LTMAN334)		0.009 (2.15)**	
D(LTMAN336)			(0.15) (-8.54)
D(LTPIB)	0.002 (0.76)*	-0.23 (-1.80)***	0.09 (1.20)
D(LUMT)	0.28 (4.34)*	0.24 (1.89)**	0.31 (0.91)
DUM	-0.001 (-0.49)	-0.04 (2.32)**	-0.03 (-3.27)**
R2	0.97	0.89	0.98
Arch	0.16 (0.69)	1.03(0.31) 0.59 (0.88)	0.04 (0.83) 0.78 (0.69)
ARCH	5.98(0.00)		
Ramsey			
Breusch-Pagan-Godfrey (LM)	0.52 (0.59)	1.09 (0.71)	1.70 (0.19)
Wald	7.77 (0.00)	4.12 (0.00)	1.67 (0.19)
CUSUM	Stable	Stable	Stable
CUSM2	Stable	Stable	Stable
Jaque Bera	3.51 (0.42)	0.12 (0.94)	

Source: created by the author.
D= first difference. *, ** and *** denote statistical significance at 1%, 5%, and 10%, respectively. Values in parentheses for t-statistics of variables and values in parentheses for LM, WALD, and ARCH tests are probabilities.

The tests showed no correlation, stability, normality, or heteroscedasticity problems in the computer and electronics and transportation equipment sectors. In the short-run estimation for the computer and electronics sector, it is observed that Mexico's GDPpc, trade openness, and the share of Mexico's total trade with the United States in Mexico's total trade were positive factors for the growth of intraindustry trade in that sector. Negative and statistically significant coefficients are observed for relative wages paid in the computer and electronics subsector and the dichotomous variable. The F-test indicated that there are cointegrating equations in the model. Furthermore, the long-run coefficients were positive and statistically significant for foreign investment, the GDPpc of the United States and Mexico, and the degree of trade openness. Likewise, the ratio of Mexico's average wages to those of the United States and the dichotomous variable presented negative and statistically significant coefficients.

Finally, tests to estimate the ARDL model for the transportation equipment subsector showed an appropriate fit. The short-run estimates exhibited positive and statistically significant coefficients for foreign investment in the sector and Mexico's GDP per capita. The coefficient of remuneration and the coefficients of the dichotomous variable for the two manufacturing subsectors were negative and statistically significant. The long-run estimates were shown to be cointegrated and yielded similar results. The coefficients of FDI, US and Mexican GDP per capita, and foreign trade in this subsector were positive and significant, and the coefficient of the dichotomous variable was negative and statistically significant. The cointegration equation was statistically significant, which implies a process of adjustment between short-run and long-run dynamics. Thus, it can be concluded that, in the long run, foreign direct investment, market size, relative wages, and the degree of openness of the Mexican economy seem to have been the determining factors in the expansion of intraindustry trade. Therefore, the results of applying the ARDL model to the analysis of the behavior of intraindustry trade between Mexico and the United States show the importance of foreign investment and the level of economic activity in Mexico in the short and long run.

These results are similar to some studies on the impact of COVID-19 on trade in other countries. This is the case of the study by Che et al. (2020), which finds a significant drop in Chinese exports due to the COVID-19 pandemic and a differentiated impact by industries, with those most affected being consumables suppliers in global value chains. Nevertheless, intraindustry trade between the United States and Mexico has better prospects than bilateral intraindustry trade between the European Union and the United Kingdom. In the case of the United Kingdom, there was a significant drop in its intraindustry trade by region, particularly with the European Union. The impact of COVID-19, Brexit, and the fall in productivity have limited the possibility of trade recovery for that economy (Du & Shepotylo, 2022). Therefore, it is possible to conclude that, in the case of the Mexican economy, factors such as foreign direct investment and the size of the US market, together with comparative advantages in terms of costs, will provide a return to the growing intraindustry trade dynamics of both economies.

Table 5
Long-run coefficients according to the ARDL model and error correction vector

	ARDL (4, 2, 3, 4, 4, 2,2, 4, 1)	(4, 3, 4, 4, 3, 3, ,4, 4, 2)	ARDL (4, 4, 4, 4, 4, 4, 4, 3, 4)
Variable	Total manufacturing	Computer-electronics subsector	Transportation subsector
LIEDM	0.01 (4.25)*		
LIED334		0.001 (5.67)*	
LIED336			0.11 (2.28)**
LPUS	-0.007 (-2.05)**	-0.29 (-3.91)**	-1.57 (-2.39)**
LPM	0.07 (2.54)*	0.11 (4.26)*	1.03 (6.90)**
LRUM	-0.13 (-2.87)*		
LRUM334		-0.57 (-3.76)*	
LRUM336			-4.84 (-8.51)*
LTMAN	0.01 (3.39)*		
LTMAN334		0.02 (1.69)	
LTMAN336			-0.45 (-6.01)*
LTPIB	-0.13 (-1.05)	-0.96 (-1.01)*	-0.25 (-0.48)
LUMT	-0.33 (-1.65)	0.8 (1.73)	5.48 (1.80)
DUM	-0.01 (-0.29)	-0.01 (-0.74)	-0.06 (-5.30)*
cointec(-1)	-0.64 (-12.94)*	-0.62 (-8.75)*	-0.34 (-15.94)*
F-statistic	8.24	5.52	13.18
Limits test			
10%	2.85	2.79	3.06
5%	3.15	3.11	3.39
2.50%	3.42	3.4	3.7
1%	3.77	3.79	4.1

