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The manufacturing industry in the northern border States of Mexico and the southern border States of the United States: an absolute convergence empirical analysis (1993 – 2021)

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Dedicatoria

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Abstract

The aim of this work is to prove the existence of absolute convergence for the manufacturing industry (manufacturing GDP per capita) of the northern border states of Mexico with the southern border states of the United States, from 1993 to 2021. To do so, it uses data of population and manufacturing GDP from both countries at a regional level to construct an absolute convergence ordinary least squares trend regression model for both sigma and beta convergence, in company with its graphic representations. The results show there is not enough evidence to affirm the existence of both sigma and beta convergence in the manufacturing GDP per capita among the U.S.-Mexico border states, despite the reduction of its coefficient of variation from 1993 to 2021 and a negative value on the *Beta* parameter in the regression model.

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Introduction

Economic growth theory is a branch of economics dedicated to study the conditions that lead to a real increase of gross domestic product in a region, usually a nation. The factors that increase the wealth of a nations is an issue as old as classical economics, as Adam Smith asked in his 1776 book *An Inquiry into the Nature and Causes of the Wealth of Nations*. Most authors from different economic thought schools have agreed in basically four needs for economic growth to happen, despite the different means to do so: an increase in physical capital and its quality, an increase in quality and quantity of human capital, the availability of natural resources, and the development of new technologies. A fifth factor would be the combination of all the previous ones. And, on public policy, Greenlaw, S., & Shapiro, D. (2017: 488) point four basic pillars for government to focus on: education, savings and investment, infrastructure, special economic zones and scientific research.

After the Second World war, despite the number of tools, policies and focus of public and private investments as alternatives to increase the growth of a nation's wealth, other questions arose during the second half of the XX century: why does some nations grow faster than others? Why does some policies work on some countries and not other? Will developing countries catch up to developed ones on GPD per capita levels? The principal motives of this questions were

> First, that economic growth is highly variable among nations (…) the second reason is that industrialized countries have overcome the worst excesses of business depressions through stabilization policies (…) The third reason is that most poor countries, many of them colonies before World War II, are now politically free and are pursuing strategies to promote economic growth and development and more flexible markets (…) The fourth reason is that the collapse of Marxian Socialism in Eastern Europe and the Soviet Union has focused much attention on growth and development in these regions (…) Finally, the rising standard of living in developing nations has become economically important to the industrially advanced nations in terms of direct investment, international trade, and international finance (Brue, S., and Grant, R. G., 2012: 505)

As these circumstances flourished, so did economic growth theory, with contributions like the Keynesian growth model established by Harrod and Domar, Solow's neoclassical growth model and Schumpeter's theory of economic development and institutional change, despite this last one was stablished before 1950.

Another theory, related to economic growth, emerged soon after and was related to developing countries catching up to developed ones: the convergence theory. Convergence is defined as "the fact that two or more things, ideas, etc., become similar or come together". That is, it happens when two or more objects, units or measures become closer together; their differences diminish. This is the theme of the present research but, unlike the comparison of lagged and leader economies' GDP per capita at a national level, the research question is if there is absolute convergence in the manufacturing industry among the northern border states of Mexico —lagged region— with the southern border states of the United States —leader region—, from 1993 to 2021.

Nevertheless, it is important to point out the differences in models of industrialization between the Mexican and U.S. border states, and its implication on this research, before digging in the study. The U.S. southern border States, especially California and Texas, based their industry in general, and manufacturing in particular, on scientific research and innovation. Mexican northern border states industry, on the other hand, is based on assembling and manufacturing; its duty is the manufacture of merchandise to export abroad, along with the production of components (like electric circuits), but not the production of capital, technology and innovation. In other words, one industrialization model is based on innovation and the other in manufacturing, making them qualitatively incomparable.

In this setting, the industrial dynamic on the southern border states of the U.S. was not enough to create an industry with similar levels of technology in the northern border states of Mexico. Contrarily, it encouraged the *Industria Maquiladora Mexicana* (IMMEX), an industry based on imported capital and technology, and export of manufactures, in which transnational companies could take advantage of

Mexico’s low wages. But, despite the differences in technology and innovation with the U.S. southern border States, the manufacturing industry in the U.S. and Mexico border States can still be studied making a quantitative research comparison of their GDP levels.

This region and industry were chosen based on the gradual importance the manufacturing project in the northern border states of Mexico has gained in the last decades, particularly since 1980, with the free trade and liberalization economic reforms, to the improvement of the economic and social conditions in Baja California, Coahuila de Zaragoza, Chihuahua, Nuevo León, Sonora and Tamaulipas. Furthermore, it was chosen to study if there is absolute convergence with the U.S. southern border states —Arizona, California, New Mexico and Texas— because of the gradual economic and trade integration between Mexico and the United States, as well as its geographical closeness, holding one of the largest borders in the world.

The remainder of the work proceeds as follows. Section 1 discusses the definition of sigma and beta convergence, as well as the absolute and conditional convergence, earlier investigation on the topic, and several examples of international and regional empiric convergence analysis. Section 2 presents the GDP, GDP per capita, manufacturing industry and business incentives of each state that conforms the region of study, plus a description of the border region in general. Section 3 is a historical chapter of the manufacturing industry in Mexico from the late 1800’s, during the presidency of Porfirio Díaz, to the second decade of the XXI century, describing the technological and fiscal problems that have remained for decades in matter of industrial policy in Mexico. Section 4 describes the sources and methodology applied for the regression analysis. Section 5 attends the results of the ordinary least square trend regression models for both sigma and beta convergence to describe if there is absolute convergence among the U.S.-Mexico border states its manufacturing industry. Finally, section 6 concludes.

1. Literature review

1.1 Introduction

The purpose of the following section is to discuss the literature concerning economic convergence. First, sigma and beta convergence are defined, as well as the absolute and conditional convergence. Then, earlier investigation on the topic is discussed, reviewing the work of Baumol (1985), Abramovitz (1986), Romer (1986, 1990) and Barro and Sala-i-Martin (1992) and its relation to convergence. Next, several examples of international and regional empiric convergence analysis are described from different authors and regions. Afterwards, a brief subsection of public policy discusses the works of Sachs and Warner (1995) and Delgado and De Lucas (2018) to enlist the determinants against divergence lead by market forces. Finally, a set of brief conclusions.

1.2. Convergence theory

The Neoclassical Growth Model by Solow (1956) and Swan (1956), which was later formalized by Cass (1965) and Koopmans (1965), that considered the previous work of Ramsey (1928), explains the factors that influence long-run economic growth in a country to try to understand the differences of output levels and growth rates across time and regions. This model predicts that, given an initial stock of capital per worker, an economy convergence to a steady state equilibrium; that is, “the situation in which various quantities grow at constant rates” (Barro and Sala-i-Martin, 2002). The previous statement leads to the idea that different Gross Domestic Product (GDP) per capita of different countries tend to converge to the same level once the saving rate, depreciation rate and population growth are taken into consideration.

Nevertheless, it is unusual that different economies reach a common steady state. Their differences in population growth rate, saving-investment rate and reach to technology and its use usually cause greater divergence than convergence among nations. The control of all determinants of economic growth may lead, then, to a steady state configuration, but it is rather difficult empirically. In any case, as pointed out by Solow (1999), the speed of convergence is the main discrepancy: it can be more measurable and manageable than the steady state. So, instead of thinking only on the conditions that will lead to a poor economy's income reach the income of a rich country, it may be necessary to acknowledge how much time would it take to do so.

1.2.1. Beta convergence

Beta convergence (β) occurs when the there is a negative relation when regressing the GDP per capita growth rate and the initial level of GDP per capita of a set of countries or regions in a period. In a linear relationship, β must be negative for this to happen.

1.2.2. Sigma convergence

The other convergence coefficient is sigma (σ), based on the cross-sectional standard deviation of the real per capita GDPs among a group of countries or regions. A decline on sigma convergence means fewer dispersion on per capita income of the regions analyzed, which translates into a tendency toward the catching up of lower income countries to high income countries. Both beta and sigma convergence are related, as pointed out by Yin, L., et al. (2003):

> β-convergence measures the average speed at which poor economies approach, in terms of real per capita GDP, to the rich countries within a specified time interval (…) σ-convergence indicates whether the cross-sectional variation of the real per capita GDPs among a group of countries decreases over time (Yin, L., et al., 2003: 194).

Basically, sigma convergence happens when the dispersion of per capita income or output, measured as its variance, decreases over time. And, as proved by Barro and Sala-i-Martin (1995), the existence of beta convergence is a necessary but not a sufficient condition for the presence of sigma convergence, and so it is not possible to observe sigma convergence without beta convergence. Which means that there must be beta to get sigma. It is possible that poor regions or countries achieve higher growth rates than rich ones, but it does not necessarily mean the dispersion of income or output on both will decrease over time.

1.2.3. Conditional and absolute convergence

Barro and Sala-i-Martin (1991) introduced the idea of *absolute convergence*, who sets that a country tends to grow faster if the gap between its long run income per capital level and present income per capita level widens, considering fixed variables in the neoclassical growth model of Ramsey (1928), Solow (1956), and Koopmans (1966). On the other hand, when there are variables that consider effects on growth beyond the initial state and the growth rate of a period, and there is a negative relation between the per capita income level at time zero and the growth rate of per capita income in the subsequent period, then there is *conditional convergence*. Assuming constant elements and that all countries hold the same steady state of real per capital GDP, and considering rich countries tend to have faster diminishing returns due to their bigger capital assets, poor countries tend to grow faster than rich ones.

The Non-Linear Square (NLS) model for absolute convergence is written as follows, according to Barro and Sala-i-Martin (1992):

$$\frac{1}{T} ln = \alpha - \frac{1- e^{-\beta T}}{T} \ln\left(y_{i,t-T}\right) + U_{it} \ , \qquad (1)$$

where:

- $y_{i,t}$ is the real per capita GDP for the country *i* in year *t*.
- $y_{i,t-T}$ is the initial period real per capita *GDP* for country *i.*
- T is the length of the time interval, in years.
- U_{it} is the error term of region *i* in year *t*.

A NLS model with conditional convergence extends equation (1) to the following, according to Yin, L., et al. (2003):

$$\frac{1}{T} ln \frac{y_{i,t}}{y_{i,t-T}} = \alpha - \frac{1- e^{-\beta T}}{T} \ln\left(y_{i,t-T}\right) + \phi X_{i,t} + U_{it} \ , \qquad (2)$$

where $X_{i,t}$ is a set of exogenous variables maintaining the steady state characteristics of the economy constant, and ϕ is a set of unknown coefficients.

However, this research uses an Ordinary Least Squares (OLS) absolute convergence model, which is described in section 4.

Considering the new parameters of equation (2), it's necessary to acknowledge that:

> if β-convergence is empirically supported in equation (2), this will not necessarily imply that poor countries' real per capita GDP converges to the real per capita GDP of the rich countries. It simply means that if all steady state characteristics of the economies could be held constant, then and only then would countries with low initial real per capita GDP grow faster than rich countries, thus catching up with them (Yin, L., et al., 2003: 194).

It is then more difficult to get to a state of conditional convergence since more variables, economic shocks and differences among a set of regions are considered. This has made a focus among some authors on rather than if the income dispersions among countries decrease over time, how long will it take for poor countries to catch-up with rich ones, as mentions previously. "In the neoclassical growth model, the parameter β captures the rate at which a country's real per capita GDP approaches its steady state rate of growth; i.e., β is a *speed of adjustment parameter*" (Yin, L., et. al., 2003: 192). In this sense, a β-convergence regression model can not only show a negative relation between the growth rate of the GDP per capita and the initial level of GPD per capita of an specific period and set or regions, but the time needed for underdeveloped countries to reach income levels of developed countries. This is clarified on section four, when describing the *Lambda* and *Halflife* parameters.

1.3. First approaches

By the introduction of Paul Romer's theoretical growth model with increasing-returns-to-scale production technology, he noted that "it seemed to be broadly consistent with the cross-country growth experience of the post-war era, in which there was no discernable trend for the poorer nations to converge with the richer nations" (Sachs and Warner, 1995: 3), idea which differs from Solow, who affirmed that GDP per capita would grow at the same rate as technological progress develops. Romer (1986) wrote, based on the data from Maddison (1982):

> If it is true that growth rates are not negatively correlated with the level of per capita output or capital, then there should be no tendency for the dispersion in the (logarithm of the) level of per capita income to decrease over time. There should be no tendency toward convergence. This contradicts a widespread impression that convergence in this sense has been evident, especially since the Second World War (Romer, 1986: 1012)

Soon after, Romer (1990) concluded, according to the result of endogenous technological change model, that policies based on subsidies in research and the accumulation of human capital are conditions that lead to remove divergences in social and private returns to research. Also, an economy with an increasing population is not the ultimate condition for faster growth, but a lager stock of human capital is. Finally, specifically about the low growth rates in underdeveloped countries, Romer said:

> the model also suggests that low levels of human capital may help explain why growth is not observed in underdeveloped economies that are closed and why a less developed economy with a very large population can still benefit from economic integration with the rest of the world (…) what is important for growth is integration not into an economy with a large number of people but rather into one with a large amount of human capital (Romer, 1990: 98).

These concluding thoughts set the implication that integrated markets and investment in human capital, even in regions with large populations, can help overcome low economic growth, and, eventually, reach convergence in the integrated economies. Particularly this is of our interest, considering the case of the US-Mexico manufacturing industry in the border.

Romer's ideas contributed at the debate about the underdeveloped countries convergence. Some authors, as Dowick and Nguyen (1989), proved that convergence seems to hold on richer countries, but it was Baumol (1985) who first suggested that there may be a *convergence club*. He emphasized the study of economic history to find empiric evidence. Using data from Maddison (1982), Baumol studied the evolution of productivity per labor hour among industrialized countries, intermediate economies, and central planned economies, to find out if there has been convergence by groups between 1870 and 1979. The convergence club was particularly integrated by the Organization of Cooperation and Economic Development (OCED) members, who all shared good initial level of human capital and, therefore, took useful advantage of technology assets. By a graph of sixteen industrialized countries (including the United States, United Kingdom, Germany, France and Japan), where growth rate is in the *y* axis and 1870 GDP per work hour in 1970 US Relative Prices is in the *x* axis, Baumol found a clear negative relation, which indicates that the countries with lower GDP per work hour in 1870 had a bigger growth rate than those whose GDP per work hour in the initial year were higher. That is a clear sign of convergence. From this, he stated:

> Rather, what is striking is the apparent implication that only one variable, a country's 1870 GDP per work-hour, or its relation to that of the productivity leader, matters to any substantial degree, and that other variables have only a peripheral influence. It seems not to have mattered much whether or not a particular country had free markets, a high propensity to invest, or used policy to stimulate growth (…) A plausible alternative interpretation is that while national policies and behavior patterns do substantially affect productivity growth, the spillovers from leader economies to followers are large at least among the group of industrial nations (Baumol, 1985: 1077)

Baumol considered that the spillover effect from an economic leader to another was a main cause of convergence among industrialized countries. He also noted that once a country produces a certain technologic innovation, other countries would follow to produce it or try to obtain access to such knowledge. This last idea is similar to Romer's (1985), who noted that innovation and knowledge is not a *rivalry good* (it can be anywhere, unlike a worker or capital), but it can be an *exclusionary good* (creators can hold the patent so the benefits can be monopolized).

Baumol concludes pointing out that, despite the spillover effects, effective growth policy does contribute to a nation's living standards and can help other developed nations too. Nevertheless, he does not explicitly describe if, for this to happened or to accelerate, is necessary the closeness of these nations: can convergence happen faster if industrialized economies are geographically close to each other?

Also, Baumol points out a key question: "If productivity growth does indeed have such public good properties, what will induce each country to invest the socially optimal effort and other resources in productivity growth, when it can instead hope to be a free rider?" (Baumol, 1985: 1079). In other word, why would a country have an active growth policy when it can wait on the leader for actions from the investors? Should a country or region take an active role in the search for industrial development, or the investment form abroad and spillovers will eventually come? He does not bring an answer to this question but, instead, contrast this interrogation with the possibility that the growth of a leader nation will not always bring a rise in the growth of the followers, but a backwash, which means that the conventional catch-up hypothesis has not always success, as conventionally written. This was Abramovitz thesis.

Abramovitz (1986) used the same data created by Maddison to study the levels of growth and labor productivity of sixteen industrialized countries from 1870 to 1979. He begins by describing the general idea of the catch-up (convergence) hypothesis: "across countries, the growth rates of productivity in any long period tend to be inversely related to the initial levels of productivity" (Abramovitz, 1986: 386), so that follower countries catch-up with leaders. As soon as he finishes this description, his critics commence, saying that the convergence process of the followers tends to be self-limiting because, as the follower's growth rate closes to the one of the leader's, the potential growth of the former tends to weaken in the long term. This potentiality depends on three issues: the facilities of the diffusion of knowledge; conditions facilitating the structural change in the composition of output and distributions of the workforce, and its relation to geographical location of the industry (this last point answers the question asked before, about the importance of space in the catching-up hypothesis); and macroeconomic and monetary economic conditions sustaining the level of growth of effective demand.

Different from Baumol, Abramovtiz focused on the levels of growth and labor productivity of fifteen industrialized countries compared to the United States, due to how, during the second Post World War, it achieved its role as global economic leader. He noted how "differences in rates of accumulation may reflect countries' opportunities to make advances in technology, but rates of capital formation may also be independent, to some degree, of countries' potentials for technological advance" (Abramovitz, 1986: 393). He describes that the expansion of the American population though the West, the increase in migrant population as labor force and the amount of natural resources available in the United States soil during the XIX century, played a key role to the formation and accumulation of capital in this country, that descended in reproduction of technology and knowledge faster than others. And, of course, the heavy state of "peace" compared to Europe during the XX century consolidated the role of the United States economy.

Even so, Abramovitz points out, there was an influential potentiality for the catching-up in the period and countries studied: "the variance among the productivity levels of the 15 follower countries declines drastically over the century from a coefficient of variation of 0.5 in 1870 to 0.15 in 1979" (Abramovitz, 1986: 393). The productivity gaps between the follower countries and the United States did indeed constitute a potentiality for fast growth in the future, and so, even after a century of obstacles, the outcome was that levels of productivity evened out. In this sense, Romer and Abramovitz coincide on the idea that, the further the growth rate of a follower country is from the leader's, the more potential it has to catch-up. The main reason for the fifteen follower countries to converge with the United States is that they all are nations who had entered a process of modern economic growth, acquired by the educational and institutional characteristics needed to use technological advances to their advantage.

