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# Trade Integration and Intra-national Business Cycle Synchronization: Evidence from Mexico's States from 1980 to 2019

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**Abstract** This study documents the adjustment in the business cycles of Mexico's states that resulted from trade liberalization. It also analyzes the relevance of the various elements that previous studies have proposed as the determining factors of the synchronization of these cycles. Our results reveal that these determinants are relevant throughout the sample period (1980-2019), but their relative importance changes over time as does their synchronization. This may be explained as follows: trade liberalization caused a regional and sectoral reallocation of resources, which in turn led to some states becoming increasingly interlinked based on their economic structures, whereas the remaining states became less synchronized with the former states. This case should be of interest to other developing countries that are dependent on the world's capital and trade flows and whose regions may respond heterogeneously if they have diverse economic structures as those of Mexico.

**Keywords:** business cycle, synchronization, trade integration, Mexican states

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# I. Introduction

To boost its economic growth, in the mid-1980s Mexico embarked on a series of long-term market-oriented policy strategies.[1)] These policies had a heterogeneous effect on the economic growth of different Mexican states. As a result, the country now has prosperous states that have become a platform for manufacturing exports to the U.S. However, there are also stagnant states whose productive structures have experienced negligible changes.[2)] The observed adjustments are consistent with the predictions of the trade theory[3)] and have been described by Gómez-Zaldívar et al. (2017), who documented the changes in Mexico's economy, such as the specialization of its states and the localization of its manufacturing industries from 1993 to 2013 due to

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trade liberalization, specifically the North American Free Trade Agreement (NAFTA).[4)]

Another consequence of the economic integration has been the change in the states' business cycles. Before NAFTA, the business cycles of all Mexican states were highly correlated, but after NAFTA, the cyclical components diverged. The changes in some states' productive structures (specialization) after NAFTA caused their business cycles to be synchronized. However, the degree of synchronization with states whose productive structure remained relatively unchanged diminished. This hypothesis is consistent with that of Imbs (1999, 2000), who suggested that what drives the business cycles of economies to become more synchronized is their having similar productive structures, and Frankel and Rose (1998), who argued that the greater economies experience business cycle synchronization, the greater their intra-industry trade.[5)]

The literature on business cycles has grown in the last decades with studies that evaluate the consequences of the increase in the international transactions of goods, services, and capital as a result of trade and investment liberalization policies implemented by various countries. Most of these studies focus on European Union countries, although NAFTA has also drawn a great deal of attention to Mexico, Canada, and the U.S. At the country level, Cuevas et al. (2003) documented how macroeconomic synchronization among the three signatory countries strengthened with the introduction of NAFTA. This increased synchronization occurred despite their different levels of economic development and is comparable to what other countries experienced in other trade agreements. Chiquiar and Ramos-Francia (2005) proved that the business cycles of Mexico and the U.S. became more synchronized because the production-side links between the manufacturing sectors became stronger after NAFTA was enacted. At the intra-national level, Mejía and Campos (2011) analyzed the degree of synchronization between the business cycles of Mexican states and the U.S. from 1997 to 2007 and found that the cycles of Baja California,

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1) Some of the strategies are reducing or eliminating government involvement in various industries, privatizing state-owned enterprises, and promoting trade and financial liberalization agreements.

2) See Hanson (1998), Chiquiar (2005), Chávez et al. (2017), Fonseca et al. (2019), and others.

3) The trade theory predicts that economic integration increases the level of concentration, and economies will tend to specialize in the economic activities in which they have a comparative advantage. The causes of the comparative advantage can be diverse, including differences in productivity, endowments, economies of scale, and trade costs.

4) Most of the relevant studies have examined the changes in the patterns of localization and specialization in developed countries. Amiti (1999), Brülhart (2001), Storper et al. (2002), Ezcurra et al. (2006), Krenz and Rübel (2010), and others have documented the changes in the patterns of specialization in the member countries of the European Union as a result of the integration process. At the regional level, studies have focused on the experience of developed economies. Kim (1995, 1999) and Mulligan and Schmidt (2005) documented regional specialization and industry localization in the U.S. Maurel and Sédillot (1999) studied the geographic concentration of French industries, and Paluzie et al. (2001) analyzed how economic integration in Europe has affected industrial geographical concentration in Spain.

5) According to INEGI, Chihuahua, Coahuila, Nuevo León, Baja California, and Tamaulipas (five of the six states on the northern border) account for approximately 53% of the value of Mexico's manufacturing exports and are among the six leading states in the country in this area. These states are the most synchronized in the country, and their manufacturing exports are primarily made up of transportation equipment, plant and machinery, primary metal industries, electronics, and electrical appliances.

Jalisco, Nuevo León, and Mexico City are highly procyclical with the U.S., whereas those of Mexico State and Queretaro are less. The synchronization of these states and the U.S. is explained by the volume of the international trade involved, maquiladora production, and the vertical integration of productive processes. Mejía and Silva (2014) also studied the synchronization of cycles between Mexican states and the U.S. from 1998 to 2012 and found heterogeneous synchronization across states over time, with border states and some states located in the central-western and central regions exhibiting strong synchronization; whereas, most central states demonstrate a moderate degree of synchronization. However, the synchronization between the cycles of the remaining states is weak and highly unstable. Delajara (2012) analyzed the synchronization between the U.S. business cycles and those of Mexican regions from 2003 to 2010 and found that (i) the cyclical disturbances in the U.S. and the regions of Mexico are stronger in Mexico's northern region than in its central and southern regions. (ii) The elasticity of the Mexican regional economic activity with that of the U.S. is higher in its northern regions than in its central and southern regions. (iii) The variance in the business cycles of the northern, north-central, and central regions is associated with shocks to the U.S. economy, whereas in the southern region, it is mostly related to shocks to the Mexican economy. Mejía-Reyes, Díaz-Carreño, and Aroca (2019) (henceforth MDA, 2019) suggested various factors for explaining the synchronization of the business cycles of Mexican states from 2000 to 2014. Their estimates suggested that as the synchronization of states increases, the greater their population density (PD), the greater the size of their economies, the larger the proportion of their manufacturing production, and the more similar their productive structures become. Conversely, as the synchronization decreases, the greater the geographical distance between them and the greater the difference in their market structures, institutions, and human and physical capital stock become.