Source: created by the author.
*, ** and *** denote statistical significance at 1%, 5%, and 10%, respectively.

Conclusions

Trade between Mexico and the United States has expanded rapidly since the establishment of NAFTA. The reduction in the tariff structure and comparative advantages in terms of transportation and labor costs boosted the development of value chains between both countries. In particular, the predominant role of manufacturing in trade has been evident, with rapid growth in exports and imports of manufactured final and intermediate goods. The maquiladora export industry is an important driver of Mexico's manufacturing exports. These exports are based on the development of vertical and horizontal supply

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chains, with consumables coming from the United States, transformed in Mexico, and re-exported to the United States. As a result, a central feature of manufacturing trade between Mexico and the United States is related to intraindustry trade, which boomed with the establishment of NAFTA. Nonetheless, recently, it has remained stable due to competition for foreign direct investment and the impact of the COVID-19 pandemic.

Two manufacturing subsectors stand out for the importance of their trade volume: electronics and computers and transportation equipment. Nevertheless, the intraindustry trade performance of these subsectors has been differentiated. On the one hand, the electronics and computers subsector showed a high intraindustry trade index, although the computer and semiconductor branches experienced significant reductions in the intraindustry trade index. On the other hand, the transportation equipment subsector reduced intraindustry trade, although the automobile branch experienced an increase in intraindustry trade, reflecting the dynamism of both exports and imports of the automotive branch in Mexico.

The results of the econometric estimations for the total manufacturing sector and the electronics and transportation equipment subsectors suggest that the factors that have determined the evolution of intraindustry trade between Mexico and the United States include wage differentials and FDI flows to Mexico and the impact of economic activity in both countries. The model for the manufacturing sector as a whole showed positive impacts, in the short run, of the variables FDI, Mexico’s GDP per capita, the share of manufacturing trade in total trade, manufacturing trade, the share of exports in Mexico’s GDP, and the share of Mexico and United States trade in Mexico’s total trade. In the long run, the same variables had a positive effect, and, in addition, the differentials of wages paid in the manufacturing sector of Mexico and the United States were negative, indicating that the level of wages paid affects the growth of intraindustry trade. Finally, the impact of the economic downturn caused by the COVID-19 pandemic affected trade behavior.

For the electronics and computers and transportation equipment subsectors, the short-run results also suggest that FDI, Mexico’s economic activity, and the degree of openness in both the short and long run promote intraindustry trade development. Likewise, the coefficients of the wage differentials between Mexico and the United States in these subsectors also indicate that the larger the wage differential, the greater the incentives for expanding intraindustry trade. Finally, in the short-run estimates, the global recession caused by the COVID-19 pandemic had a negative impact on intraindustry trade.

Thus, the analysis of intraindustry trade between Mexico and the United States highlights that FDI flows from the United States in Mexico’s main manufacturing subsectors have expanded production for export based on imports of consumables and goods belonging to the same subsectors, to be transformed in Mexico and re-exported to the United States. Moreover, the dynamics of intraindustry trade between Mexico and the United States are driven by the relatively lower wages paid in Mexico’s manufacturing sector, combined with geographic proximity, which has encouraged FDI. Furthermore, trade liberalization policies, NAFTA, and the T-MEC have boosted the trade integration process of both countries. Finally, the results suggest that, in the short run, the recessionary effects generated by the pandemic had an adverse effect on intraindustry trade. Nonetheless, the recessionary effects of the pandemic were not proven in the long run, suggesting that the variables that positively impact intraindustry trade maintain their long-run impact on intraindustry trade between Mexico and the United States.

The importance of intraindustry trade between the United States and Mexico in automotive and electronics activities leads to the conclusion that it is important to continue promoting this type of trade between the two economies. The possibility of boosting this trade to capture greater FDI flows and take advantage of the US market should become a viable long-run trade policy objective. Therefore, complementary policies to improve marketing channels and export infrastructure and reduce non-tariff trade barriers should continue to be promoted to boost intraindustry trade.

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