About convergence *within* the fifteen follower countries, Abramovitz writes how the catching-up process happened slowly and weakly before World War II, but accelerated from that period forward. Before the Second Great War, productivity levels in Europe were low because of its dependence on agricultural activity and the insufficiency of know-how on the use of most advance methods of production. This could have made a higher potential capacity of growth for these countries, according to the convergence hypothesis ideas of Romer and Abramovitz, but it was lacked by World War I and the results of 1929 Financial World Crisis:

> The unfulfilled potential of the years 1913-1938 was then enormously enlarged by the effects of World War II. The average productivity gap behind the United States increased by 39 percent between 1938 and 1950; the poorer countries were hit harder than the richer. These were years of dispersion, not convergence (Abramovitz, 1986: 395)

The Second Post War period, after 1945, constitutes the beginning of convergence among the industrialized countries of the West mainly for two reasons: "enlarged social competence, reflecting higher levels of education and greater experience with large-scale production, distribution, and finance; and conditions favoring rapid realization of potential" (Abramovitz, 1986: 395). These factors resulted in high and rapid growth rates, close country association of initial growth rates and GDP per capita growth, and reduction of productivity levels with-in the follower countries and with the United States.

The United States had advantages of large land, natural resources and labor force (due to the flow of European migrants) compared to Europe, making it the leader, as noted before. Nevertheless, it may not happen in the future, because "countries have unequal abilities to pursue paths of progress that are resource-biase" (Abramovitz, 1986: 398). The United States advantages in the past may not be as relevant in the future: the opening of markets and increase in international trade, along with the investment on social capability, have created access for natural resources and human capital in the industrialized follower countries, enable them to be more competitive, use and create their own technology, and narrow the productivity gap with other nations.

Abramovitz continues his analysis with the limitations that could lead to a scenario in which the simple convergence hypothesis could not take place. In the interaction between followers and leaders, he describes an example of how the catch-up hypothesis simple form (followers borrowing technology from leader; leaders' spillovers of benefits and knowledge to the followers) did not happen:

> The rise of British factory-made cotton textiles in the first industrial revolution ruined the Irish linen industry. The attractions of British and American jobs denuded the Irish population of its young men. The beginnings of modern growth in Ireland suffered a protracted delay. (Abramovtiz, 1986: 398).

Considering Great Britain being the leader and Ireland the follower, the advantage taken from the former did not benefit the later; the loss of young labor force form Ireland lacked their capacity of growth during that period when, accordingly to the simple catch-up hypothesis, it should've been the opposite.

Besides technological borrowing, Abramovitz concludes enlisting interactions between followers and leaders to consider in the convergence hypothesis, to analyze the previous case and any other:

- *In trade, there could be rivalries*; followers exploit the advances of technologies from leader countries by import substitution and, if being successful doing so, competition could lead to negative effects on economic leaders: "the expansion of exports from Japan and the newer industrializing countries has had a serious impact on the older industries of America and Europe, as well as some of the newer industries" (Abramovitz, 1986: 399). When this occurs, there is trade shift that benefits the industry in general, but the old industries (leaders) suffer a loss of comparative advantage and the new ones (followers) a gain, ascribed to an increase in prices with lagged productivity in the former and declines in prices with rapid productivity in the later.

- *Interactions via population movements*; during the Postwar period, migration was from poorer countries of South Europe and North Africa to rapidly growth nations in North Europe and America. In more recent year, the reason of migrations varies from prospects of higher income to political and social reason that may reflect complexities in the convergence process.
- *Interaction via capital flows*; the generalization is that capital flows from leaders to followers, but this only applies on new investments, when follower's growth is supported by lead's capital movement. If investment in a follower country accumulates and reproduces enough capital, it can distribute its investments to leader nations.
- *Interactions via flows of applied knowledge*; as in the point described previously, it is the general idea that knowledge flow from leader to follower. However, as the technological gap narrows, "countries that are still a distance behind the leader in average productivity may move into the lead in particular branches and become sources of new knowledge for older leaders" (Abramovitz, 1986: 401), generating new potential of growth for the former leaders. Competitive pressure could be a stimulus for faster innovation as well as for protection of patents, situations that, once again, leads us to Romer (1985), about how innovation and knowledge are not rivalry goods, but could be exclusionary.
- *Constrains on change: intangible capital and political institutions*; the position of the United States and most of the countries of the North Atlantic required of the study of technics, management, bureaucracy and science in the private and public sector. Do these countries have a disadvantage to the followers derived from the need to renew their institutions and technics? Not necessarily, but it implies high costs that both the public and private sector must afront. The Welfare State build in Europe and the United Stated, but principally in Europe, had brought the institutions necessary for the adaptation of capital and labor to transition on the use of new technologies and

knowledge, to avoid falling behind to the followers, despite the fact that these have reach a similar level of competitivity, such as Japan and, nowadays, China.

1.4. Regional convergence empirical analysis

1.4.1. United States

Barro and Sala-i-Martin (1992) studied if there was convergence in income and output for the United States' states between 1840 and 1963, using the neoclassical growth model, in which "the per capita growth rate tends to be inversely related to the starting level of output or income per person (…) if economies are similar in respect to preferences and technology, then poor economies grow faster than rich ones" (Barro and Sala-i-Martin, 1992: 224). By using the per capita personal income and per capita gross state product, they found a negative correlation between per capita growth rate from 1880 to 1988 and the logarithm of the 1880 per capita personal income of the U.S. states, which proved the existence of convergence for the long run among the different states in both conditional and absolute perspectives.

Nevertheless, considering a shorter time-period, the per capita growth rate from 1840 to 1880 and the logarithm of 1840 per capita personal income, had a negative correlation, but in two separate groups: in a graph, the southern states made a line bellow the line of the non-southern states, but both with negative slopes. This indicates bigger levels of initial income per capita and growth rates for the non-southern states, despite there was convergence in both set of states, due to the consequences of the Civil War in the U.S.

In the gross state product (GSP) convergence, Barro and Sala-i-Martin acknowledged:

> The main finding is that convergence shows up significantly within these sectors of production, especially for manufacturing (…) The main inference from these results is that poorer states grow faster not only in terms of overall GSP per person, but also in terms of labor productivity within various sectors of production (Barro and Sala-i-Martin, 1992: 239)

The agricultural sector, on the other hand, did not converge as deeply as the manufacturing in the U.S. states in terms of GSP.

In the same paper, Barro and Sala-i-Martin compared the U.S. states situation with an analysis of ninety-eight countries, finding a positive relation in per capita growth rate from 1960 to 1985, and the logarithm of 1960 per capita GDP of these countries, which means there was no convergence. In fact, there was a tendency for initial rich countries to growth faster than the developed countries. And, as Baumol (1985) noted, Barro and Sala-i-Martin also agree in the existence of convergence for the OECD countries, considering a cross-country variation in steady-state value, that is, conditional convergence. However, the levels of the coefficient beta are higher in the case of the U.S. states in the same years.

Barro and Sala-i-Martin conclude that they found convergence on the long-run: poorer states tend to grow faster in per capita terms than rich ones, both in constant and absolute terms. And, for the ninety-eight countries data from 1960 to 1985, convergence is slightly smaller than in the U.S. states in conditional terms, that is, holding constant variables such as initial school enrollment rates. The biggest contribution of the research is the introduction of the concepts of conditional and absolute convergence.

A more recent research by Yamamoto (2008) studied the regional income disparities in the U.S. from 1955 to 2003. He focused on scalar effects, that is, comparing regional per capita income disparities across different scales: region, state, economic area, and county. The motive of this disaggregation of scales is to highlight the spatial disparities among different scales during the same period, going beyond the beta and sigma convergence analysis. About the different approaches to study regional inequality, Yamamoto cites Martin (1999):

> despite the rising awareness over the importance of scales in economic geography, there has been little or no discussion of whether there is an appropriate regional scale at which to analyze convergence, nor analyses that seek to determine whether different trends in regional convergence may be occurring at different spatial scales (Yamamoto, 2008: 82, from Martin, 1999).

The main two ways to analyze spatial phenomenon at multiple scales used by Yamamoto are a systematic repeat of one method in every scale (for example, inequality indexes at all scales) and the second one is to specifically design methods for each scale (such as scale variations, semi-variances and inequality decomposition techniques). The data used for this research is the regional average per capita income, obtained from the U.S. Bureau of Economic Analysis, covering 48 states and counties within those states. Nevertheless, Yamamoto makes a note similar to the one made by Yin, L. (2003), regarding the problem of different prices and inflation per region:

> The issue of differential inflation rates and purchasing powers across regions presents a major challenge in regional convergence studies. Price levels and their rates of change clearly differ across space even within a country (…) Yet, unlike national income data, for which purchasing power parity (PPP) data are increasingly being facilitated, we do not have reliable and comprehensive regional PPP data at state or sub-state scales in the USA, forcing me to resort to unadjusted regional income data (Yamamoto, 2008: 90).

Considering the case of the convergence analysis of the manufacturing industry in the northern border of Mexico and southern border of the United States, this remarks our interest, as our research deals with similar problems: since there is not a purchasing power parity data available for this specific region, the Implicit Price Deflators for Gross Domestic Product was used, from the Bureau of Economic Analysis, for states of both regions to homogenize prices, as it will be described in section 4.

Since the most common form of reginal income disparities is at a state level, Yamamoto firstly points out three aspects at this scale, measured by the coefficient variation (CV), Gini index, Theil index, the mean logarithm deviation (MDL) and the variance of the logarithm (Var Log): a clear convergence is attributable before the 1970 decade in the U.S., as well as two periods of divergence during the 1980 and 1990 decades; there was a high mobility of income and spatial correlation levels per state during the 1980 and low in the 1990, which means that income levels varied among states more during the former decade than the later.

According to Yamamoto's results using the repetition of a single-scale method, "there has been a downward shift in scale at which spatial income inequality is pronounced ('downscaling' of spatial inequality) in the past few decades (…) increased inequality at the county scale has been driven by a small number of super-rich counties" (Yamamoto, 2008: 91). Which means and remarks an interesting point: inequality in the US is higher as the scale of measurement becomes smaller; there has been, from 1955 to 2003, mayor inequality by county that by states, region or a higher scale. Also, the relative position of relative income levels has become more rigid from 1990 onward; neighboring counties per capita income differences are becoming higher (indicating a lower spatial correlation in income terms) and qualitative differences in the divergence periods of the 1980 and 1990 decades.

Following the repetition of a single scale-method, Yamamoto (2008) plots the coefficient variation (CV) and Theil indices to see the tendency in spatial income inequality for all different scales from 1955 to 2008. He describes that the difference between the two indices is insignificant, and how, besides the overall tendency for all scales has been negative, the real difference is set by scale. The county level is the one with higher inequality indices in the complete period, with surges in the mid-1970 and the beginning of the millennium; both economic area and state levels have almost the same tendency at the same numbers, and the region level is the one with the lesser degree of inequality in the U.S. The most important conclusion from this graph is that divergence seems to be broader at larger scales during the 1980's surge, while, from the 1990's onward, it seems to be broader in smaller scales (state or county). This is a manifestation of the growth of income inequality: since more income is concentrated in fewer hands in the U.S., the spatial income divergence has widened at smaller scales. Which also reflects in the distribution of income: at the state level there is higher distribution of per capita income in all the periods, so there is less polarization (inequality). On the other hand, the county level is the ones with lower distribution. Finally, about the spatial autocorrelation, even though the county scale maintains the higher level since 1970, it is from 1980 that the region scale has an immense surge that will standardize until the mi 1990's.

On the scalar effects measure by the different methodologies (that is, by scale variances), Yamamoto constructed “quasi-regional boundaries” by aggregating economic areas to the boundaries of state or county with a higher portion of the economic area at issue. Then he plots the scale variance based on per capita income by county, economic area, quasi-state and quasi-region: as in the case of a single-scale method, the largest income variation occurs at the smallest scale (county), with two peaks, each in mid-1970’s and in the first years of the millennium; the region scale shows a decline from 1970 to 1985, then a surge and decline in 1990.

Yamamoto concludes stating that the episodes of divergences since 1970 are not only caused by technological change, globalization, and the higher assets of capital in urban areas. Also, these possible causes do not explain the growing income spatial disparity at a county level. He counterargues saying that “the information technology bubble of the 1990’s had a major effect on the spatial distribution of the income in the USA” (Yamamoto, 2008: 99); regional inequality peaks in 1988, after de stock market crash of the year before. Looking to the divergence periods from a geographical view, Yamamoto continues,

> during the 1980s, real estate investment played a major role in the creation of the financial bubble, and one of its major destinations was the northeast region (…) Unlike the 1980s situation, the financial bubble in the late 1990s involved speculative investment in a wide range of internet-based, ‘dot-com’ businesses (Yamamoto, 2008: 99).

That is to say, during the divergence episode in the 1980’s in the U.S., there was a spatial concentration of regional income; instead, in the 1990’s, there was a surge in the polarization of income, making the county variation higher than any other scale.

1.4.2. Europe

Yin, L., et al. (2003), from a set of the 15 countries (Belgium, Denmark, Germany, Greece, Spain, France. Ireland, Italy, Luxembourg, Netherlands, Austria, Portugal, Finland, Sweden, and UK), then all the current European Union members (as of 2003), made a sigma and beta convergence analysis from 1960 to 1995 using real per capita GDP, average nominal investment to nominal GPD radio, average population growth rate, average inflation rate and average nominal government expenditures to nominal GDP ratio. They also used three political variables: average number of annual cabinet changes, average number of riots per year for the period and literacy rate. All nominal variables were converted from 1990 current national currency to 1990 US dollars using the Purchasing Power Parity (PPP). A final consideration is that not all countries in this study were part of the E.U. from 1960 to 1995, but most of them signed treaties to gradual liberalization and free trade.

Yin, L., et al. found that the cross-sectional standard deviation of the real per capital GDP for the European Union during the 1960-1980 period have declined, even considering the integration of other countries, but rose in all subgroups from 1980 to 1985; this is derived from the slow growth rates during this five-year period in all Europe. Then, sigma convergence declined again during the next five years. However, the original six members sigma convergence increased from 1990 to 1995.

In the case of absolute and conditional convergence, Yin, L., et al. first present a graph with the EU-15 countries, with the 1960-1990 annual growth rate measure in percentage in the *y* axis, and the logarithm of the 1960 per capita GPD in the *x* axis; there is a negative relation, which indicates that the countries with low initial GPD have caught-up with the ones with higher initial levels of GDP. Next, using the neoclassical model, they made a regression for the real per capital GDP growth across all the EU15 set of countries, but in four different variants of the model: a basic equation, which does not consider economic, Dummy and political variables; an equation with other economic variables; an equation with dummy and economic variables; and finally, an equation with dummy, economic, socio-political and policy variables. Only the first model, the basic equation, is the one that reflects *absolute convergence*, because of the lack of variables not considered. They conclude that convergence has been achieved in both absolute and conditional cases, both in five and ten years period models, for the EU15 set.

Finally, Yin et al. compared the catching-up hypothesis among different regions in the world by the measure of the coefficient of variation (CV) of real per capita GDP of Africa, America, Asia, Europe, Oceania, the APEC countries, the European Union and the World, from 1960 to 1995. Since a decline in the CV indicates convergence, the EU15 is the entity who has achieved a deeper convergence, compared to the other continents, followed by Europe. This evidences how giving more priority to coordinated economic policies than to national policies can diminish income and production inequality over a region.

1.4.3. Spain

Martínez-Galarraga and Tirado (2015) researched the evolution of regional inequality in Spain for the long run, from 1860 to 2008, making a regional convergence research with-in a European country. They collected data from different sources, such as BBVA and previous research, but only from 1930 onward; in the period before, 1860-1930, data was estimated, particularly for the years 1860, 1900, 1910, 1920 and 1930, using Spanish output per worker and sector, working population, and nominal wages by sector and region from the Rural History Study Group, the Spanish Statistical Yearbook, and previous research. To do these estimates, they depart from “the principle that the sum of all regions’ GDPs (in the case provinces, Nomenclature of Territorial Units for Stadistics-3) is equal to the country’s GDP” (Martínez-Galarraga and Tirado, 2015: 507), following the methodology of Geary and Stark (2002). The data was created by each of the seventeen regions of Spain, separated by agriculture, mining, manufacturing, construction, and services to study the with-in and between sector convergence.

When plotting the σ convergence for the long-term GDP per capita, GDP per worker and the economic activity rates, Martínez-Galarraga and Tirado (2015) general results show an inverter “U” tendency, which means that regional convergence has been achieved from 1860 to 2008 in Spain. Between 1860 and 1900, there was a period of growth in inequality, followed by its decline until 1980, speaking of GDP per capita; GDP per worker declined until 1990. After that, sigma levels have standardized, even considering the Spanish integration with the European Union.

Considering the disaggregation of the Theil index into two components, *within-sector* and *between-sector* inequality (the former is comparing inequality in the same sector among different regions, while the latter is comparing different sectors among the regions), during the whole period, the inequality has been greater in the *between-sector* component, but, in the last two decades, the *within-sector* and *between-sector* gap has narrowed. This points out that sectors that had less endowments, human capital, and investment, have reached closer levels of economic structure to sectors who have had historically more economic assets. Hence, as the authors show, two hypotheses can be confirmed by the performance of income inequality in Spain: the structural differences across regions are caused by the process of regional industrial concentration during the XIX century, and convergence in sectors lead to convergence in regions.

One argument from Martínez-Galarraga and Tirado (2015) that is of our particular interest is the consideration that regional convergence reaches a limit when sectoral structures reach convergence, but not productivity levels by regions:

> the process of convergence in regional sectoral structures was the major determinant of convergence in productivity and per capita income in Spain during the years 1960–1985 (…) the end of the regional convergence process in the last years of the twentieth century is related to the exhaustion of the process of convergence in regional sectoral structures and the persistence of significant differences in sectoral productivity levels across regions (Martínez-Galarraga and Tirado, 2015: 510).

Which opens the question, will this be the case for the manufacturing industry in the northern states of Mexico and the southern states of the United States, since northern manufacturing industry of Mexico has been trying to catch up with the southern U.S. sectoral structures, even though both regions keep different productivity levels?

Martínez-Galarraga and Tirado conclude that the empirical evidence of the long-term income inequality behavior in Spain happens to fit in both Neoclassical Growth and Trade, and New Economic Geography (NEG) theory explanations. First, "the advance in the process of national market integration could have favored the reduction of regional income inequality in the long-term" (Martínez-Galarraga and Tirado, 2015: 514) through the mobility of factors and technology. That was the case, for example, of the Basque Country and Cataluña, who have had an increase in productivity and wages due to mobility of assets to their regions. On the other hand, following the NEG theory, even though the increase of economic integration in Spain, both in a regional and international level, the *within-industry* differences have gain weight in the last decades. So, despite the movement of assets, economic integration and lower transport and transaction costs, which made a decline of inequality until the 1980's, the productivity differences per region maintain stagnant levels of convergence.

1.4.4. France

Another research of regional convergence in Europe is Combes, P. P, et. al (2011), about the long-run spatial economic inequality among the French departments. Using a database that includes value-added, employment and population, they analyzed spatial inequality for the agriculture, manufacturing, and services sector for the years 1860, 1930 and 2000, considering these benchmark years to compare France disparities within and between regions over time for all 88 departments. The eighty-eight departments and three industries in three years sum up to 792 observations. The data was collected from Agricultural and Manufacturing surveys, population censuses, fiscal surveys, Toutain (1997) previous research, and the National Institute of Statistical and Economic Studies (INEE) of France. All monetary figured were deflated by annual price index of 2000 published by the INEE.