Our goal is to explain the well-documented change in the business cycles of Mexico's states. We hypothesize that NAFTA caused some Mexican states to specialize in economic activities in which they have a comparative advantage.[6] As documented by previous studies, the states in question increased their trading activity with the U.S., which increasingly integrated them into the productive cycle of the U.S. and increasingly less integrated into the cycles of other Mexican states, mainly those in the country's southern region.

We find evidence to support this hypothesis by demonstrating that the factors identified by MDA (2019) are also relevant to explaining the synchronization of Mexican states for a longer period, i.e., 1980-2019. However, their relative importance differs in the 1980-1993 and 1994-2019 sub-periods, corresponding to the pre- and post-NAFTA periods, respectively. There is also evidence that there is an association between the amount of a state's international trade and

6) The states that benefited most (i.e., those that experienced the greatest growth in per capita GDP after the signing of the treaty) were those who were best endowed in terms of human and physical capital and those that had better levels of communication and transport infrastructures.

the extent to which it is synchronized with other states.

Our paper is related to two strands of economic literature. First, it contributes to the study of intra-national business cycles by analyzing a developing country whose case is interesting due to the rapid and significant decrease in trade barriers and costs that the country faced in a relatively short period. Most previous studies have focused on the experience of developed countries, such as Beine and Coulombe (2005) and Aguiar-Conraria et al. (2017), who studied states in the U.S.; Barrios and de Lucio (2003), Correia and Gouveia (2013), and Bierbaumer-Polly et al. (2016), who analyzed the experience of the European Union countries; Artis and Okubo (2010), who analyzed intra-national business cycles in the U.K.; and Artis and Okubo (2011), who did the same for Japan. Second, we contribute to the literature that looks at and describes the consequences of the Mexican economic integration. According to the various studies mentioned previously, this integration did not only bring about a heterogeneous change in the growth performance of the states but also induced subtle structural changes in their economies—changes that took longer to become apparent.

The remainder of this article is organized as follows. Section 2 presents the data used to measure the cyclical component of the states' economic activity and provides evidence about the change in the synchronization of their business cycles after NAFTA came into effect. Section 3 presents the methodology for testing the relative importance of the factors identified by MDA (2019) before and after the implementation of NAFTA and discusses the results. Lastly, Section 4 presents the final comments.

# II. State Business Cycles Before and After NAFTA

In this section, we explain how the business cycles and synchronization of the states are measured and provide statistics to reveal the change in the states' business cycles before and after NAFTA. The two variables employed to measure the economic activity of the states are Gross Domestic Product (GDP) and the *Indicador Trimestral de la Actividad Económica Estatal* (or ITAEE), which is a quarterly indicator of state-level economic activity.[7), 8)] The cyclical component of these series is obtained using different de-trending procedures—those of Hodrick and Prescott (1997), Baxter and King (1999), and Christiano and Fitzgerald (2003) (hereafter referred to

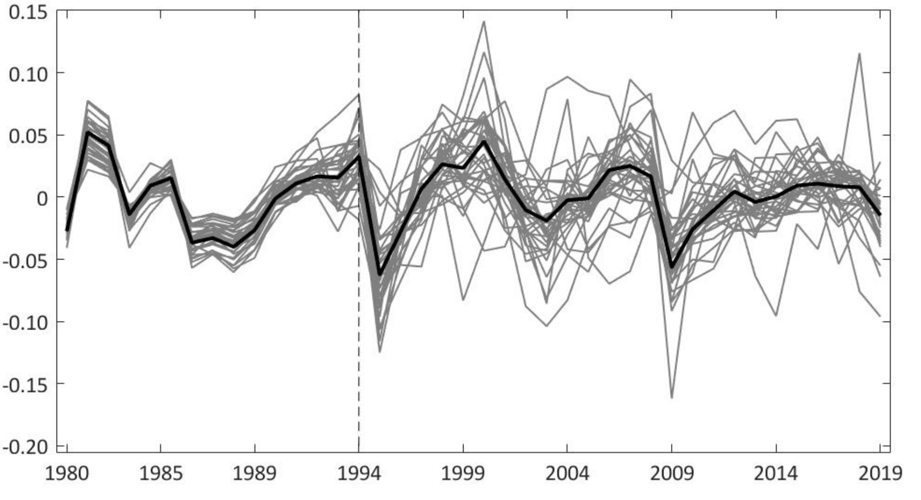
7) To measure the states' economic activity, MDA (2019) used the total formal employment series provided by the Mexican Institute of Social Security. We are unable to use the same series as they are only available from 1997 onward.

8) The GDP and ITAEE series are from the Bank of Economic Information (BIE) of Mexico's National Institute of Statistics and Geography (INEGI). The GDP series are annual, and those of the ITAEE are quarterly; the sample period is 1980-2019. The ITAEE provides short-term information that enables us to provide an overview of the economic evolution of the 32 states.

as the HP, BK, and CF filters, respectively).[9)]

Figure (1) contrasts the HP cycle of the GDP of Mexico's states (in gray) with that of the national GDP (in black)[10)] and reveals the co-movement of all cycles before 1994. Most of the states' cycles follow the same pattern, and the fluctuations in their cycles have the same length. After 1994, the states that follow the country's upwards and downwards cycles became less obvious. In fact, the figure depicts that some states move in an opposite direction to the national cycle.