Combes, P. P, et. al (2011) sympathize with the New Economic Geography theory, considering how diminishing transportation costs translate into technological and economic development. They agree with how agglomeration economies are first developed by the cluster of firms attracted to a place by its larger markets and labor force, making it more attractive to other firms, but, eventually, this agglomeration leads to higher costs of rent, congestion and wage rents, making the place less attractive to firms of the same industry and workers, which makes them leave to other regions or the periphery. The authors name this tendency a "bell-shaped" curve in spatial concentration, which can be seen in France during the period of study.

Using the Theil Index and an economic model with the logarithm of the variables, within and between regions, the results on spatial aggregate dynamics show how the spatial concentration has a "bell-shaped" curve for the manufacturing and the service sectors over the long-run, but not for services, where 1930 is the highest point of the curve, and 1860 and 2000 are the further points. Also, regional inequality has stayed the same since the 1930's; inequality in the departments (states) of each region has increased, even though labor productivity has converged among departments in the long-run: "alongside an increase in the spatial concentration of the population and production is a decrease in labor productivity inequality across departments" (Combes, P. P, et. al, 2011: 9).

Contradictory to the New Economic Geography theory, even though there were high costs of transportation between 1860 and 1930, firms reached large markets to increase their profitability. Years later, with transport costs reduced, openness to international trade and growth of high skilled activities, human capital took a major role in spatial distribution of productivity in France:

> More precisely, skilled workers and skill-intensive firms tend to cluster in order to benefit from technological or informational spillovers, and from a better match between jobs and workers. During the 1860-1930 period, human capital did make positive contributions to the average level of productivity, but without playing a significant role in the emergence of inter-regional disparities (…) In contrast, human capital has played a significant role in structuring France's economic space more recently. This is especially true of higher education. Indeed, the metropolitization of the economy involves the clustering of high value-added activities in large urban agglomerations. (Combes, P. P, et. al, 2011: 3-4)

Following other remarks, the Theil Index on population shows a spatial concentration increased in a few departments during the whole period of study, making an impact on employment's Theil Index, which is even more pronounced through time. On the other hand, even though value-added's Theil Index is greater through time than the population's or employment's, its growth is less rapid than in these last variables. Inequality in distribution of both employment and value-added kept growing within regions in France, especially in the last decades: "during the 1930-2000 sub-period, while spatial inequality between regions became stable, it kept growing within regions. Consequently, spatial inequality in France occurs mostly within rather than between regions" (Combes, P. P, et. al, 2011: 9). The concentration of wealth decreased in the value-added per capita from 1860 to 1930, going from north to center of the country, and maintained the same levels in the following years. On the other hand, spatial distribution of value-added in manufacturing decreased, distributing from northern departments to ones in the center, which means that inequality in this sector got higher.

And, particularly speaking of employment, "it turns out that the French work force exhibits a greater rise in concentration than the value-added, especially between 1860 and 1930" (Combes, P. P, et. al, 2011: 10). Which means, less spatial inequality of labor productivity is not in function of the dispersion of economic activity in France; there could be economic activity dispersion and still spatial inequality of labor productivity could remain.

Now, about the spatial dynamic of sectors, Combes, P. P, et. al (2011) describe a historic process of rural to urban transition in France, which was stressed in some regions more than others. In this case, the Theil Index "measures the gap between the observed and the uniform distributions of a given sector" (Combes, P. P, et. al, 2011: 12). In the agricultural sector, even though the spatial distribution of employment kept almost the same though 140 years, the spatial distribution of value-added doubled from 1930 to 2000. This may be because some regions acquired more technology than others or the transport costs inter and intra regions diminished. This proves that even if a sector is not spatially concentrated in terms of one variable (in this case, employment), its valued added can be.

In manufacturing, “while a considerable increase in concentration characterizes the first sub-period, this trend is reversed and fully undone during the second sub-period, the level of dispersion in 2000 exceeding the 1860 level” (Combes, P. P, et. al, 2011: 13). For last, in the service sector, there is an increase in the spatial concentration (that is, a decrease in spatial distribution) of employment and value added. This may be because of how the service sector is less spatial intensive and because few cities concentrate most of the tourism in the country.

1.4.5. Latin America

Rodríguez, D., Perrotini, I., and Mendoza, M. (2014) studied the long run economic growth and convergence of Latin America with two leading economies: the United Stated and the whole subcontinent average GDP, from 1950 to 2010; this in accordance with the hypothesis of absolute and conditional convergence in per capita GDP. Their methodology was based on Manddala and Wu (1999), and Pesaran (2007), through first and second-generation cointegration and unit root panel tests for the whole period. About the data, the authors do not specify their sources or the homogeneity process of currencies and prices, if necessary.

The results show that the convergence process of Latin America with the United States and the region’s average did not happen during the whole period and the first sub-period, (1951-1990):

> Manddala and Wu (1999) and Pesaran (2007) tests carried out with and without trend show that for the total sample and the first subperiod it is not possible to reject the unit root null hypothesis for any case in the panel considered when GDP per capita of the USA is assumed as leading economy (…) Both tests applied to the restricted version of the test taking average gdp per capita of the region as leading economy, provide a similar result for both the total sample and for the first subperiod given that it is not possible to reject the unit root null hypothesis of this variable for any case in the panel (Rodríguez, D., Perrotini, I., and Mendoza, M., 2014: 278, 280).

However, Latin America did converge with both the US and the region’s average during the second sub-period, 1990-2010, corresponding to the liberalization and economic openness span. And, according to the cointegration test, Economic integration has been achieved in Latin America countries from 1990 to

2010. However, the authors stress, there cannot be a conclusive statement about absolute convergence of Latin America when the US is considered lead economy during the second sub-period with the econometric methodology employed in their research.

1.4.6. Chile

Duncan and Fuentes (2006) question the existence of convergence in GDP and income for the thirteen regions of Chile in a time frame of 40 years, from 1960 to 2000. Their methodology consists of cross-sectional and panel data tests, and unit root test developed for panel data, using as sources the Central Bank, National Institute of Statistics and CASEN survey of Chile.

The cross-sectional test for the reginal GDP showed a negative relation between the initial GPD per capita and the growth rates from 1960 to 2000, with a negative coefficient of regression and a half-life gap of 96.8 year for catching up. Applying the unit root test of Levin, Lee and Chu (2002), Breitung (2000), Fisher - ADF by Manddala and Wu (1999), and Choi (2001) for regional GDP, in both five- and ten-year panel, only the Fisher ADF presents a p-value greater than 0.05. This implies that, since three of the four tests gave significant results, there was sufficient evidence to confirm absolute convergence. On the contrary, the cross-sectional test for income does not show evidence for convergence among the Chilean regions.

For the beta conditional convergence test they incorporated fixed effects for each region and explanatory variables, such as mining and education, to capture their effect on convergence. The results show the existence of conditional convergence in GDP, and that regions rich in natural resources converge differently from others:

> Years of education of the labor force and the share of other sectors on total GDP were not statistically significant for explaining growth. This means that regions that are abundant in mineral resources will converge to a different steady state from the rest (Duncan, R., and Fuentes, R., 2006: 97).

With this, the authors emphasize how important it is to considerer the assumption in convergence theory that all economies have the same production function, as so, all economies tend to the same steady state. However, the Chilean case proves the contrary in a regional level: different natural assets will lead to different steady states, contradicting the main hypothesis of convergence.

On sigma convergence in Chilean regions, constructed by the variance of the logarithm of the GDP per capita over time, it decreases over time, which accomplish the idea of σ convergence type. On the other hand, sigma convergence in regional income does not have significant changes from 1987 to 2000. So, over the long run, there is no sufficient evidence to affirm there has been sigma convergence in the regions of Chile. This is the same conclusion of Badia-Miró (2015), as noted bellow.

Badia-Miró (2015) focused, unlike Duncan and Fuentes (2006), on local economic activity in the long-run and the drivers of spatial distribution by region, particularly of mining and nitrates production, from 1890 to 2000. He collected national data from Díaz, et al. (2007), official sources from the Chile's government, and of his own elaboration and estimation, using the methodology proposed by Geary and Stark (2002).

Through a sigma convergence and Theil Index analysis, the author describes that sigma convergence is achieved due to a tendency of lower income dispersion among region in the long-run. He affirms that the main reason of lower income dispersion though the XX century in Chile is the change of focus on natural endowments exploited in different regions: from 1890 to the end of World War I, it was the nitrates, concentrated in a few regions; then, a copper cycle began, which was exploited through a more spatially diverse mining sector until 1990. So, considering that the natural endowments made possible the growth of investment and capital assets in diverse regions, reducing spatial inequality, it is possible to affirm that the Neoclassical Growth Theory hypothesis applies to the Chilean economy, contradicting the New Economic Geography, because the main source of economic growth was the placement of capital on location with natural resources and not the effect of agglomeration economies.

Then, Badia-Miro (2015) plotted the density functions for the GDP per capita of the Chilean provinces by year —1890, 1910, 1930 and 1970— using the methodology proposed by Quah (1997). The contrast of the different density functions through time evidences the decline of spatial inequality between the provinces, showing how the peak of the 1890's distribution is the highest (2.0), gradually reducing to the 1970 levels (1.0). As the drivers behind this spatial configuration, the author explains that

> both the copper and the nitrate cycle boosted the economic growth of other regions, due to the demand for non-durable consumer goods in the leading regions. What differentiates the two is the magnitude of this impact. Whereas nitrate mining was labor intensive (and therefore boosted consumption which was largely not satisfied by local production) the copper cycles were far more capital-intensive (…) In parallel, migratory movements went in the opposite direction and tended to reduce the difference between levels of per capita GDP since people abandoned the poor regions (increasing their per capita GDP) towards the rich regions (decreasing those levels of per capita GDP) (Badia-Miró, M., 2015: 8).

One different approach to analyze the spatial behavior of mining provinces and non-mining provinces is through polarization in income inequality, employing the methodology proposed by Zhang, X. and R. Kanbur (2001). By the division of Theil Index within regions by the Theil Index between regions, it is possible to measure the *degree of polarization* in a particular region or sector, as Badia-Miró did. The results show that polarization is not related with having or not a mining sector, but rather the presence of dynamic sectors; that is, sectors with modern economic structure and higher productivity, as the nitrate and cooper in contrast with the coal provinces.

Finally, the author uses the Hirschman-Herfindal Index (H-H Index), which measures the market special concentration, a referent of spatial inequality, from 1895 to 2000. Until the 1920's, the H-H Index kept stagnant since the nitrate and cooper cycles maintained the growth of several provinces. After that year, with the application of the Import Substitution Industrialization (ISI) model, the protectionism policies propelled the spatial inequality, and so the H-H Index, due to the stress in sector such as manufacturing: "these policies, which on most of the cases relied on the impulse of manufacturing production, did not generate enough sustained linkages towards the rest of the regional economy" (Badia-Miró, M., 2015: 14). It was until 1973, with the imposition of an open market economic model, that the process of deindustrialization began, leading a way for regions with natural endowments reached a recovery focused on the export of natural and semi-manufactured goods.

1.4.7. Mexico

Normand, A., and Quintana, L. (2010) researched about the convergence hypothesis for the thirty-two states of Mexico, from 1970 to 2008, considering the GDP per capita per state, to identify the formation of convergence or divergence clubs within the Mexico states, based on a spatial cross-regression model. First, plotting the variance of the logarithm of the GPD per capita of the Mexican states in the y-axis, and time in the x-axis, they described the sigma convergence as a "U" shape: a diminishing slope of the curve from the subperiod of 1970 to 1986 meant that convergence was achieved in this period, but an increase in the slope from 1986 and forward indicated a growth in divergence.

The division of the period of study is visualized by two beta convergence graphs of each subperiod: in the first graph, corresponding to the first subperiod, which measures the GDP per capita growth rate from 1970 to 1986 on the y-axis and the logarithm of the GPD per capita in 1970 on the x-axis, there is a negative relation, which indicates the achievement of beta convergence in the states of Mexico; on second graph, corresponding to the second subperiod, which measures the GDP per capita growth rate from 1986 to 2008 on the y-axis and the logarithm of the GDP per capita in 1986 on the x-axis, there is a positive relation, which evidences divergence within the 32 states of Mexico in this subperiod:

> The estimated models for the two subperiods show evidence of how there is absolute convergence in the first period, because of its negative and statistically significant coefficient. Contrary to the second period, where its coefficient, even though is not statistically significant, has a positive sign, indicating the possible existence of an absolute divergence process (Normand, A., and Quintana, L., 2010: 94).

Furthermore, Normand, A., and Quintana, L. (2010) use of Moran's I spatial autocorrelation index, and the visualization of its quadrants in a map to indicate the spatial aggrupation of states with greater to lesser GDP per capita growth in the second subperiod, to make a deeper analysis on why there was divergence and find convergence clubs. The graph's quadrants, in which the both y and x-axis measure the GDP per capita growth rate from 1986 to 2008, show how just a few states are beneficiated from spill-over effects: the northern states and the ones dedicated to tourism, in the Yucatan peninsula. Which is not aleatory, as the authors conclude, because the catch-up hypothesis in the long run does not hold up; regional inequality of the Mexican states has tended to increase. There is only convergence in the period from 1970 to 1986, which corresponds to an era of more State intervention and active industrial policies; as from 1986 to 2008, convergence clubs emerged, principally in the northern states, the center, occidental center, and the peninsular region with the greater growth rate, while the poorer states have the smaller growth rates.

Another more recent and ambitious studies of convergence in Mexico is Aguilar (2016) doctoral dissertation thesis, in which he analyzed the regional income inequality in this country from 1895 to 2010 in different approaches. First, Aguilar estimated the GDP per capita of the benchmark years of the primary exports period (1895-1930), which are 1895, 1900, 1919, 1921 y 1930. He calculated GDP per capita and GPD per worker to use them as indicators of regional income in his research. Once the data was structured, he proceeded to analyze the long run in the Mexican regional disparities for the entire period, 1895 to 2010, through different coefficients, such as Coefficient of Variation and Gini Index, along with Kernel distribution and Moran's I to identify the intensity of capital autocorrelation among Mexican states. Finally, he decomposes convergence into three components to provide new evidence on the causes of regional income inequality in Mexico during the XX century:

> *Within–sector* captures the labor productivity convergence of each sector with the corresponding one in benchmark region, and is a component that is usually associated to neoclassical forces. The *labor reallocation* component measures the share of convergence due to inter-sectoral workforce movements (…), and the

between-sector component measures the contribution to convergence of intersectoral labor productivity convergence (Aguilar, 2016: 29).

Aguilar (2016) results reveal a long disparity between the northern and southern region of Mexico, an “N” shape for of the regional income disparities in the long run, with a focus on each economic model that Mexico has followed since the end of the XIX century. He coincides with the thesis of Normand, A., and Quintana, L. (2010), considering how rank mobility across states has been very low, which means that the poor regions have remained poor (the south) and the rich regions have remained rich (north and center); he remarks, by the Moran’s I statistic spatial correlation results, a persistent cluster of poor states during the entire period, but not a constant cluster for rich regions. About the northern states, he depicts an angular point of view, related to the topic of convergence of the manufacturing industry in the northern border states of Mexico and southern border states of the Unites States: “there has been no significant spatial clustering in the north during the period under study, which confirms that the northern states’ good economic performance has been exclusively associated with its integration with the US market” (Aguilar, 2016: 161).

Regarding the decomposition of convergence in three components, Aguilar (2016) exposes how the causes of achieving or not convergence have differed according to the historic period:

> During the agro-export led-growth period (1895-1930), Mexico experienced a strong phase of regional divergence. This was replaced by substantial convergence during the ISI period. Finally, a new period of regional divergence started in the 1980s, coinciding with the beginning of trade reforms. During the primary-export-led growth period (1900-1930), divergence was associated with a spatially uneven process of structural change, and especially with the differential impact of labour-reallocation. Later on, during the State-led industrialization period (1930-1980), both the within-sector and between-sector components (largely linked to intense domestic migration) contributed to regional labour productivity convergence. Lastly, from the mid-1980s onwards, regional divergence was mainly the result of neoclassical forces (the within-sector component) (Aguilar, 2016: 28-30).

He finishes remarking how the evidence portraited in his research supports the idea that no theoretical foundation can be taken as a general explanation for regional income inequality, especially in the long run. Another acknowledgment is the necessity of studies of earlier periods (previous 1870) and the collection or estimation of more data; the study of economic openness, market potential, human capital, and institutions on their relationship with income inequality; and the consideration of other variants, besides the ones used by him (GPD per capita and GDP per worker) for future research.

1.5. Public policy and convergence

Sachs and Warner (1995) enlist three different explanations about the absence of convergence in most countries in the world: the first, the absence of returns to scale (that is, the increasing of production due to the accumulation technological knowledge, or due to spillovers of knowledge in near areas) in poor countries, but tends to make industrialized countries richer; the second one, convergence only happens in a small group of countries with a solid and prepared amount of human capital; the last one, poor countries tend to have a low long run growth. Convergence has been achieved in the *convergence club* by public policy, rather than initial levels of human capital. For poor countries, convergence with rich ones happens when those follow market-based economic policies:

> all developing countries that have satisfied certain unexceptionable conditions on economic policy have experienced positive economic growth during the decades of the 1970s and 1980s, and in almost all cases these countries have shown a tendency to grow more rapidly than the developed economies, and thereby to converge (Sachs and Warner, 1995: 6)

According to the authors, the proper foundations that an economy should follow up to generate convergence growth are two: property rights and integration of the economy in international trade. In their research, from a universe of 120 countries, they separated the ones that appeal to these market-based policies (qualify countries) from those who didn't (unqualify countries), between 1970 and 1989, to analyze if there was any convergence during that period in each set and in the total. The result was that every country with policies based in these criteria had a per capital growth rate of 2 percent and annual per capita income of $4000 dollars (from 1970), while the countries with closed economies did have a growth rate of less than 2 percent.

Nevertheless, between the few exceptions, there was one that highlighted among the others: China. The authors believe that the oriental country had a per capita growth rate of 3 per cent during the study period because of the economic reforms established during the last years of the 1970 decade.

Delgado and De Lucas (2018), in a more recent paper, researched about the effects of economic policies on convergence among the European Union 15 (EU-15) members and its speed of achievement, from 1980 to 2010. Collecting data of employment, population, GDP and gross investment (these last two expressed in Parity Purchasing Power international US dollars from 2000, using information from Eurostat), they made a regression of the GDP growth in the long-run against initial GDP levels and a set of explanatory variables in a cross section of countries, as it is the most common measure of convergence. The estimation of convergence equation was carried out using a panel data for the region and period mentioned.

In general, the results show a negative relation in the regression of the initial GPD per worker and growth per worker for the EU-15 during the sample period. Particularly, the results focus on the speed of convergence accomplished by increasing rate of investment in infrastructure and education. A higher expenditure on infrastructure does contribute to a higher speed of convergence among nations. Public investment does lead to convergence, but it hits a point in which speed of convergence slows even if public investment keeps growing, “and the resultant speed of convergence could have been achieved also with lower investment rates” (Delgado and De Lucas, 2018: 38). Looking at the EU-15 speed of convergence in response to increases in the public investment rate of infrastructure in the European economies separately, the authors affirm that there is no significant response in the rate of convergence given a growth in the rate of public investment in infrastructure.

About the rates of expenditure in education, the authors stressed how greater investments in this branch allow higher rates in convergence, but only if it’s through a common continental policy rather than separately. Independent measures of each member to increase education quality does not lead to convergence in the EU-15 because it does not necessarily mean that other countries will apply similar expenditure rates in education. For example, “in the case of Netherlands and Luxembourg, results show that if these countries increase their rate of expenditure in education, the speed of convergence in the EU decreases” (Delgado and De Lucas, 2018: 39). A coordinated program within all member is more probable to lead to convergence among all.

In conclusion, Delgado and De Lucas support the idea that public investment in education and infrastructure is sufficient to counter the market forces that lead to divergence, only though the coordination and cohesion of policies between the member states.

1.6. Conclusions of the section

The types of convergence are beta (β) and sigma (σ): the former occurs when the there is a negative relation when regressing the GDP per capita growth rate and the initial level of GDP per capita of a set of countries or regions in period, and the later, based on the cross-sectional standard deviation of the real per capita GDPs among a group of countries or regions, happens when the dispersion of per capita income or output, measured as its variance, decreases over time. And, as proved by Barro and Sala-i-Martin (1995), the existence of beta convergence is a necessary but not a sufficient condition for the presence of sigma convergence, and so it is not possible to observe sigma convergence without beta convergence. They also introduced the idea of *conditional convergence*, considering fixed variables in the neoclassical growth model; on the other hand, when all parameters in the model are variable, and there is a negative relation between the per capita income level at time zero and the growth rate of per capita income in the subsequent period, then there is *absolute convergence*.

Baumol (1985), on the first approaches of convergence, remarks the existence of a *convergence club* among industrialized countries, particularly the OCED members; he affirmed that the spillover effect from an economic leader to another was a main cause of convergence among industrialized countries, and concluded that effective growth policy does contribute to a nation's living standards and can help other developed nations too. Nevertheless, he lacks the importance of closeness or space in his analysis. Baumol finished asking the question that would be one of the main Abramovitz points: why would a follower country take and active industrial policy to engage growth when they can expect to be a "free rider" and wait for spillover effects of leader country? Abramovitz (1986) critics the convergence hypothesis to be self-limiting because, as the follower's growth rate closes to the one of the leader, the potential growth of the former tends to weaken in the long term. This potentiality depends on three issues: the facilities of the diffusion of knowledge; conditions facilitating the structural change in the composition of output and distributions of the workforce, and its relation to geographical location of the industry (this last point answers the question asked before, about the importance of space in the catching-up hypothesis); and macroeconomic and monetary economic conditions sustaining the level of growth of effective demand. He supports the need of countries to invest in educational and institutional characteristics to use technological advances to their advantage for growth and convergence, avoiding being a "free rider".

The research reviewed in this section embrace different scales and methodologies applied in different experiences across nations and regions. Barro and Sala-i-Martin (1991) and Yamamoto (2008) results show how the convergence hypothesis holds up for the US states, even though the former used the Neoclassical Economic Model framework and the later scalar effects. Yamamoto stresses the growth in divergence at county level since the 1980's in the United States, derived from financial and technological bubbles, which means that inequality has raised in the US at smaller scales.

In Europe, the experiences in a continental, national and regional level vary. Yin, L., et al. (2003) found that the cross-sectional standard deviation of the real per capital GDP for the European Union during the 1960-1980 period have declined, even considering the integration of other countries, but rose in all subgroups from

1980 to 1985. They conclude that convergence has been achieved in both absolute and conditional cases, both in in five- and ten-years period models, for the EU15 set. Inside some European countries, Martínez-Galarraga and Tirado (2015) main conclusions on Spain regional inequality on the long-run were that the structural differences across regions are caused by the process of regional industrial concentration during the XIX century, and convergence in sectors lead to convergence in regions. In France, Combes, P. P, et. al (2011) spatial aggregate dynamics results show how a "bell-shaped" curve for the manufacturing and the service sectors over the long-run, but not for services, and the concentration of wealth decreased in the value-added per capita from 1860 to 1930, going from north to center of the country, and maintained the same levels in the following years. On the income and production disparities among nations and within regions in Europe, Delgado and De Lucas (2018) support the idea that public investment in education and infrastructure is sufficient to counter the market forces that lead to divergence, only though the coordination and cohesion of policies between the member states.

In Latin America, Rodríguez, D., Perrotini, I., and Mendoza, M. (2014) results proved that the convergence process of Latin America with the United States and the region's average did not happen during the whole period (1951-2010) and the first sub-period, (1951-1990), but did converge with both the US and the subcontinent's average during the second sub-period, 1990-2010, corresponding to the liberalization and economic openness span. The process of liberalization, at least in these last subperiod, has made possible for the subcontinent to reduce the GDP disparities with the US.

However, Chile and Mexico reveal the growth in inequality at smaller scales. Duncan and Fuentes (2006) emphasize how important it is to considerer the assumption in convergence theory that all economies have the same production function, as so, all economies tend to the same steady state, but the Chilean case proves the contrary in a regional level: different natural assets will lead to different steady states, contradicting the main hypothesis of convergence. And Badia-Miro (2015) describes that sigma convergence is achieved due to a tendency of lower income dispersion among Chilean's region in the long-run, because of the change of focus on natural endowments exploited in different regions and the liberalization of the economy since 1973.

In Mexico, Normand, A., and Quintana, L. (2010) affirm that the catch-up hypothesis in the long run does not hold up. There is only convergence in the period from 1970 to 1986; as from 1986 to 2008, convergence clubs emerged, principally in the northern states, the center, occidental center, and the peninsular region with the greater growth rate, while the poorer states have the smaller growth rates. Result that does not differ from Aguilar (2016), since a long disparity between the northern and southern region of Mexico, an "N" shape for the regional income disparities in the long run, with a focus on each economic model that Mexico has followed since the end of the XIX century.

As final remark in this section, the different convergence experiences show these particular characteristics: there are different methodologies to study convergence, being the most common the neoclassical growth model, cross-sectional standard variation, coefficient of variation, Theil Index, but also scalar effects. Both the Neoclassical Growth Theory and the New Economic Geography can explain the reason behind the convergence phenomenon: the former considering the importance of capital moving to places richer in natural and human resources, and the later though the effects of diminishing costs though the effects of agglomeration economies. Convergence among rich nations is more prone to happen than in underdeveloped nations with rich ones, as comparing the Europe experience with Latin America and the United States.

And, generally, the previous researches show three things: first, as the scale of study is smaller, divergence tend to be greater, since income inequality has risen, particularly in the last forty years; second, most authors recognize the necessity of liberalization of trade, economic integration and coordination on national, regional and government public policies if the goal is to reduce income and output disparities across regions; third, most of the studies developed in regions that englobe different currencies had to use the Purchase Power of Parity or had difficulties homogenizing currencies by selecting a specific method, which is a challenge that our research encourages too.

2. Delimitation and description of the region and industry

2.1. Introduction

Section 2 presents an economic description of the U.S.-Mexico border, along with its states. First, a description of area, GPD, and population in 2021 about the border region is stablished to take into consideration its wealth and size. Then, a short segment defining the concept of *manufacturing industry* according to Mexican and U.S. North American Industry Classification System (NAICS). After that, a description of the current state of the manufacturing industry in both sets of states: the northern border states of Mexico and southern border states of the U.S. border states. Next, an economic overview by states, in which their principal economic activities are enlisted, making an emphasis on the role the manufacturing industry plays on them and the business incentives and fiscal stimulus their governments offer to attract investment. Finally, a comparative analysis of both sets of states and brief conclusions.

2.2. Characteristics of the United States' and Mexico's border region

Before describing the characteristics of each state of the region, it is necessary to describe the region itself. The United States and Mexico share one of the largest borders in the world, with 3,145 km. of length, and has less than two centuries of creation, since it was stablished in 1853 after the final sell of two territories of Arizona and New Mexico from the Mexican to the North American government (Massey, 2016). It is composed by four U.S. states and six Mexican states: California, Arizona, New Mexico and Texas; Baja California, Sonora, Chihuahua, Coahuila de Zaragoza, Nuevo León and Tamaulipas. Together, all these states represent 2,525,084 km^2; that is almost fifth of the US territory and 561,084 km^2 more than the Mexican territory. Both countries share 23 U.S. districts and 39 Mexican municipalities along the border (Wikipedia, 2022).

Figure 1: Vectorial map for the border districts and municipalities along the U.S. and Mexico border

Source: Lesniewski, R. (2020, May 8)

As for demographics, the total population of the northern and southern borders states of Mexico and the United States in 2021 was 101.4 million people; that is one third of the US population and 28 million people less than Mexico's. On production, its GDP in 2021, measured in current dollars, was 7.45 trillion[1] dollars; that's a quarter of the United States' GDP and six times Mexico's, which was 1.27 trillion dollars at the time (World Bank, 2022).

The American and Mexican economy are among the most integrated in the globe. "The United States is Mexico's top trading partner, and Mexico— which has gained macroeconomic stability and expanded its middle class over the last two decades—is the United States' second largest export market and third largest trading partner" (Wilson and Lee, 2013: 60). Nevertheless, the post conditions of the terrorist attacks of September 11th, 2001, not only reinforce the border security, but the scrutiny of passing by and the speed of trade for both people and merchandise.

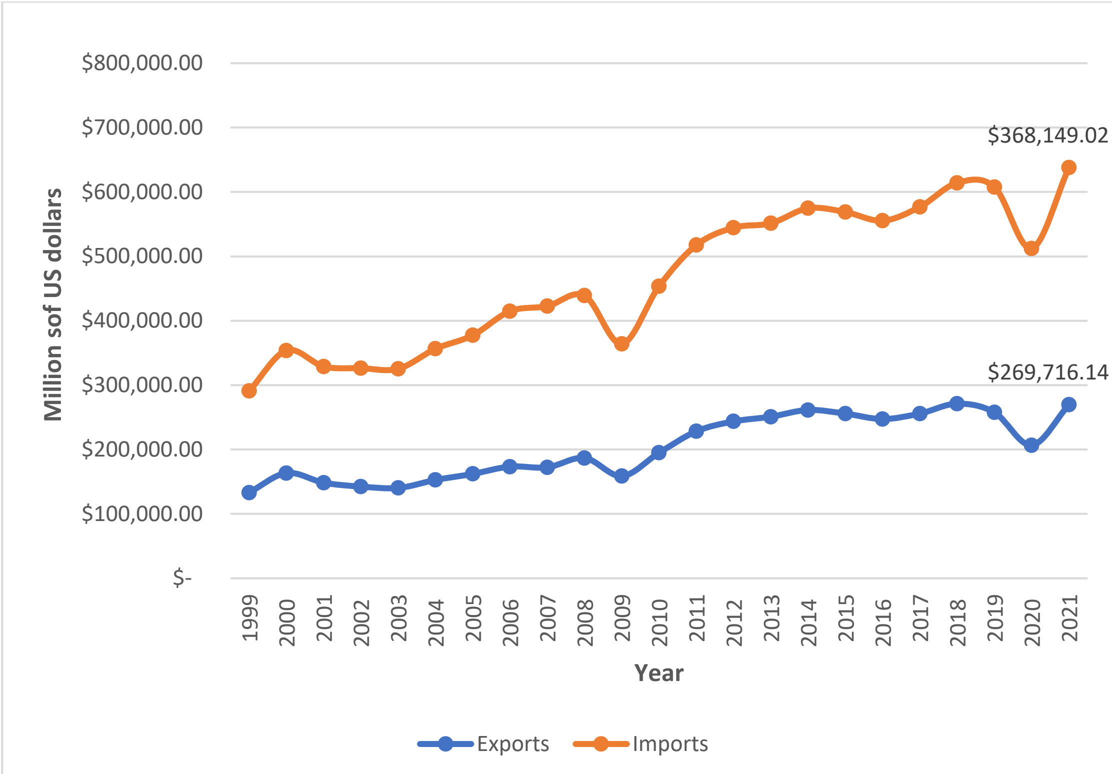
[1] Trillion as in the short scale, where 1 trillion = $1x10^{12}$ = 1,000,000,000,000

Bilateral trades and policies have been arranged through US and Mexico history, especially since the 1994 establishment of the North America Free Trade Agreement (NAFTA), but long efforts are needed to maximize its economic and trade capacity. Quantitatively, the international trade between both nations has grown significantly:

> since the implementation of the North American Free Trade Agreement in 1994, total trade between the two countries has more than quintupled, and goods and services trade is now at a half trillion dollars per year. An estimated six million U.S. jobs and probably even more Mexican jobs depend on bilateral trade (Wilson and Lee, 2013: 62)

The next graph can give proof on the previous statement. On figure 2, in 1999, from values under $200,000 million dollars annually, exports and imports of US with Mexico went up to almost of $369,000 and over $268,000 million dollars in 2021, respectively. The growth on international trade, aside from the shock generated by the 2008-2009 financial crisis and the repercussions of the COVID-19 pandemic, has been constant since the signed of the NAFTA agreement.

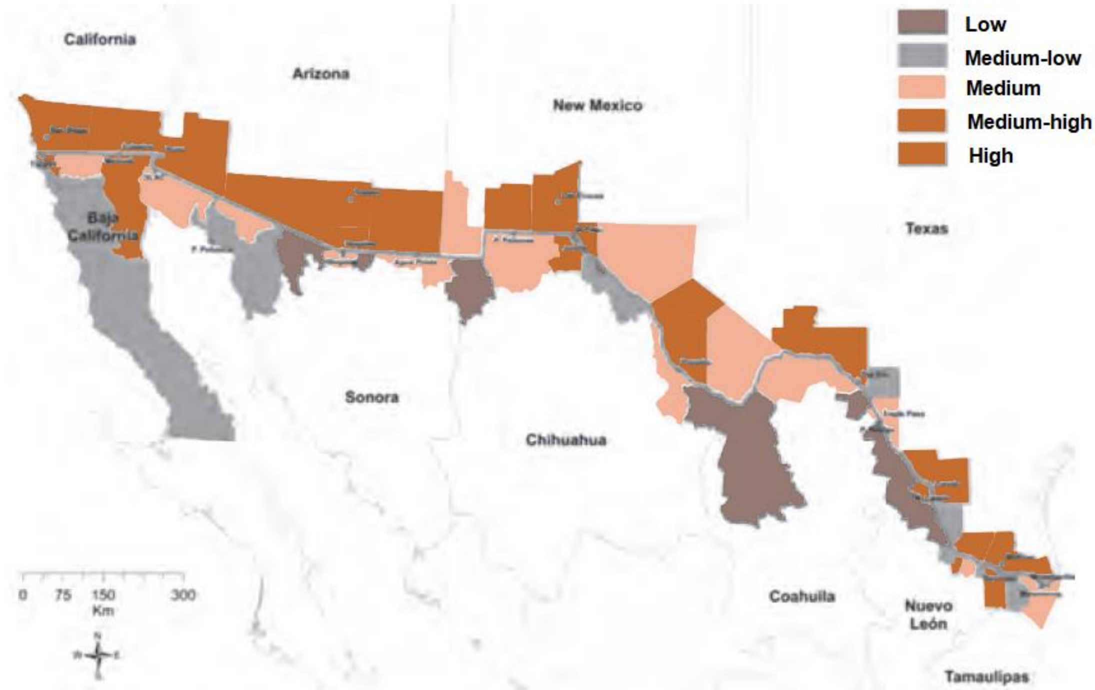
Figure 2: U.S. International Trade in Goods and Services with Mexico: 1999-2021 (real 2012 US dollars)



Own elaboration with data from the U.S. Bureau of Economic Analysis

Despite the usual international analysis of the US-Mexico border, efforts and research on regional, state, district and municipal levels are ought to be made if development on both sides of the border is desired. It's been historically common, as Wilson and Lee (2013) point out, that cities across the border see themselves as competitors, looking for who attracts better businesses; "communities throughout the region are seeking to strengthen their bases of local suppliers so that an ever-greater portion of the value-added processes can take place (and therefore support jobs) locally" (Wilson and Lee, 2013: 83). Nevertheless, as shown in figure 3, most of the high productivity tools and activities, as of 2013, remain in US districts, and Mexico remains with high population districts but few high productivity activities. This makes a clear division on competitiveness.

Figure 3: Composite Transborder Competitiveness Index



Source: Wilson and Lee (2013); Transborder Development Index, El Colegio de la Frontera Norte and Dr. Francisco Lara Valencia in collaboration with the Border Research Partnership

Efforts like the U.S.-Mexico Border Mayors Association and local policies are needed to even the productive and competitive conditions over the border. Only three municipalities in Mexico have a rank of Medio-High to High in the Transborder Competition Index, while seventeen on the same level are found on the US, as seen on Figure 3.

2.3. Definition of manufacturing industry

Since the NAFTA began in 1994, Mexico and the United State homogenized their National Account Systems (NAS), now called North American Industry Classification System (NAICS). This permitted easier ways to compared both economies and trade relationship. And, with equal NAS, they both have very similar definitions of manufacturing industry. The National Institute of Statistics, Geography and Information (INEGI) defines the manufacturing industry as

> a sector that includes economic units dedicated mainly to the mechanical, physical or chemical transformation of materials or substances in order to obtain new products; to the serial assembly of manufactured parts and components; to the mass rebuilding of industrial, commercial, office and other machinery and equipment, and to the finishing of products manufactured by dyeing, heat treating, plating and similar processes. Likewise, the mixture of products to obtain different ones, such as oils, lubricants, plastic resins and fertilizers, is included here (National Institute of Statistics, Geography and Information, 2022).

And, according to the United States Bureau of Economic Analysis, following the North American Industry Classification System (NAICS), this industry is defined as

> The Manufacturing NAICS sector comprises establishments engaged in the mechanical, physical, or chemical transformation of materials, substances, or components into new products. The assembling of component parts of manufactured products is considered manufacturing, except in cases where the activity is appropriately classified in Sector 23, Construction. Establishments in the Manufacturing sector are often described as plants, factories, or mills and characteristically use power-driven machines and materials-handling equipment. However, establishments that transform materials or substances into new products by hand or in the worker's home and those engaged in selling to the general public products made on the same premises from which they are sold, such as bakeries, candy stores, and custom tailors, may also be included in this sector. Manufacturing establishments may process materials or may contract with other establishments to process their materials for them. Both types of establishments are included in manufacturing (Bureau of Economic Analysis, 2022).