**Figure 1.** Mexican state HP cycles (1980-2019)




We use the cyclical components of economic activity to calculate the co-movement/ synchronization of the states' business cycles. This measure is computed per pair of states ($\forall \ i \neq j$) in three non-overlapping sub-periods ($t$ = 1, 2, and 3, corresponding to 1980-1993, 1994-2004, and 2005-2019, respectively) using the Pearson correlation coefficient $(\rho_{i,j})$.[11)]

Figure (2) depicts the distribution of the HP GDP correlations for the three sub-periods. During the first sub-period (the pre-NAFTA stage), all the correlations are positive and close to one, averaging 0.945. There is a clear difference in the second and third sub-periods, with averages of around 0.579 and 0.386, respectively, whereas their ranges are wider and include negative numbers. These negative numbers highlight the following important feature worthy of study: after NAFTA, states do not follow the same cycles, and, in some cases, they move

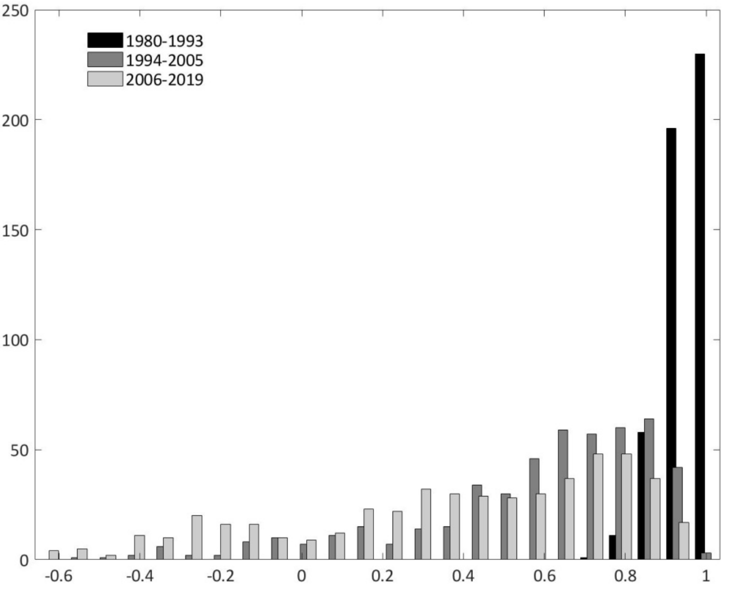
9) As the GDP series are annual and the BK filter generates a loss of data points at the beginning and end of the series, the cyclical component of the GDP series was not obtained using the BK filter, as we could not afford to lose information.

10) The results in Figure 1 are similar to those of the other variable, ITAEE, and with the remaining filters, CF and BK. The tables and figures are available upon request.

11) Later, we will define a second measure for quantifying the synchronization of states.

in opposite directions.

**Figure 2.** GDP cycle correlations of Mexican states




Now, let us consider the export profiles of the states and their relationship with synchronization. To do this, we divide the 32 states into two groups—13 states in the first group ("the exporters") and 19 in the second group ("the non-exporters").[12], [13] Figure (3) reveals that in the initial year, the first group accounted for 77% of Mexico’s exports, rising to almost 87% by 2019. This implies that each state in the first group is responsible for an average of 6.25% of the country’s exports. However, in the second group, each state accounted for less than 1%, which is a very significant difference.

12) The export data for the states are available from 2007 onward (www.inegi.org.mx/temas/exportacionesef/#Tabulados).

13) *Exporters:* Aguascalientes, Baja California, Coahuila, Chihuahua, Guanajuato, Jalisco, Mexico State, Nuevo León, Puebla, Querétaro, San Luis Potosí, Sonora, and Tamaulipas. *Non-exporters:* Baja California Sur, Campeche, Colima, Chiapas, México City, Durango, Guerrero, Hidalgo, Michoacán, Morelos, Nayarit, Oaxaca, Quintana Roo, Sinaloa, Tabasco, Tlaxcala, Veracruz, Yucatán, and Zacatecas. From 2007 to 2019, Mexico’s total exports increased by 75.59%. We use this figure to differentiate between exporter and non-exporter states. The states whose exports increased by more than 75.59% during this period belong to the exporter group and those whose exports increased by less than this are in the non-exporter group.

**Figure 3.** Exporter and non-exporter states

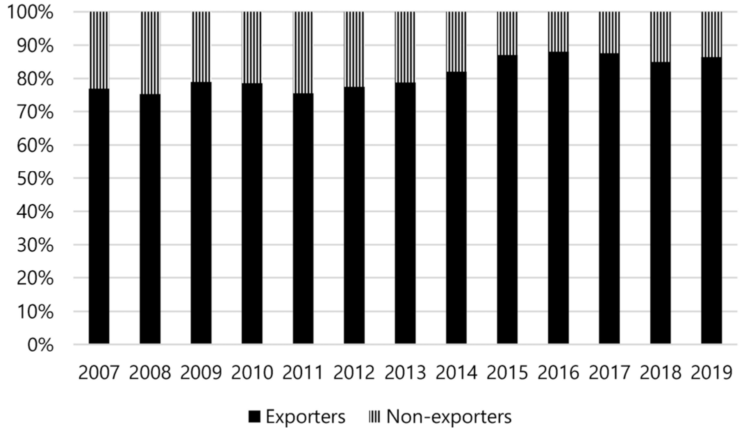



Table 1 presents the statistics of the remarkable change in the synchronization of the non-exporter states after NAFTA and the somewhat more stable synchronization of the exporter states.