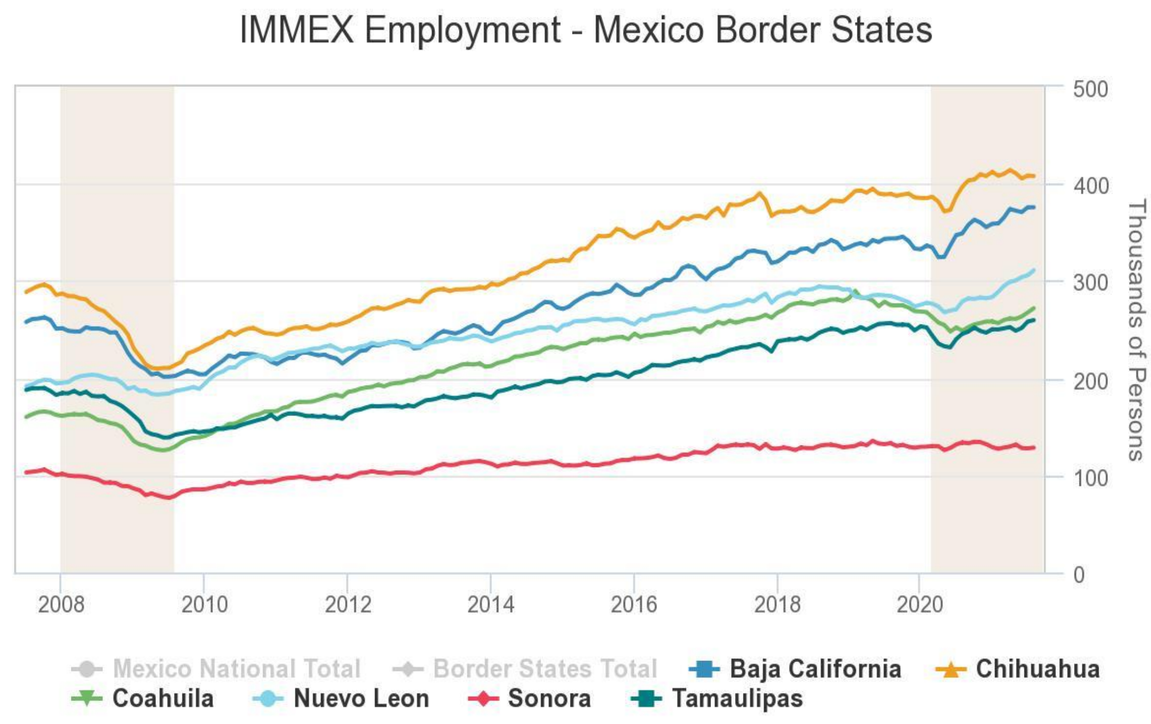
So, since both definitions englobe concept and characteristics such as transformation and assembling of materials and substances through mechanical and chemical processes thorough heavy machinery to build new products (industrial, commercial and other machinery equipment), exempting the construction sector and the transformation of materials in homemade general products, and the two countries share a National Account System, the United States and Mexico's definition of manufacturing industry are almost equal and, therefore, manageable for comparison.

2.4. Manufacturing industry in the U.S. and Mexican border

Since both countries play a different roll on each other's economy, the conditions of the manufacturing industry we'll be described in two sets of states: Mexican States and US states.

As it'll be described in section 4 with more detail, the maquiladora model of production has been one, if not the, backbone of the industrialization of Mexico's northern border states. Most of the maquiladora plants in Mexico remain in the north, despite the foundation and development of plants in center states. The proximity factor to the US border is a key point for maquiladoras to stay in the northern states of Mexico, because of the reduction of costs due to a lesser distance from output and input markets.

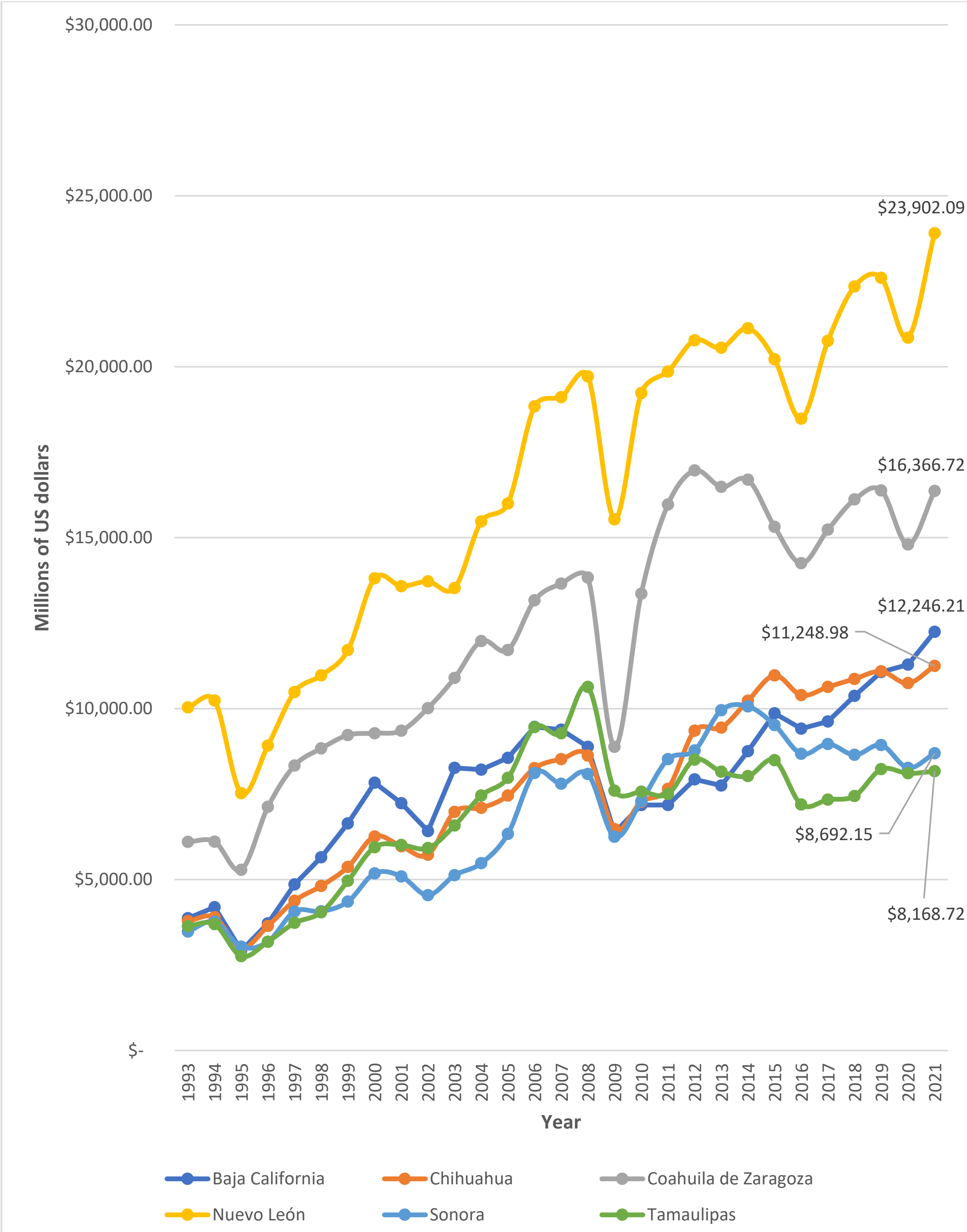
Figure 4: Industria Maquiladora Mexicana (IMMEX) Employment in the northern border states of Mexico: 2007-2021



Source: Arizona-Mexico Economic Indicators, Eller College of Management of the University of Arizona.

Figure 4 shows the IMMEX employment in the northern border states of Mexico. Among the northern border Mexican states, the IMMEX employment during August of 2021, in descending order, was as follows: Chihuahua, with 407 thousand jods; Baja California, with 375 thousand; Nuevo Leon, with 310 thousand: Tamaulipas, with 259 thousand; Coahuila de Zaragoza, with 271 thousand; and Sonora, with 128 thousand. Chihuahua has stayed as the number one state in IMMEX employment for the last fourteen years. Sonora, its west neighbor, on the other hand, has remained on last place, with a poor growth on employment in this branch, even though is consider one of the most important manufacturing states in Mexico.

Figure 5: Manufacturing industry GPD of the northern border states of Mexico: 1993-2021 (real 2012 US dollars)



Own elaboration with data from INEGI and Bureau of Economic Analysis.

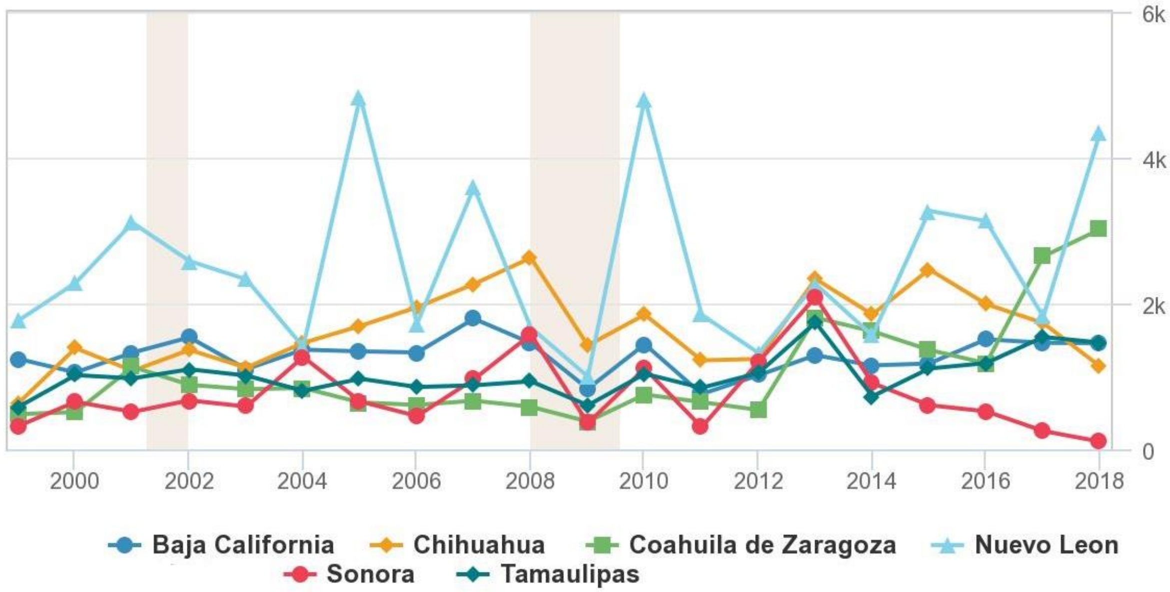
The GPD scenario for the Mexican set of states is different. In figure 5, from 1993 to 2021, Nuevo León and Coahuila de Zaragoza have had the biggest GDP in manufacturing industry among the northern border states, while the rest have remained below these two. In 2021, in descending order, the manufacturing gross domestic product of these states, measure in millions of dollars, was: $23,902.09 in Nuevo León, $16,366.72 in Coahuila de Zaragoza, $12,246.21 in Baja California, $11,248.98 in Chihuahua, $8,692.15 in Sonora and $8,168.72 in Tamaulipas.

In the case of Mexico, the employment and manufacturing GDP of each state are really correlated with the foreign direct investment in the region. As describe by the Eller College of Management's Arizona-Mexico Economic Indicators web site:

> Foreign Direct Investment (FDI) is a key characteristic of international economic integration. The importance of FDI to a host country is that it brings additional capital, creates jobs, encourages transfer of technology and know-how, and contributes to a wider promotion of products on international markets. Benefits to investor countries include access to an expanded labor force, and wider promotion of products in international markets. Mexico ranks among the top developing countries in the attraction of foreign investors seeking to expand into the NAFTA area (Eller College of Management of The University of Arizona, 2022).

According to figure 6, Nuevo León highlights as the top state in FDI on the Mexican set of states, being the one with the highest levels in the last two decades, despite its summits and bottoms. In 2018, the foreign direct investment in millions of dollars in the northern border states of Mexico was, in descending order: $4,343.10 in Nuevo León, $3,016.60 in Coahuila de Zaragoza, $1,463.00 in Tamaulipas, $1,453.5 in Baja California, $1137.20 in Chihuahua and $105.10 in Sonora. Again, Sonora is placed as the Mexican border states with lower measure.

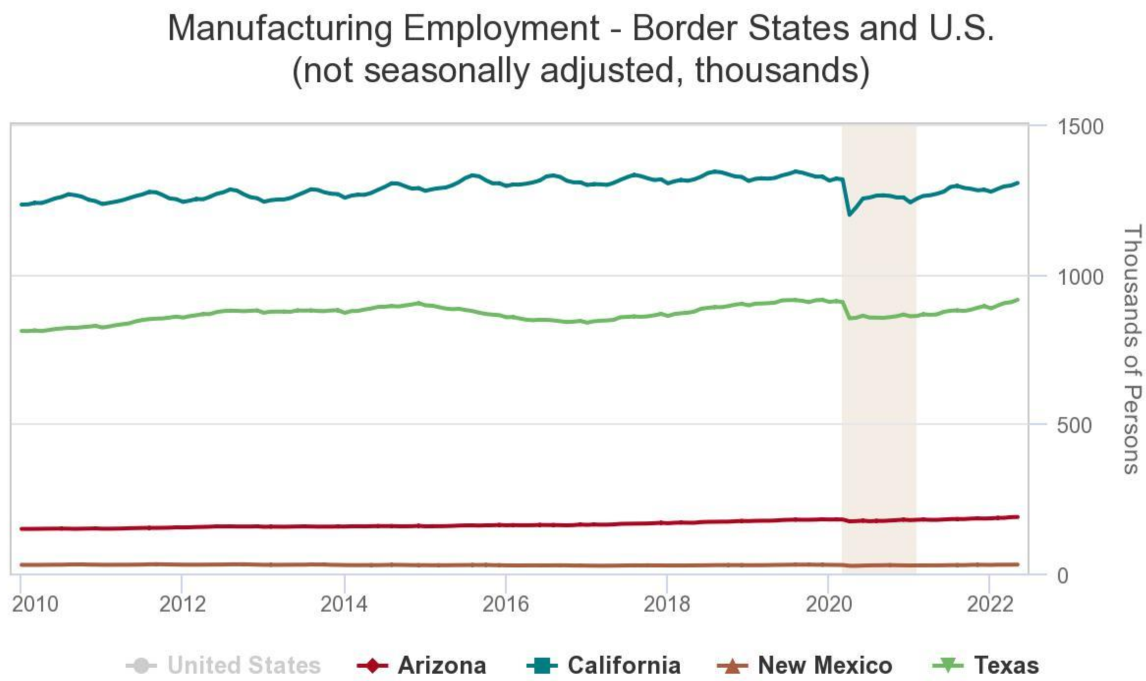
Figure 6: Foreign Direct Investment in the northern border states of Mexico: 1999-2018 ($US Millions)



Source: Arizona-Mexico Economic Indicators, Eller College of Management of the University of Arizona.

The second set of states, composed by the ones in the US southern border, has larger figures than the IMMEX in both employment and production. The manufacturing employment of Texas and California highlights, as having more than 800 thousand workers every year for the last ten years; that's a greater amount than any other border state, both from Mexico and the US. Arizona and New Mexico reach employment levels under 200 thousand workers in the same periods. In comparison, Baja California, Chihuahua, Coahuila de Zaragoza, Nuevo León and Tamaulipas have had more workers each year during the same period. Only Sonora is below the manufacturing employment level of Arizona, but above New Mexico, with almost 200 thousand; New Mexico has had under 30 thousand workers in this industry, which makes it one of the least competitive among all states in this branch, as seen in figure 7.

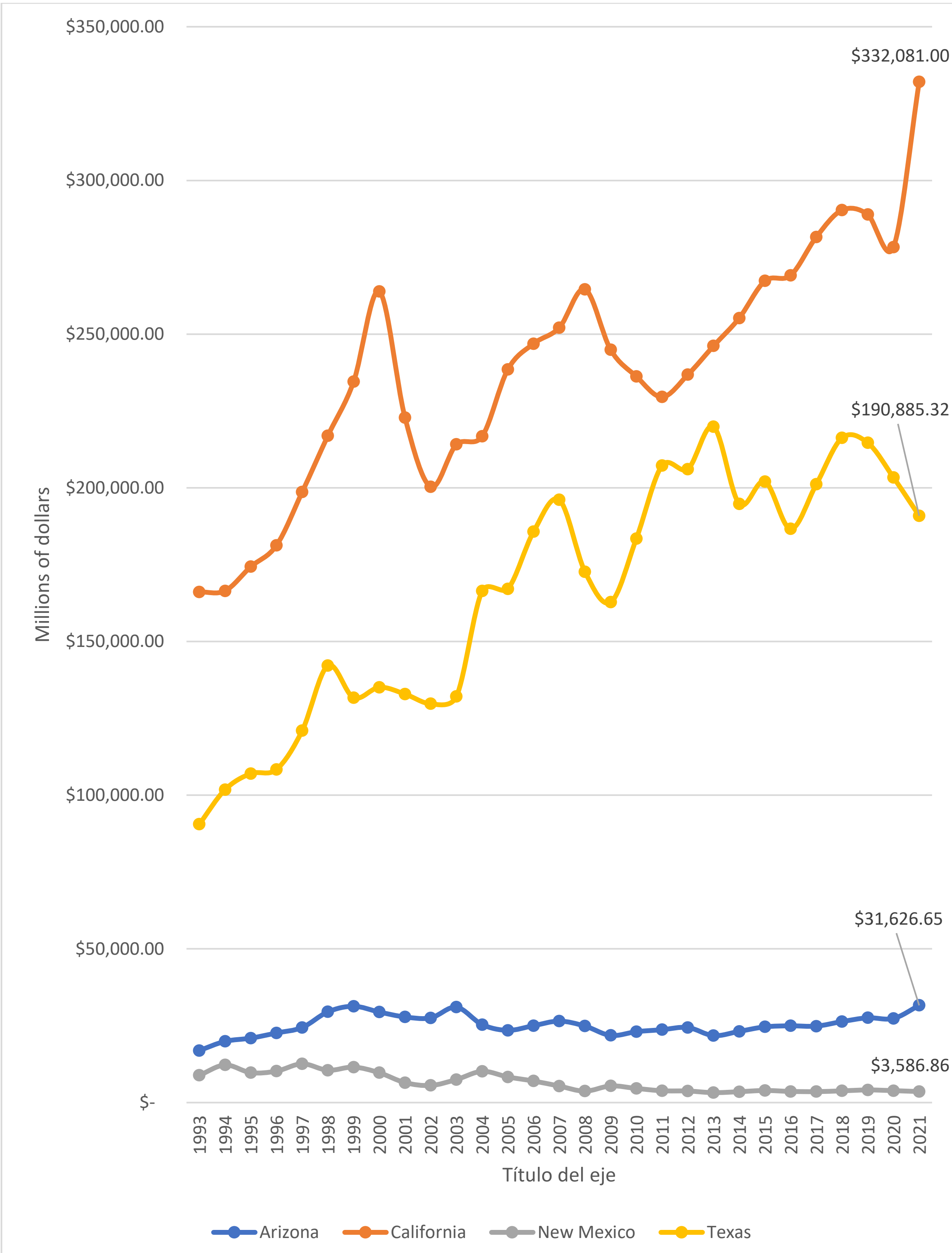
Figure 7: Manufacturing Employment in the U.S. southern border states: 2010-2022



Source: Arizona-Mexico Economic Indicators, Ellen College of Management of The University of Arizona.

And, contrary to the set of Mexican states, the tendency in manufacturing GDP and employment is very similar for the set of US states. In figure 8, California and Texas stand out again as the top manufacturing producers among all American and Mexican states, with a rapid growth and large numbers in their production. In 2021, the manufacturing GPD of each American southern border state was, in millions of dollars: $332,081.00 in California, $190,885.32 in Texas, $31,626.65 in Arizona and $3,586.86 in New Mexico. These means that the U.S. border set has both the state with higher employment and GDP in the manufacturing industry, California, and the one with lower levels in the two measures, New Mexico, in all the U.S.-Mexico border region.

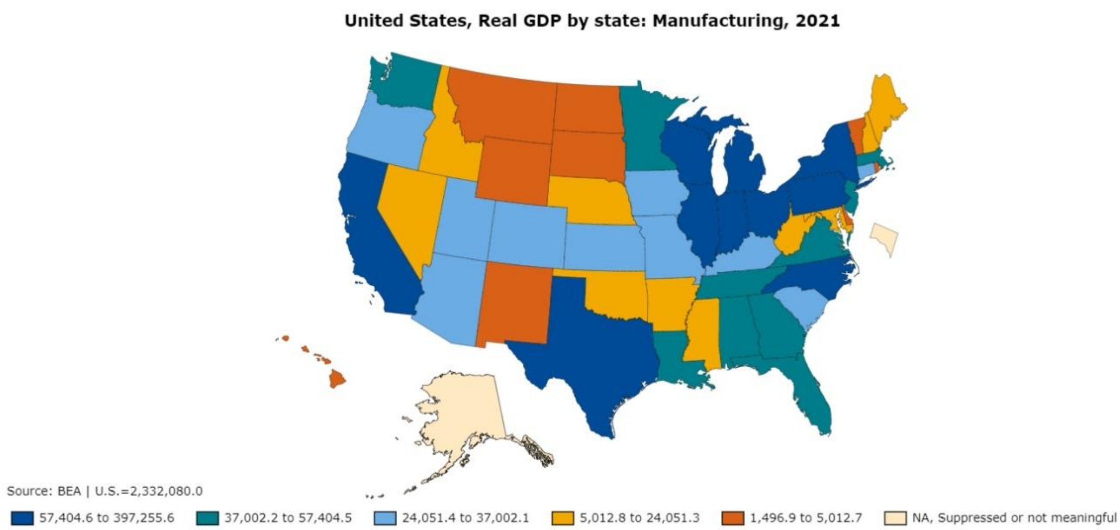
Figure 8: Manufacturing industry GPD of the southern border States of the U.S.: 1993-2021 (real 2012 U.S. dollars)



Own elaboration with data from the Bureau of Economic Analysis.

The map on figure 9 shows the distribution of the manufacturing GDP in the United States in 2021. It depicts a particular feature: the southern border of the U.S. contains two of the wealthiest states in matter of manufacturing production — California and Texas— with manufacturing GDP higher than any state of the Midwest and West Cost: in millions of real 2012 U.S. dollars, Wisconsin registered $58,392.9; Illinois, $107,328.4; Indiana, $101,896.9; Ohio, $107, 554.4; Pennsylvania, $96,413.00; Michigan, $89, 961.30; New York; $66, 500.30. On the other hand, California and Texas registered $397,255.60 and $231,108.10 million dollars, respectively.

Figure 9: United States Real GDP by state: Manufacturing, 2021



Source: Bureau of Economic Analysis (2022).

To comprehend the actual differences among the US and Mexico border states, and particularly in matter of industrial policy and the manufacturing industry, the economic characteristics of each of them will be described. What policies or action have they take to attract investment in manufacturing? Have these policies increase or lower their income discrepancies in the manufacturing industry?

2.4. Economic overview by states: characteristics and tax incentives for the manufacturing industry

2.4.1. Baja California

Baja California is the 9th largest state of Mexico, with an area of 71,450 km^2. Its northern frontier collides with California and Sonora; with the former, stands out the Tijuana-San Diego border, the busiest land border crossing in the world (San Diego Association of Governments and City of Tijuana Instituto Metropolitano de Planeación, 2014). In 2021, its population was 3.6 million people, and its real GDP per capita was $14,668.36 dollars; the compound annual growth rate of Baja California's GDP per capita from 1993 to 2021 was -0.22%.

Figure 10: Baja California GDP per capita: 1993-2021 (2012 US real dollars)

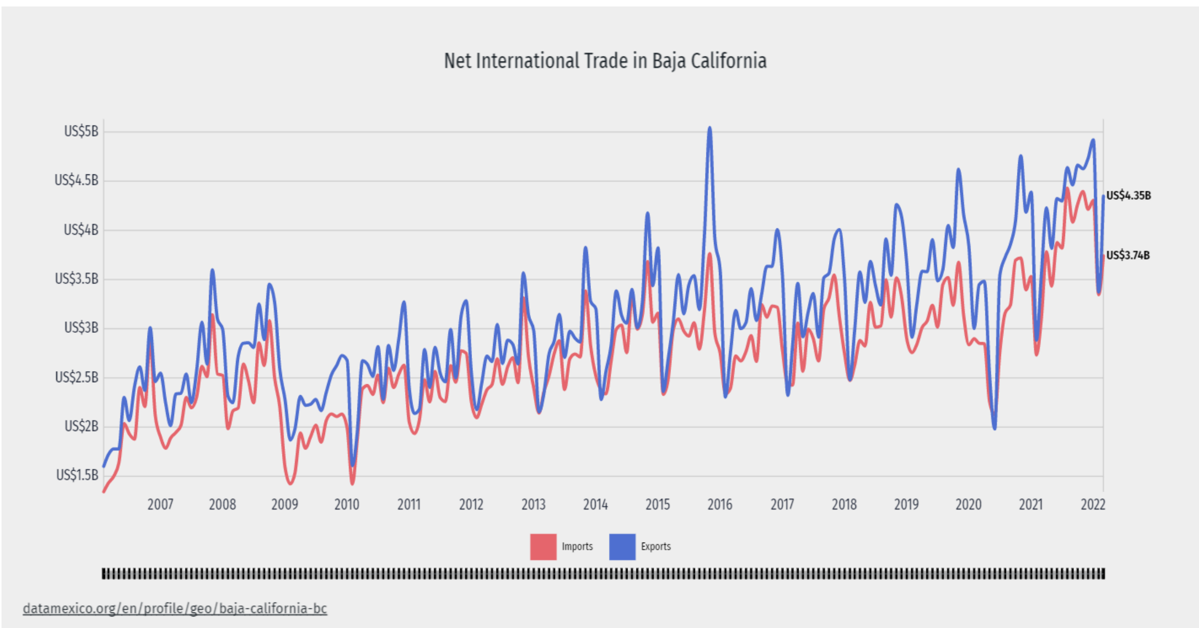
Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis.

Baja California's economy is chiefly based on the tertiary sector, which represented 52.4% of its GPD in 2021. Among the tertiary sector activities with highest state representation in that year, there was real estate services and rental of movable and intangible assets (8.6%%), wholesale trade (10.8%), and retail trade (10.2%). The second largest sector in the economy are secondary activities, with a representation of 45.2% of its GPD in 2021; the activities that highlight are the manufacturing industry (32%) and manufacture of machinery and equipment (18%). Finally, the last sector is the primary sector, with just 2.4% of the state GDP.

Speaking of its industrial structure, the manufacturing sector represents 32% of its GPD, as said previously, equivalent to $17,311.27 million dollars. The highlighted subbranches were manufacture of machinery and computer equipment, 18.19% of its GDP; food Industry, with 3.07%; and basic metal industries, 2.07%.

Figure 11 shows Baja California net international trade has maintained an upwards tendency since 2009, after the global recession. Nevertheless, the imports compound annual growth rate is slightly greater than the exports compound annual growth rate in the period 2006-2021; each of them, respectively, is 4.72% and 4.43%.

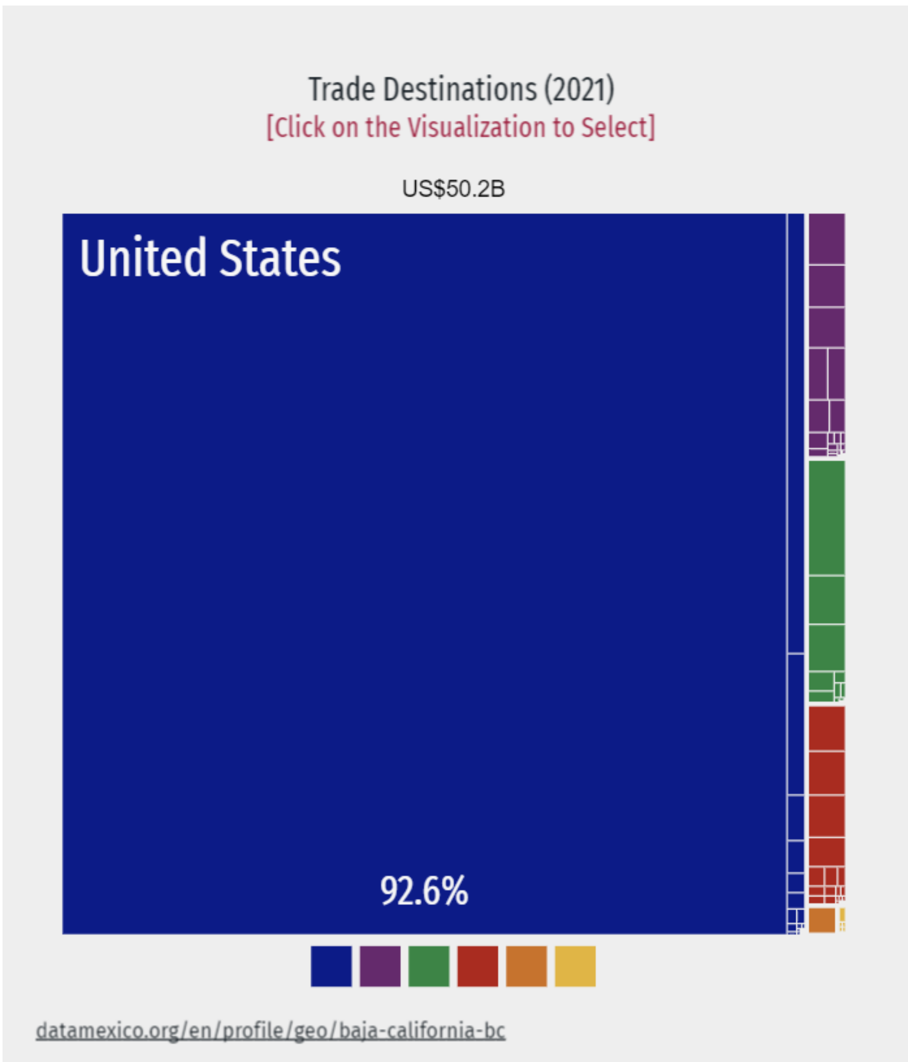
Figure 11: Net International Trade in Baja California: 2007-2022



Source: DataMÉXICO (2022g)

Figure 12 complements the previous graph, since it's the trade destination of $50.2 billion dollars worth of goods exported by Baja California in 2021, where blue represents North America, red Asian, purple Europe, green South America, yellow Africa and orange Oceania. It is remarkable how integrated Baja California's economy is with the United States: 92.6% of its total exports go to this country. In that sense, most of the other destinies are, in contrast, irrelevant for most of the state's economy.

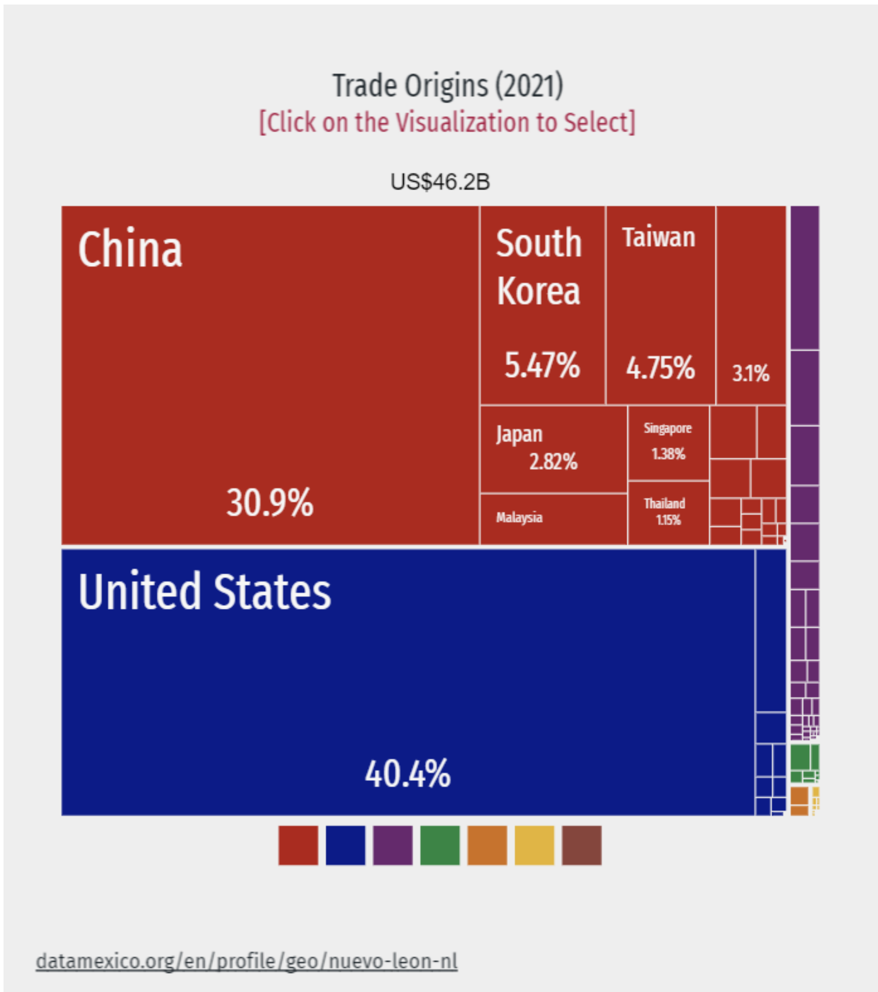
Figure 12: Baja California Trade Destination: 2021



Source: DataMÉXICO (2022h)

Likewise, most of the trade origins of Baja California in 2021 came from the U.S. (40.4%), as seen in figure 13. Nevertheless, the proportion is much lower, and China represents almost as a bigger parts of trade origin as the North American country, with 30.9%. Also, the following trade origin countries are from Asia, proving that Baja California international trade is based mostly on Asian inputs to produce outputs destinated to North and South American markets.

Figure 13: Baja California Trade Origins: 2021



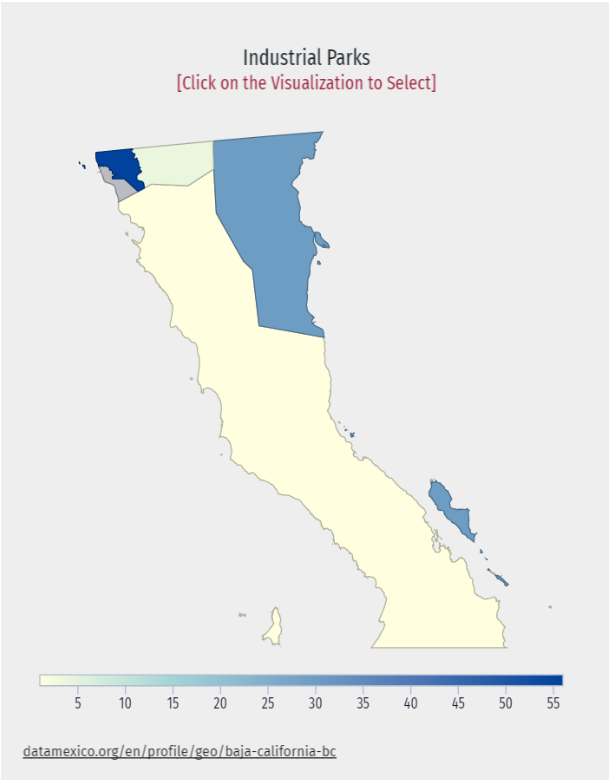
Source: DataMÉXICO (2022i)

In the manufacturing, maquila and export services industry (IMMEX), Baja California stands out as the state with higher number of companies in this branch: 927, which is 17.8% of Mexico's total manufacturing companies in 2019 (Gobierno del Estado de Baja California, 2019). This is reflected in figure 12, on a map of the distribution of industrial parks in the state. An industrial park is

> a delimited, urbanized land, with all the services, permits and infrastructure for the optimal operation of manufacturing and logistics companies, it offers infrastructure and equipment for the industry, in addition to basic services such as water, electricity and telecommunications, among others. (DataMÉXICO, 2022a).

Baja California "registered 60 industrial parks, 23 micro parks and 8 industrial parks under construction" (DataMÉXICO, 2022a), distributed by municipality in the following ascending order: Tijuana, with 56; Mexicali, with 30; Tecate, with 4; and Ensenada, with just one. Figure 14 shows a map where the darker the color of the municipality is, the more industrial parks it has.

Figure 14: Industrial Parks by municipality in Baja California: 2020

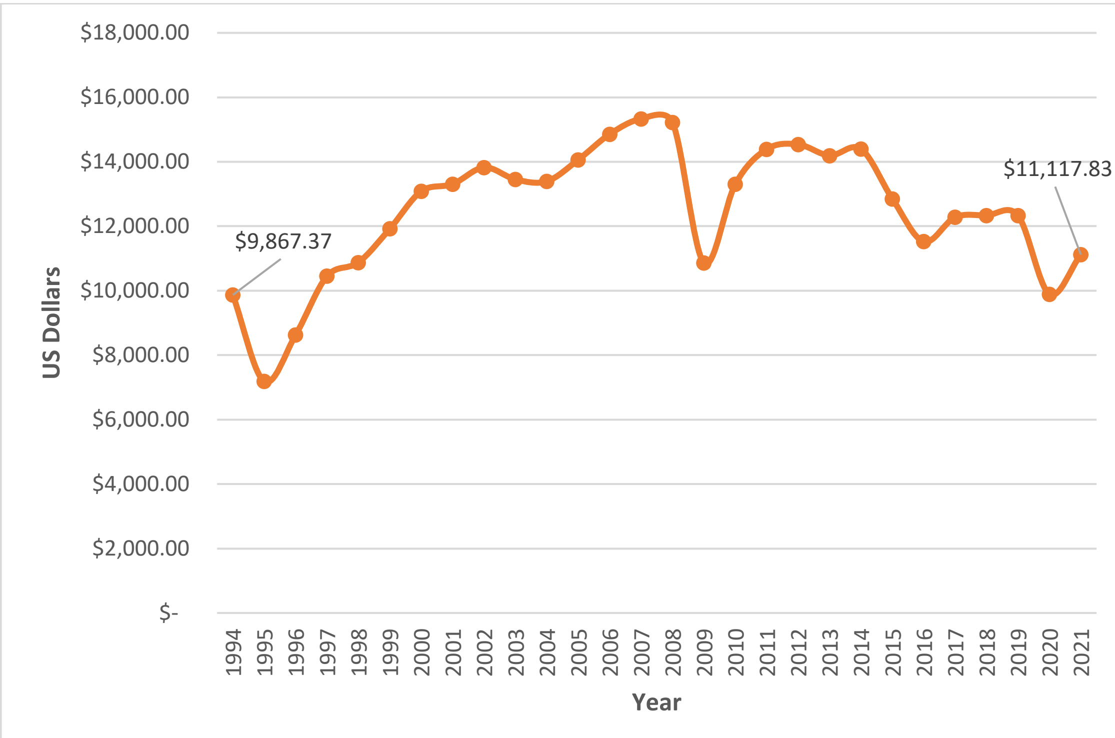


Source: DataMÉXICO (2022j)

2.4.2. Coahuila de Zaragoza

The state of Coahuila is the third largest state of Mexico, with an area of 151,571 km^2. It had a GDP of $36,258.13 million dollars in 2021, along with a GDP per capita of $11,117.83 dollars. Its GDP per capita compound annual growth rate from 1993 to 2021 is 0.46%, the third highest among the Mexican set of states.