**Table 1.** *Cyclical Component Correlations of Exporters and Non-exporters**

| | | ITAEE HP | ITAEE CF | ITAEE BK | GDP HP | GDP CF |
|---|---|---|---|---|---|---|
| Average correlation of all states (significant correlations) | 1980-1993 | 0.906 (496) | 0.866 (496) | 0.828 (496) | 0.945 (496) | 0.842 (464) |
| | 1994-2004 | 0.611 (429) | 0.637 (438) | 0.580 (427) | 0.579 (292) | 0.527 (315) |
| | 2005-2019 | 0.386 (356) | 0.438 (373) | 0.375 (313) | 0.386 (238) | 0.341 (303) |
| Average correlation of exporter states (significant correlations) | 1980-1993 | 0.970 (78) | 0.958 (78) | 0.933 (78) | 0.977 (78) | 0.945 (78) |
| | 1994-2004 | 0.752 (77) | 0.760 (76) | 0.732 (77) | 0.775 (66) | 0.766 (63) |
| | 2005-2019 | 0.711 (78) | 0.741 (78) | 0.725 (78) | 0.761 (76) | 0.710 (64) |
| Average correlation of non-exporter states (significant correlations) | 1980-1993 | 0.867 (171) | 0.809 (171) | 0.767 (171) | 0.933 (171) | 0.777 (150) |
| | 1994-2004 | 0.538 (136) | 0.570 (143) | 0.503 (134) | 0.476 (73) | 0.380 (84) |
| | 2005-2019 | 0.222 (91) | 0.278 (104) | 0.199 (69) | 0.202 (49) | 0.141 (88) |

* The number of observations in each group, i.e., all states, exporters, and non-exporters, is different, being 496, 78, and 171, respectively. The total number of pairs (combinations) that can be formed from the 32, 13, and 19 states are 496, 78, and 171, respectively.

The results reveal the same trend regardless of the variable or filter used. The average correlation from 1980 to 1993 is high, especially for states in the exporters' group; it decreased in the first ten years of NAFTA and remained low during the last sub-period. In the non-exporters group, the decline in correlation immediately after NAFTA is sharper—a trend that continued in the last sub-period. The average is calculated regardless of the statistical significance of the correlation.

If we consider the statistical significance of the correlations, the disparity between the groups' average correlation is even higher in the last two sub-periods. In the second and third sub-periods, most of the correlations of the exporter states are significant. In the non-exporters group, the number of significant correlations decreases by at least 20% and 50% in the second and third sub-periods, respectively. Therefore, the difference in the groups' average correlation discussed in the previous paragraph is even more substantial.

As we have provided evidence about the change in the synchronization of the states from the pre- to the post-NAFTA sub-periods, especially among the non-exporter states, we now attempt to establish the main state characteristics associated with the business cycle synchronization in the various sub-periods.

# III. Methodology and Results

To be able to employ conventional regression analysis, we calculate the second measure of synchronization based on the first. We apply Fisher's $z$-transformation to the previously estimated Pearson correlation coefficients $(\rho_{i,j})$, as shown in Equation (1).[14]

$$z_{(i,j),t} = 0.5*\log\left(\frac{1+\rho_{(i,j),t}}{1-\rho_{(i,j),\ t}}\right). \tag{1}$$

## A. Finding the factors that contribute to the co-movement of cycles in the entire period

To measure the statistical relationship between the variable that measures the co-movement of the states' business cycles ($z_{(i,j)}$) and the factors suggested by MDA (2019) and to determine the relative importance of those factors before and after NAFTA, we propose the following model:

$$z_{(i,j),\ t} = \alpha + X_{(i,j),\ t} \cdot \beta + \xi_{(i,j),t} \cdot t + u_{(i,j),t}, \tag{2}$$

14) Artis and Okubo (2010, 2011) suggested performing this transformation to increase the limits of $\rho_{i,j}$ beyond the interval (-1,1) and to avoid the truncated variable problem.

where $(i, j)$ denotes each pair of states (1, 2, 3, …496), and $t$ denotes the two sub-periods under consideration—pre-NAFTA (1980-1993) and post-NAFTA (1994-2019). The variables included in $X_{(i,j),t}$ are as follows:

(i) GDP: It is defined as the log of the average of the product of the per capita GDP of each pair of states $(i, j)$;[15]

(ii) PD: It is defined as the log of the average of the product of the population densities of each pair of states $(i, j)$.[16] The states' GDP and density are the *mass* determinants, and both are expected to have a positive and significant effect on the synchronization of the states;

(iii) Distance (D) and (iv) Distance squared ($D^2$): Distance is defined as the log of the shortest route between the capital cities of each pair of states $(i, j)$.[17] Distance is expected to be negatively associated with the states' synchronization but at a declining rate (the associated parameter of distance squared is expected to be positive);

(v) GDP per capita (GDP pc): It is defined as the log of the average of the absolute value of the difference in the per capita GDP of each pair of states $(i, j)$. This difference is used by MDA (2019) as a measure of the relative level of the development of each state or a measure of the similarity of their market structures, institutions, and human capital. It is expected that the lower this difference, the higher the level of synchronization of the states' business cycles;

(vi) Manufacturing production as a proportion of total GDP (Man): It is defined as the average of the sum of the share of manufacturing production in the total production of each pair of states $(i, j)$. This variable is expected to be positively associated with the states' synchronization, as states with more manufacturing production tend to be linked economically.

(vii) A specialization index (SI): It is an index that measures the similarity between the productive structures of each pair of states and[18] is defined as follows:

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15) The GDP data are from INEGI, and the population data are from the National Council of Population available at www.inegi.org.mx/sistemas/bie/ (Cuentas nacionales/PIB bruto por entidad federativa, base 2013) and https://datos.gob.mx/busca/dataset/proyecciones-de-la-poblacion-de-mexico-y-de-las-entidades-federativas-2016-2050 (Población a mitad de año).

16) The population data are from the same source as the above, and the data on the geographical extension of the states are from INEGI.

17) It is based on information retrieved from Google Maps.

18) The last two variables, Man and SI, are constructed from INEGI data on the states' GDP disaggregated by economic sector. The nine economic activities are agriculture (forestry, fishing, and hunting); mining; electricity, gas, and water production; construction; manufacturing; wholesale and retail trade, accommodation, and food services; transportation, warehousing, and information services; finance, insurance, real estate, and rental and leasing; and other services and public administration.

$$SI_{(i,j)} = \sum_{k=1}^{9} \left| \frac{GDP_{i,k}}{\sum_k GDP_{i,k}} - \frac{GDP_{j,k}}{\sum_k GDP_{j,k}} \right| \quad (3)$$

where $GDP_{i,k}$ and $GDP_{j,k}$ indicate the GDP of economic activity $k$ ($k$ = 1, 2, 3, …9) in states $i$ and $j$, respectively; $\sum_k GDP_{i,k}$ is the total GDP of state $i$. The value of the index falls within the interval [0,2]; the closer the value is to zero, the greater the similarity between the economic structures of the two states; the closer it is to two, the greater the difference between them. The SI is expected to be negatively associated with the states' level of synchronization; the more similar the states' economic structures are, the higher the degree of synchronization because the economies of states whose economic structures are more similar react to a homogeneous shock more similarly.

The model also includes a time dummy variable ($\xi_{i,j,t}$) to capture the common factors that affect the synchronization of the states' business cycles in each sub-period.

Standard panel techniques are used to estimate Model (2). The Breusch-Pagan test based on the Lagrange multiplier indicates that a panel estimation is preferred to the pooled model,[19] whereas the Hausman test suggests that a fixed-effects model is more suitable than a random-effects model.[20] The estimation is done using panel corrected standard errors (PCSE) as the Wald test suggests the presence of heteroskedasticity.[21]

Table (2) presents the results of Model (2) for the entire sample, all pairs of states, and the two sub-periods. All the parameters have the expected sign and are statistically significant, except for *PD* in column 6 and *manufacturing proportion* in columns 2, 4, and 5.[22]

On the one hand, the relationships of the demand-side independent variables with the states' co-movement are (i) the larger the product of the PD of each pair of states, the more synchronized their cycles, and (ii) the greater the disparity between the per capita GDPs of states $i$ and $j$, the less synchronized their cycles, i.e., the greater the difference in their market structures (e.g., institutions, markets, and infrastructure), the less similar their behavior during shocks. On the other hand, the relationships of the supply side independent variables with the states' co-movement are (i) the larger the product of the GDP of states $i$ and $j$, the stronger their synchronization, which is probably because the size of their combined economy explains the intensity of their interaction; (ii) the larger the share of the combined manufacturing production

19) The null hypothesis of the Breusch-Pagan test is overwhelmingly rejected, which implies that the random-effects model is preferable to the pooled model.

20) The null hypothesis of Hausman is rejected, which implies that the fixed-effects model is preferable.

21) According to Beck and Katz (1995), PCSE is a solution for the estimation of unbiased standard errors in the presence of heteroskedasticity, autocorrelation, and contemporaneous correlation. This method yields more precise standard errors than those of feasible generalized least squares, although there is no evidence of autocorrelation or contemporaneous correlation.

22) Distance and distance squared are always not significant and thus are excluded from all models.

of each pair of states, the more synchronized their cycles, which is probably an indication of the existing intra- and inter-sectoral linkages, and (iii) the more similar the states' economic structures, i.e., the closer to zero the SI index of each pair of states is, the more similar their behavior in terms of employment in their various sectors.

**Table 2.** *Panel Corrected Standard Errors (PCSE) Results (the Entire Sample)*

| | Dependent variable | | | | |
|---|---|---|---|---|---|
| | (2)<br>ITAEE HP | (3)<br>ITAEE CF | (4)<br>ITAEE BK | (5)<br>GDP HP | (6)<br>GDP CF |
| Constant | -1.443***<br>(-3.48) | -1.655***<br>(-3.42) | -1.696***<br>(-4.34) | 0.850***<br>(1.55) | -2.026***<br>(-2.73) |
| PD | 0.070*<br>(1.86) | 0.103**<br>(2.19) | 0.082**<br>(2.17) | 0.123**<br>(2.07) | 0.022<br>(0.77) |
| GDP | 0.358***<br>(7.69) | 0.360****<br>(6.61) | 0.345***<br>(7.85) | 0.152**<br>(2.47) | 0.426***<br>(5.084) |
| GDP pc | -0.096***<br>(-3.41) | -0.127***<br>(-3.85) | -0.103***<br>(-3.87) | -0.110***<br>(-2.94) | -0.085*<br>(-1.67) |
| Man | 0.026<br>(0.10) | 0.576**<br>(2.07) | 0.114<br>(0.49) | -0.335<br>(-1.095) | 1.157***<br>(2.93) |
| SI | -0.622***<br>(-8.71) | -0.574***<br>(-5.37) | -0.579***<br>(-6.62) | -0.563***<br>(-4.19) | -1.077***<br>(-4.79) |
| *t* | -1.141***<br>(-44.64) | -0.882***<br>(-30.27) | -0.801***<br>(-33.67) | -1.426***<br>(-43.58) | -0.871***<br>(-19.52) |
| $R^2$ | 0.738 | 0.589 | 0.639 | 0.729 | 0.538 |
| N | 992 | 992 | 992 | 992 | 992 |

*Note.* *t*-values are in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Lastly, the time dummy variable is highly significant, which suggests the existence of common factors that negatively affect the states' synchronization.