Figure 15: Coahuila de Zaragoza GDP per capita: 1993-2021 (2012 U.S. real dollars)

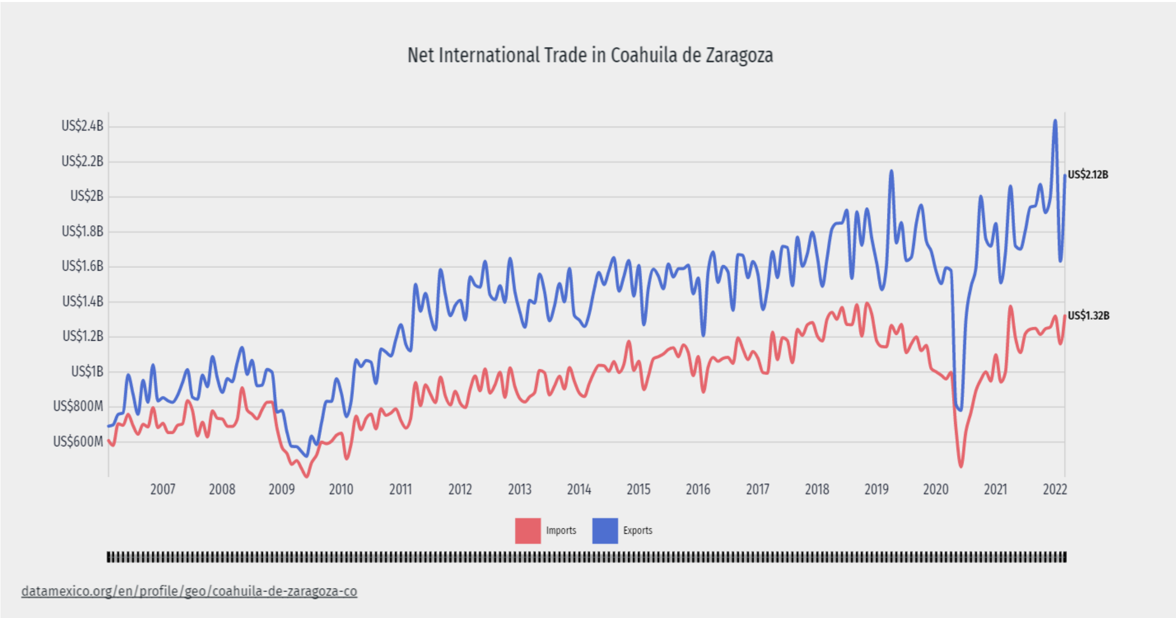


Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis

The economic activities of Coahuila represented the following proportion of its total gross value added in 2021. The primary sector is minimum, with just 2.4% of Coahuila's gross value added in agriculture, raising and exporting animals, forestall activities, fishing and hunting. The secondary sector represented 55.3%, in which the manufacturing industry outstands (43.8%); within this industry, the greater subbranch is the fabrication of machinery, equipment, computer equipment and electronic components, with 20.9% of Coahuila's gross value added. The tertiary sector represented 42.3%, in which some branches with a bigger proportion are real estate and property rental, with 7.1%, and retail trade, with 7.8%.

Figure 16 shows the net International Trade in Coahuila, from 2006 to 2021. It kept a general surplus: the exports compound annual growth rate was 5.62%, while the imports compound annual growth rate was 3.76%.

Figure 16: Net International Trade in Coahuila de Zaragoza: 2006-2022

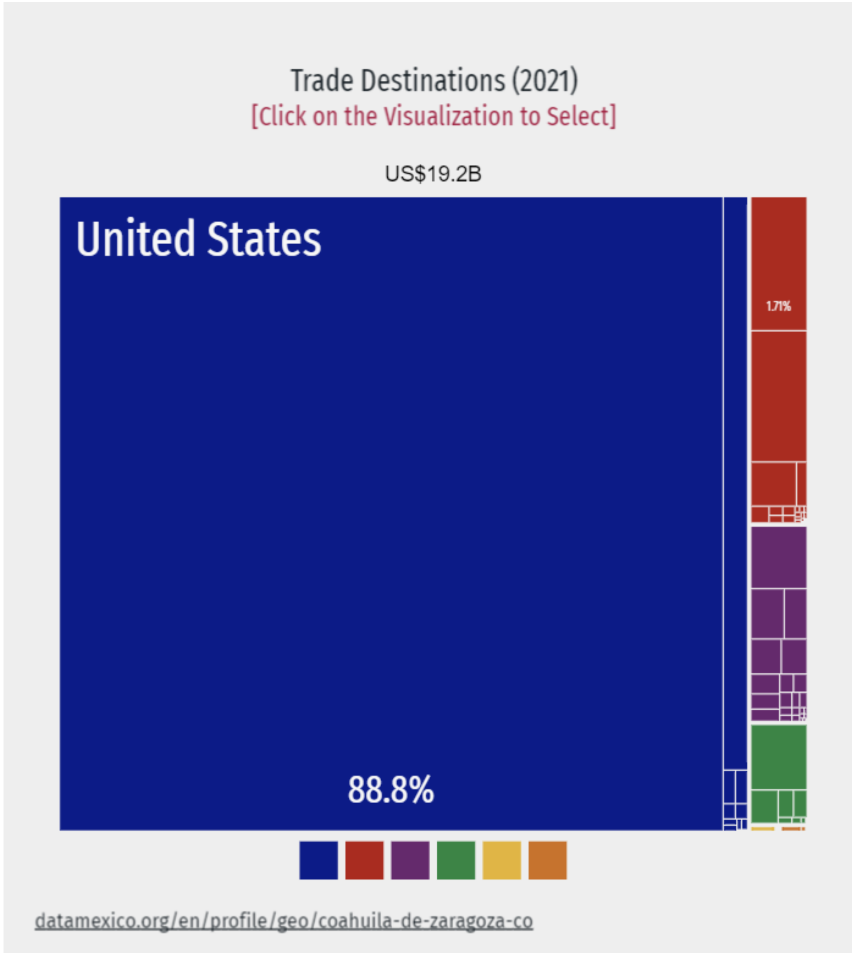


Source: DataMéxico (2022k)

Coahuila's international trade was $19.2 billion dollars in 2021. As shown on figure 16, most of its sells were destinated to the United States (88.8%), followed by Canadá, Guatemala, Puerto Rico, Japan and China. The destinations of this states are more diversified than Baja California's.

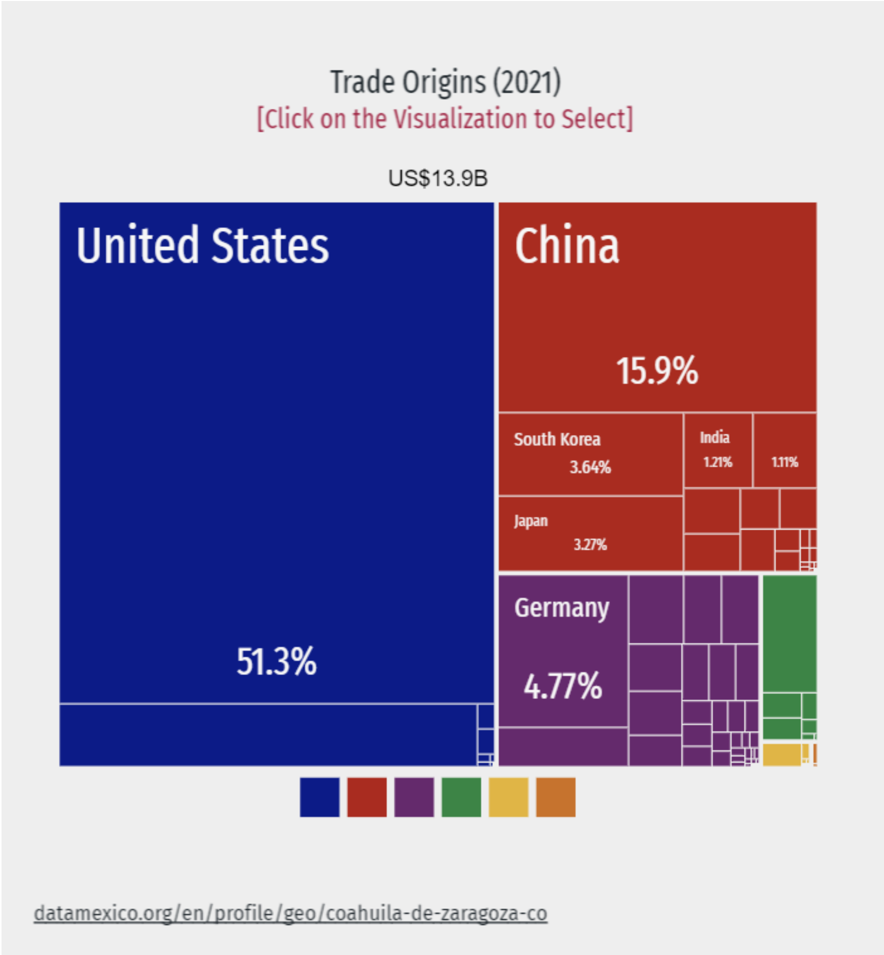
And, on figure 17, there are the trade origins in 2021 for Coahuila de Zaragoza: the United States was the biggest partner, with 51.3%, followed by China (15.9%), Canada (6.17%), Germany (4.77%), South Korea (3.64%) and Japan (3.27%), among others. On figure 18, the trade destination partners of Coahuila, who are similar to the trade origin ones, but with different proportions; China has a major role here.

Figure 17: Coahuila de Zaragoza trade destinations: 2021



Source DataMÉXICO (2022l)

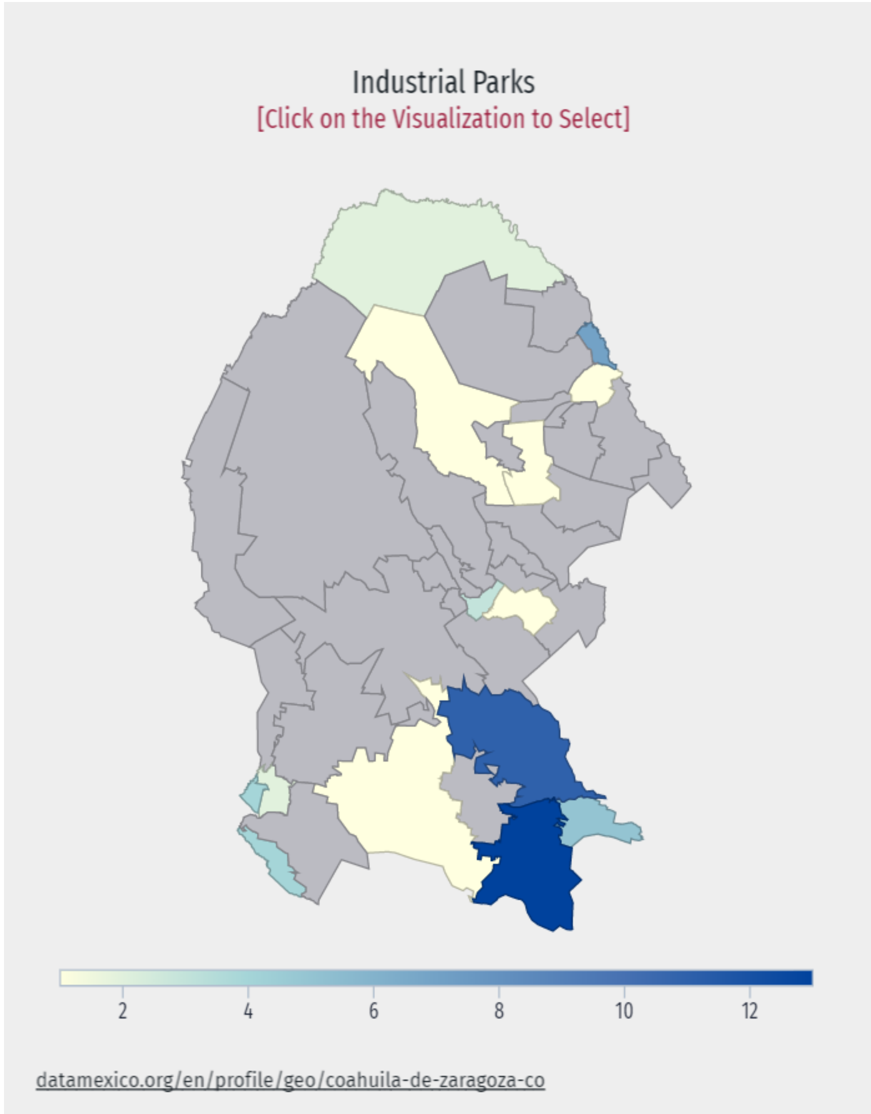
Figure 18: Coahuila de Zaragoza trade origins (2021)



Source: DataMÉXICO (2022m)

Figure 19 shows that, in 2020, Coahuila "registers 38 industrial parks, 1 micro park and 13 industrial parks under construction" (DataMÉXICO, 2022c). They are distributed in the following cities: 13 in Saltillo, 11 in Ramos Arizpe, 7 in Piedras Negras, 5 in Arteaga, 4 in Torreon, 3 in Frontera, 2 in both Matamoros and Acuña; Parras, Monclova, Sabinas, Múzquiz and Nava had one in each city.

Figure 19: Industrial Parks by municipality in Coahuila de Zaragoza (2020)



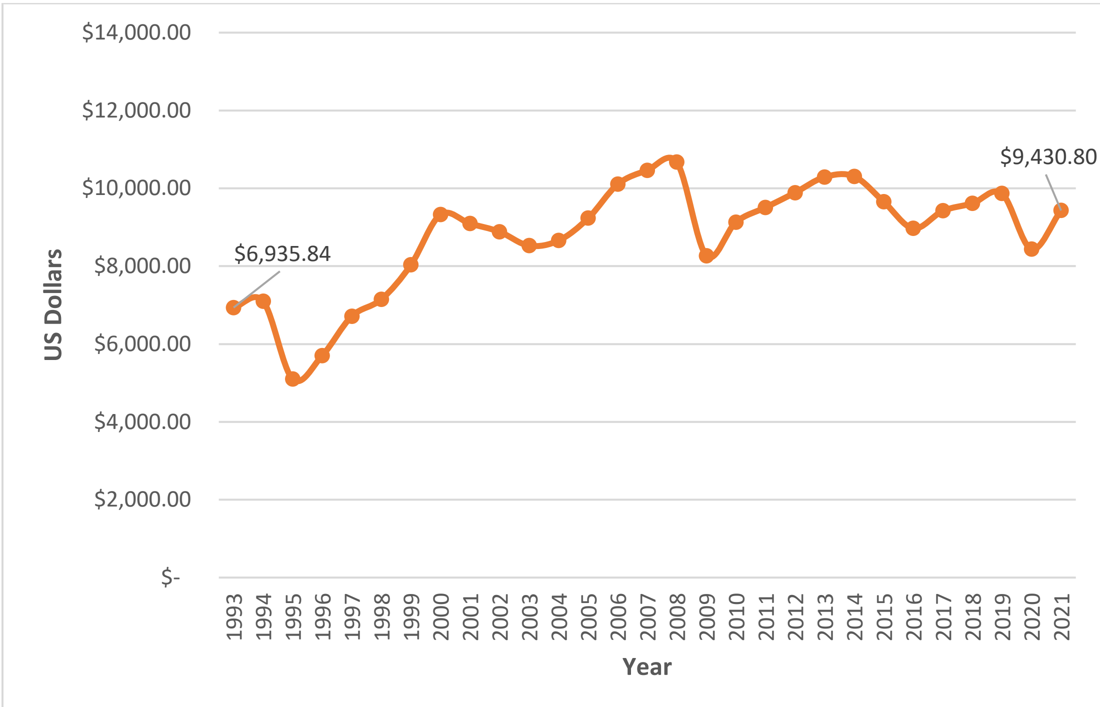
Source: DataMÉXICO (2022n)

2.4.3. Chihuahua

Chihuahua is the biggest state of Mexico, with an area of 247,455 km^2. It registered a population of 3,836,506 people in 2021, along with a GDP of $36,181.32 million dollars (INEGI, 2021). Even the largest state of Mexico does not compare in size with its North American border peers: California is 1.7 times bigger than Chihuahua and had 10 times its population in 2021; Texas is 2.8 times bigger than Chihuahua and had 7.6 times its population in that same year.

The state of Chihuahua had a GPD per capita of $9,430.80 dollars in 2021. Its GDP per capita compound annual growth rate, from 1993 to 2021, is 1.10%, the highest among the Mexican northern border states.