We hypothesize that the relevance of the set of factors proposed by MDA (2019) varies in the sub-periods. Specifically, we expect the factors associated with the supply side of the economies to be more important after NAFTA, i.e., the greater their manufacturing production as a proportion of their total GDP or the more similar their economic structures, the more synchronized the pair of states *i* and *j* will be.

## B. Finding the factors that contribute to the co-movement of cycles in the first and third periods

The purpose of this sub-section is to demonstrate the relative difference in the relevance of the variables associated with the synchronization of the states' business cycles (GDP, PD, GDP pc, manufacturing share, and SI) during the years before and after NAFTA. To provide empirical evidence of this, we estimate Equation (4) using data from two sub-periods—the pre-NAFTA period (1980-1993) and the NAFTA consolidation period (2006-2019), both of which have the same number of years.[23)]

$$z_{(i,j)} = \alpha + X_{(i,j)} \cdot \beta + u_{(i,j)}. \tag{4}$$

Table (3) presents the results about the two sub-periods. Overall, the results are similar regardless of the variable or filter. The demand-side variables are relevant to explaining the co-movement of the states' cycles in the first sub-period (1980-1993) due to the level of the significance of the estimated parameters. *PD* and the difference in *GDP pc* are more significant than those estimated over the entire period (1980-2019) in the previous sub-section. In contrast, *Man* is statistically irrelevant in almost all the models. Finally, the significance of the SI is lower than in the panel estimation, which is similar to that of the GDP variable.

The results about the sub-period 2006-2019 suggest that the supply side variables are more relevant to explaining the co-movement of the states' cycles in this phase due to the level of the significance of the estimated parameters. The PD and GDP pc of this sub-period are not significant, whereas manufacturing production, the SI, and GDP do not only have the expected sign but also are estimated to have a higher level of significance than they do in the period as a whole and the pre-NAFTA sub-period.

The results obtained are consistent with the conclusions of other studies that analyzed the transformation of Mexico's regional economies after NAFTA. They can be summarized as follows: the observed changes in Mexico's intra-national business cycles are due to the economic integration of Mexico, Canada, and the U.S. through NAFTA. As predicted by the trade theory and documented in empirical studies, due to the trade agreement, some Mexican states specialized in economic activities in which they have a comparative advantage. The states in question—located along the country's northern border, in its northern-center region, and, in some cases, in the central region—have increased their trading activity with the U.S., which has caused increasing integration with the production cycle of the U. S. and decoupling from the cycles of other Mexican states, especially those in the southern region.

The evidence of the differences in the synchronization between the business cycles of the U.S. and those of Mexican states before and after NAFTA is presented in Appendix 1. The synchronization between the business cycles of the U.S. and all Mexican states in the pre-NAFTA period is almost the same. After NAFTA, the exporter states experienced a greater increase in synchronization than non-exporter states.

23) We employ ordinary least squares (OLS) to estimate Equation (4) because it is not a panel estimation.

**Table 3.** *OLS Estimation Results*

| | First period (1980-1993) | | | | | Third period (2006-2019) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) ITAEE HP | (2) ITAEE CF | (3) ITAEE BK | (4) GDP HP | (5) GDP CF | (6) ITAEE HP | (7) ITAEE CF | (8) ITAEE BK | (9) GDP HP | (10) GDP CF |
| Constant | -0.016 | 0.527 | 0.219 | 4.894*** | 2.039** | -4.257*** | -5.131*** | -3.822*** | -6.128*** | -9.735*** |
| | (-0.02) | (0.70) | (-0.34) | (6.13) | (2.12) | (-7.15) | (-6.49) | (-6.57) | (-5.86) | (-5.34) |
| PD | 0.079** | 0.131*** | 0.107*** | 0.074*** | 0.209*** | -0.027* | -0.023 | -0.039* | 0.004 | 0.032 |
| | (2.30) | (3.55) | (3.45) | (4.90) | (4.43) | (-1.68) | (-1.07) | (1.94) | (0.15) | (0.65) |
| GDP | 0.230*** | 0.145* | 0.209*** | -0.252*** | 0.093 | 0.493*** | 0.600*** | 0.450*** | 0.673*** | 1.022*** |
| | (2.95) | (1.73) | (2.95) | (-2.82) | (0.86) | (8.01) | (7.35) | (8.49) | (6.23) | (7.42) |
| GDP pc | -0.166*** | -0.163*** | -0.160*** | -0.110*** | -0.116** | -0.005 | -0.058 | -0.028 | -0.015 | 0.052 |
| | (-3.55) | (-5.25) | (-5.79) | (-6.07) | (-1.96) | (-0.15) | (-1.32) | (-0.88) | (-0.26) | (0.51) |
| Man | -0.403 | 0.322 | -0.382 | -0.296 | 3.022** | 3.08*** | 3.919*** | 4.045*** | 3.684*** | 2.361*** |
| | (-1.13) | (0.84) | (-1.19) | (-0.732) | (2.20) | (9.19) | (8.82) | (12.36) | (6.27) | (6.20) |
| SI | -0.256*** | -0.436*** | -0.359*** | -0.173* | -0.908*** | -0.705*** | -0.593*** | -0.547*** | -0.745*** | -1.226*** |
| | (-3.15) | (-5.00) | (4.89) | (-1.87) | (-8.14) | (-11.39) | (-7.22) | (-12.05) | (-8.86) | (-6.47) |
| $R^2$ | 0.17 | 0.18 | 0.17 | 0.14 | 0.22 | 0.47 | 0.37 | 0.49 | 0.29 | 0.25 |
| N | 496 | 496 | 496 | 496 | 496 | 496 | 496 | 496 | 496 | 496 |

*Note.* *t*-values are in parentheses. The symbols ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

## C. International trade and synchronization (2007-2019)

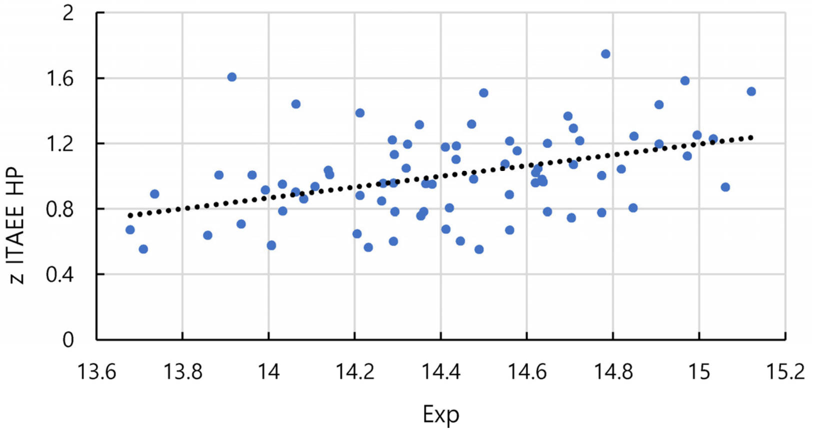
In Section 2, we demonstrated how exporter states tend to be more synchronized than non-exporter states from 2005 to 2019. In this sub-section, we look at the relationship between the states' export variable and their level of synchronization.

Manufacturing production accounts for a greater share of the GDP of exporter states than that of non-exporter states. Furthermore, from 2007 to 2019, manufacturing exports represented 87.1% of all exports. The linkages of the manufacturing sector could be the key element underlying the synchronization of the states during this sub-period, as previous studies have suggested.

Figures (4) and (5) illustrate the relationship between the states' synchronization and the level of trade of exporter and non-exporter states, respectively. In both figures, the x-axis denotes the annual average log of the export product of each pair of states ($i$, $j$) from 2007 to 2019, [$\text{Exp} = \log\left(\overline{\exp}_i * \overline{\exp}_j\right)$], whereas the y-axis denotes the measure of synchronization obtained with the ITAEE and the HP filter in the third sub-period.[24)]

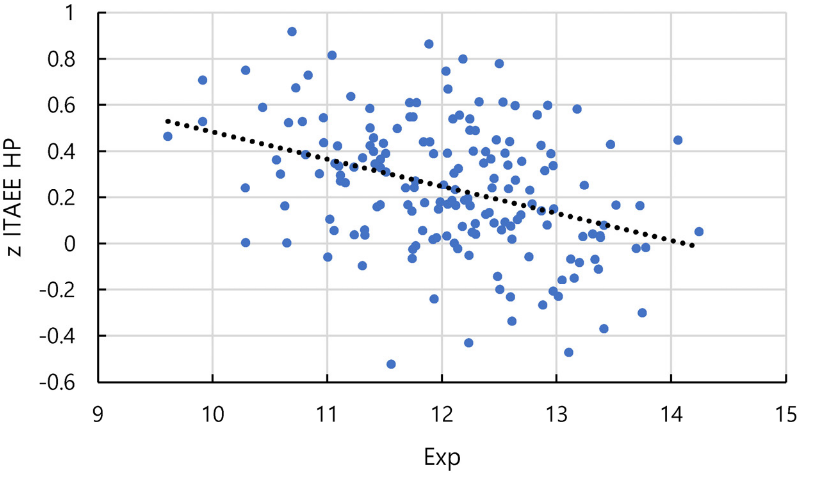
24) This relationship holds for all the five different measures of synchronization calculated.

**Figure 4.** Exporter synchronization and exports (2007-2019)




On the one hand, these two variables reveal a positive relationship for exporter states. As depicted in Figure (4), the greater the level of exports of the pair of states, the greater their level of synchronization. On the other hand, for non-exporter states, the greater the level of exports of the pair of states, the less synchronized they are with the rest of the states in this group, as depicted in Figure (5).

**Figure 5.** Non-exporter synchronization and exports (2007-2019)




To confirm that the relationship between synchronization and exports holds when the rest of the variables are considered, we estimate Equation (5). This is similar to that of Equation (4), but the only difference is that in Equation (5), the set of independent variables ($X'_{(i,j)}$) includes an additional variable $\mathrm{Exp}$, which was defined previously.

$$z_{(i,j)} = \alpha + X'_{(i,j)} \cdot \beta + u_{(i,j)}. \tag{5}$$

The results in Table (4) confirm our previous findings about the variables that are relevant to explaining states' cycles co-movement in the last sub-period (2007-2019).[25] For both exporter and non-exporter states, the higher their levels of Man and the more similar their productive structures (SI), the more synchronized they are. The main difference between these two groups is the effect of their level of exports on their synchronization. When exporter states are *more* synchronized, the greater their level of exports, whereas for non-exporter states, when they are *less* synchronized, the greater their level of exports.

**Table 4.** *Exporter and Non-exporter States (2007-2019)*

| | Exporters | | | Non-exporters | | |
|---|---|---|---|---|---|---|
| | (2) ITAEE HP | (3) ITAEE CF | (4) ITAEE BK | (5) ITAEE HP | (6) ITAEE CF | (7) ITAEE BK |
| Constant | -0.392 | 2.059 | 0.714 | -0.078 | 0.350 | 1.347 |
| | (-0.16) | (0.66) | (0.31) | (-0.07) | (0.25) | (1.36) |
| PD | -0.030 | -0.140* | -0.054 | -0.060* | -0.086* | -0.060* |
| | (-0.55) | (-1.93) | (-1.04) | (-1.88) | (-1.96) | (-1.92) |
| GDP | 0.157 | -0.083 | -0.022 | 0.190* | 0.200 | 0.013 |
| | (0.99) | (-0.39) | (-0.15) | (1.94) | (1.47) | (0.14) |
| GDP pc | -0.036 | -0.032 | -0.042 | 0.058 | -0.006 | 0.002 |
| | (-0.60) | (-0.40) | (-0.73) | (1.05) | (-0.08) | (0.05) |
| Man | 3.414*** | 4.826*** | 3.584*** | 5.045*** | 8.134*** | 5.700*** |
| | (3.44) | (3.65) | (3.74) | (3.99) | (4.65) | (4.61) |
| SI | -0.900** | -0.887* | -0.414* | -0.361*** | -0.145** | -0.063** |
| | (-2.63) | (-1.94) | (1.85) | (-3.36) | (-2.36) | (-2.42) |
| Exp | 0.030*** | 0.012** | 0.040** | -0.130*** | -0.152*** | -0.097*** |
| | (4.12) | (2.50) | (2.59) | (-5.07) | (-4.29) | (-3.87) |
| $R^2$ | 0.25 | 0.30 | 0.34 | 0.33 | 0.24 | 0.25 |
| N | 78 | 78 | 78 | 171 | 171 | 171 |

On the one hand, the greater the export level of an exporter state, the more synchronized it will tend to be with other exporting states because it will more closely resemble those in that group. On the other hand, the greater the export level of a non-exporter state, the less synchronized it will tend to be with other non-exporter states because the more it exports, the more different it will be from its fellow non-exporters.

25) PD is marginally significant for some filters, especially for non-exporter states.

# IV. Final Comments

We study the adjustment in the business cycles of Mexican states that occurred as a result of NAFTA. We begin by describing the properties of the states’ business cycles and evaluate the degree of synchronization across them to assess the role of demand and supply factors in driving these cycles.

Our results prove that there is a difference in the degree of synchronization between the states in the pre- and post-NAFTA periods. Before NAFTA, we see a significant correlation between the cycles of all states. However, after NAFTA, the level of synchronization remains high for states with similar economic structures, those with a higher share of manufacturing production, and those with higher exports.

The trade agreement led to a regional and sectoral reallocation of resources that triggered manufacturing sector specialization, which in turn caused states to become increasingly interlinked based on their industrial production. Hence, the supply side of the economy became more relevant to the states’ business cycles during this sub-period. The treaty also boosted both production-sharing schemes and the bilateral intra-industry trade between Mexico and the U.S., creating a stronger cyclical movement among states that were the greatest exporters.

Previous studies have analyzed the effect that Mexico becoming increasingly integrated into North America’s capital and trade flows has had on the business cycles of Mexico and the U.S. The results of this study shed light on the consequences of the synchronization of Mexico’s states—an issue that, to the best of our knowledge, has not been studied before.

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# Appendix

We start by obtaining the annual and quarterly U.S. real GDP series from the Federal Reserve Bank of St. Louis and then obtain their cyclical components. Next, we calculate the correlation between the U.S GDP cycles and the cycles of each Mexican state for the following periods: (i) 1980-1993 and 1994-2019 (i.e., the periods before and after NAFTA) and (ii) 1994-2005 and 2006-2019 (i.e., we divide the period after NAFTA into two sub-periods). Lastly, we calculate the average correlation for exporter and non-exporter states in each sub-period.

**Table A1.** *Average Business Cycle Correlation between the U.S. and Mexico's Exporter and Non-exporter States*

| | | Filter and time frame | | | | |
|---|---|---|---|---|---|---|
| Sub-period | Group | HP annual | CF annual | BK quarterly | HP quarterly | CF quarterly |
| *Before NAFTA* | | | | | | |
| 1980-1993 | Exporter states | -0.458 | -0.608 | 0.173 | -0.127 | 0.371 |
| 1980-1993 | Non-exporter states | -0.488 | -0.575 | 0.084 | -0.145 | 0.315 |
| *After NAFTA* | | | | | | |
| 1994-2019 | Exporter states | 0.676 | 0.750 | 0.692 | 0.706 | 0.717 |
| 1994-2019 | Non-exporter states | 0.332 | 0.285 | 0.407 | 0.431 | 0.455 |
| *1st sub-period after NAFTA* | | | | | | |
| 1994-2005 | Exporter states | 0.609 | 0.727 | 0.575 | 0.578 | 0.631 |
| 1994-2005 | Non-exporter states | 0.316 | 0.449 | 0.400 | 0.406 | 0.427 |
| *2nd sub-period after NAFTA* | | | | | | |
| 2006-2019 | Exporter states | 0.788 | 0.818 | 0.771 | 0.767 | 0.765 |
| 2006-2019 | Non-exporter states | 0.362 | 0.371 | 0.423 | 0.444 | 0.478 |

The results in Table A1 are robust and reveal the same trend regardless of the time frame of the variable or the filter used. They indicate that before NAFTA, the average correlation between non-exporter states and the U.S. and exporter states and the U.S. was almost the same. After NAFTA, the correlation of both groups increased, especially the exporter states. Moreover, if we divide the post-NAFTA period (1994-2019) into two sub-periods (1994-2005 and 2006-2019), the exporter states become increasingly synchronized with the U.S. as NAFTA consolidates, whereas the synchronization process of non-exporter states comes to a halt.