Figure 20: Chihuahua GDP per capita: 1993-2021 (2012 US real dollars)

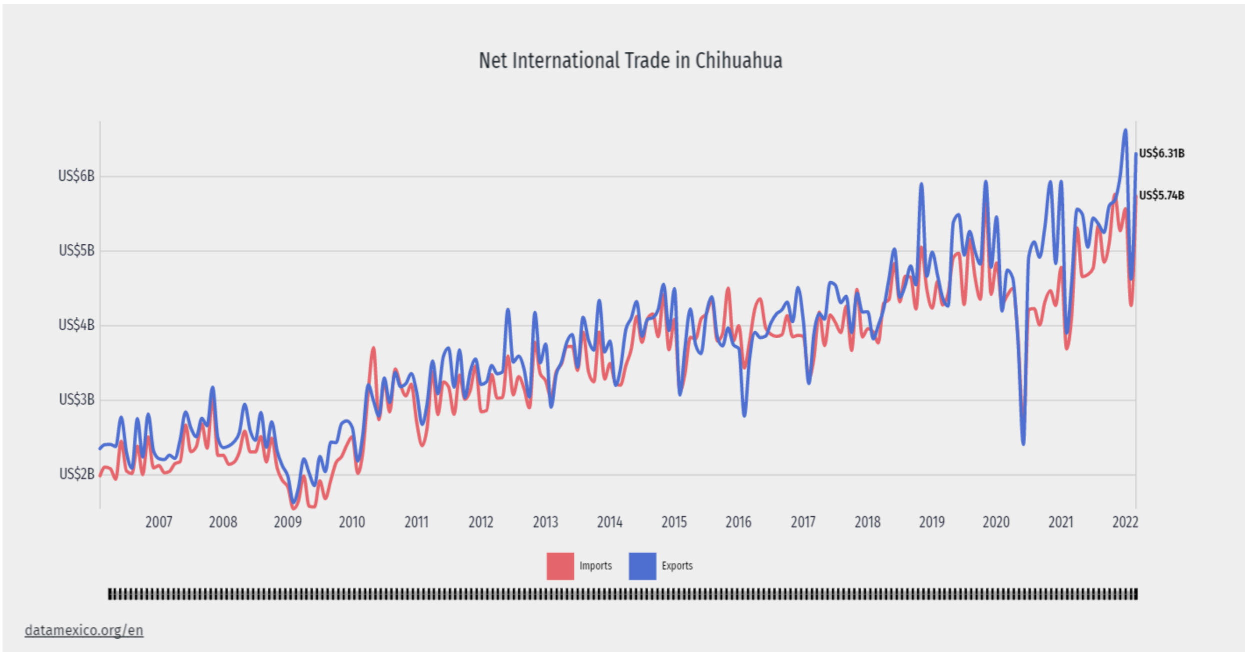


Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis

Chihuahua's economy structure registered the following proportions in 2021. The primary sector represented just 5.9% of its GDP, even though Chihuahua is one of the main states on agricultural production. The secondary sector registered a proportion of 39.9% of the state's GDP, in which 28.8 percentage point correspond to the manufacturing industry; the branches with higher representation in such industry are the fabrication of machinery, equipment, computer equipment and electronic components, with 19.4% of Chihuahua's gross value added, and the food industry, with 2.8%. The tertiary sector is the largest, with a representation of 54.2% of the state GDP. The highlight branches are real estate services and rental of movable and intangible assets (12.4%), wholesale trade (9.1%), and retail trade (8.4%).

In international trade, Chihuahua has a slightly greater speed in its imports than its exports from 2007 to 2021: its import annual compound growth rate is 5.7%, while the exports compound annual growth rate is 5.46%. Figure 21 shows the net international trade in Chihuahua.

Figure 21: Net International Trade in Chihuahua: 2021.

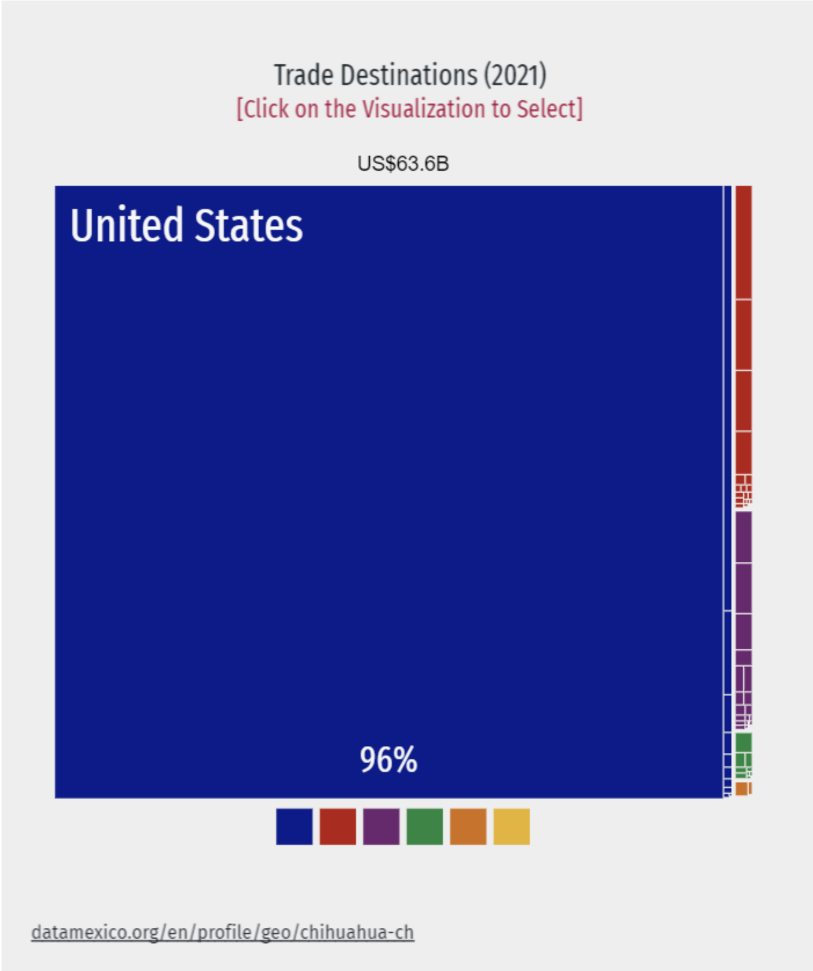


Source: DataMÉXICO (2022ñ)

As seen on figure 21, in 2021, the $63.6 billion dollars worth of merchandise exported by Chihuahua had a mayor destination to the United States, with 96% of its exports, a greater percentage than Baja California's, 92.6%. The next destination countries in descendent order were Canada, El Salvador and Puerto Rico.

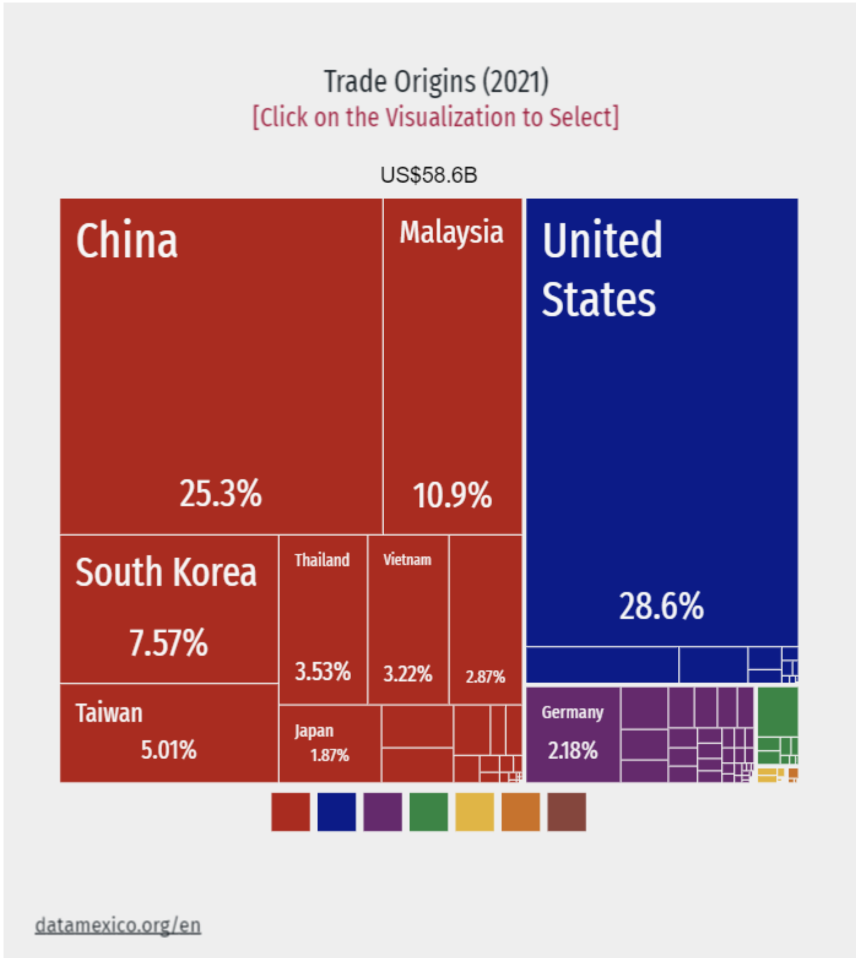
On trade origin, however, as showed in figure 23, the scenario is much different. The United States is the mayor trade origin partner of Chihuahua, with a representation of 28.6%. Nevertheless, China is very close to that level, with 25.3%, making it a trade origin partner as important as the U.S. In descending order, some other important Chihuahua's trade origin partners were all Asian countries: Malaysia (10.9%), South Korea (7.57%), Taiwan (5.01%), Thailand (3.53%), Vietnam (3.22%) and Philippines (2.87%).

Figure 22: Chihuahua trade destinations (2021)



Source: DataMÉXICO (2022o)

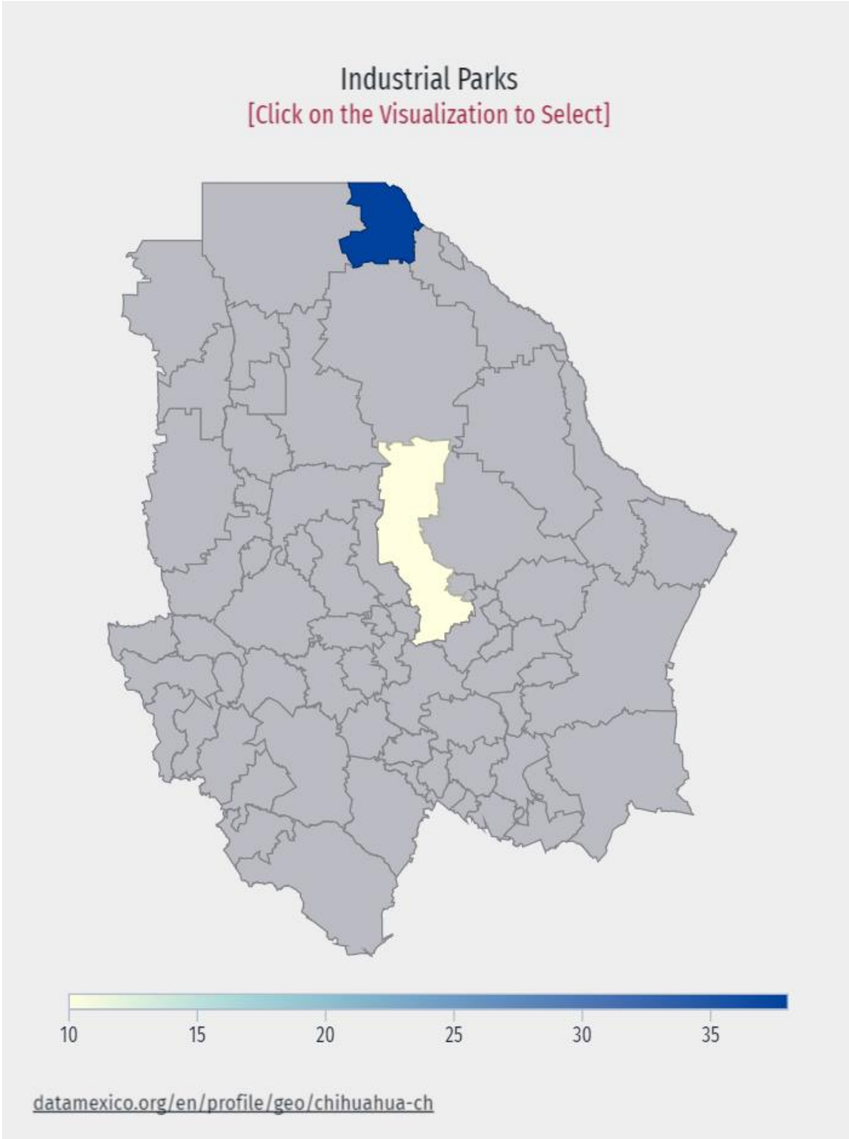
Figure 23: Chihuahua trade origins: 2021



Source: DataMÉXICO (2022p)

Chihuahua "registers 42 industrial parks, 2 micro parks and 4 industrial parks under construction" (DataMÉXICO, 2022), making a total of 48 industrial parks. They are divided in two cities: most of them in Ciudad Juárez, with 38, and the rest in Chihuahua City, with 10. Compared to Sonora and Baja California, there is a greater degree of centralism since the industrial parks of Chihuahua are only in two cities.

Figure 24: Industrial Parks by municipality in Chihuahua (2020)

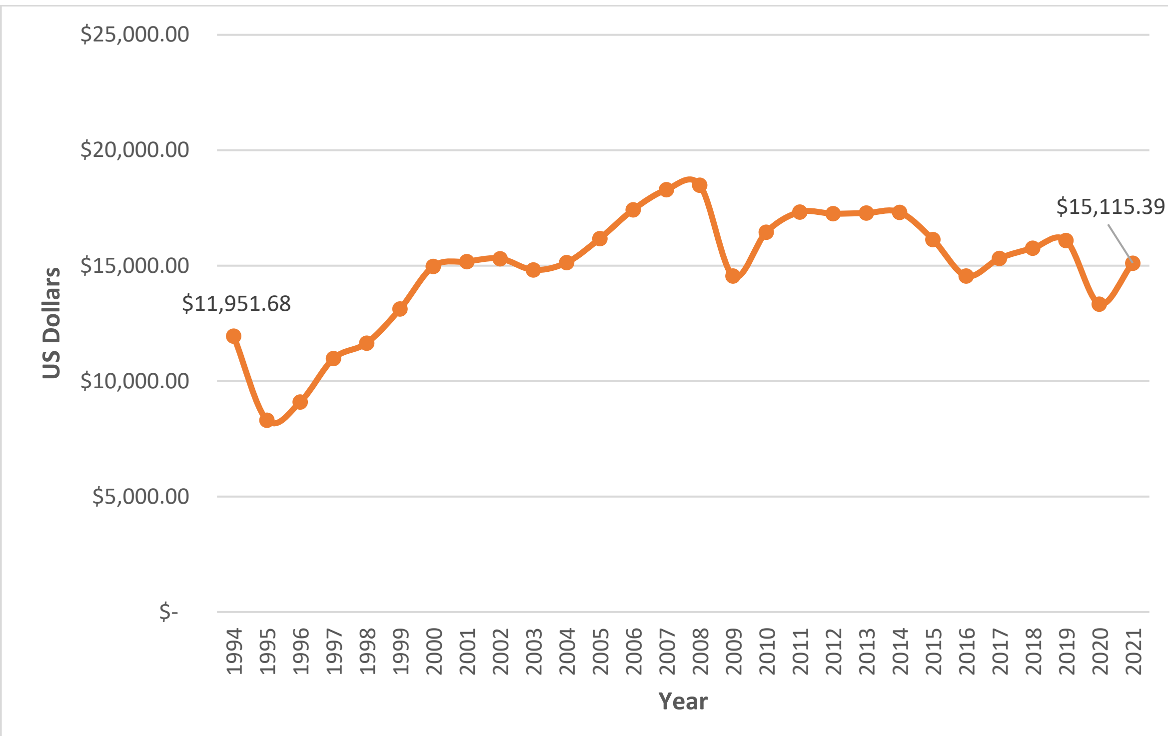


Soruce: DataMÉXICO (2022q)

2.4.4. Nuevo León

Nuevo León has an area of 64,924km^2 and had a population of 5,685,888 people in 2021 (INEGI, 2022). This makes it the smallest state on both US and Mexican border states on size. Nevertheless, it is the richest state on the Mexican states set. In 2021, it registered a GDP of $85,944.44 million dollars; that is almost three times the GDP of Tamaulipas and almost double of every other Mexican northern border state. In GDP per capita terms, it registered $15,115.39 dollars, and, from 1993 to 2021, a compound annual growth rate of 0.96% on that measure, just bellowed Chihuahua's.

Figure 25: Nuevo León GDP per capita: 1993-2021 (2012 U.S. real dollars)



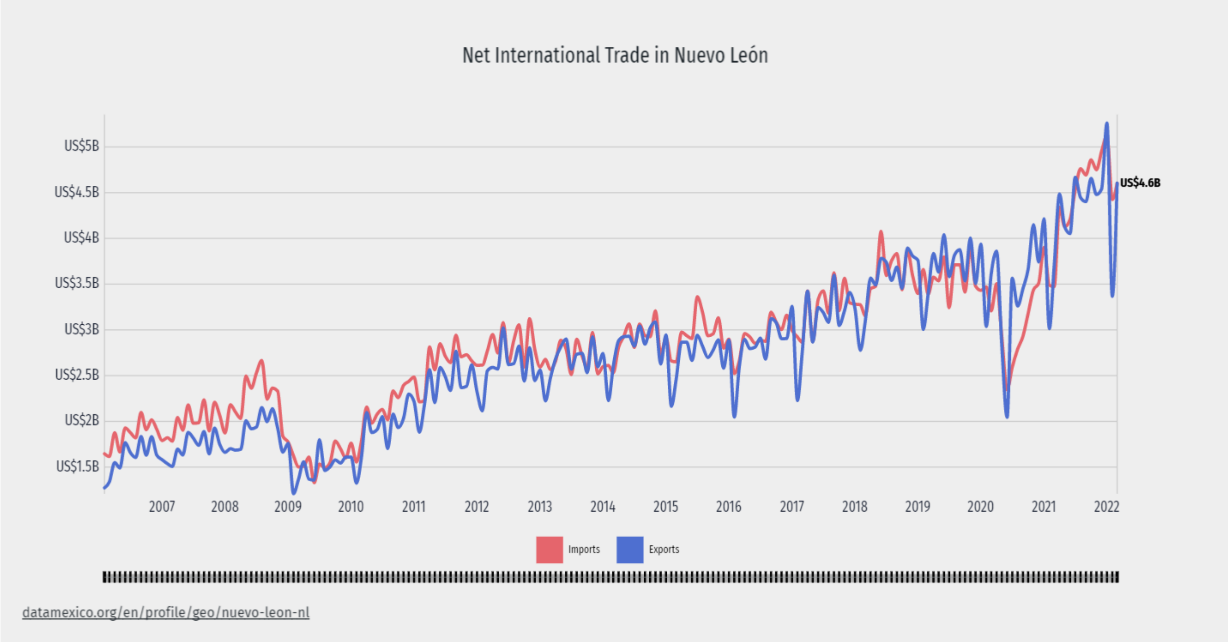
Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis.

Nuevo León's economic activities had the following representation in 2021, according to INEGI (2022). The primary sector just represented 0.5% of the state's gross added value. The secondary sector represented 35.2%, in which the branch with highest representation was the manufacturing industry, with 23.32% of the state gross added value. Finally, the tertiary sector is the largest in Nuevo León, with

64.4%; some of the branches that with great representation are real estate and rental property (9.7%) and retail trade (9.5%).

The net international trade of Nuevo León presents faster growth than Baja California, Chihuahua, Sonora and Tamaulipas. The exports compound annual growth rate from 2006 to 2021 was 6.85%, while the imports compound annual growth rate was 6.03%. In figure 26 there is the tendency of deficit trade balance for Nuevo León from 2006 to the first years of the next decade, when the tendency begins to shift, until there is a tendency to surplus trade balance from most of 2019 onwards.

Figure 26: Net International Trade in Nuevo León: 2021

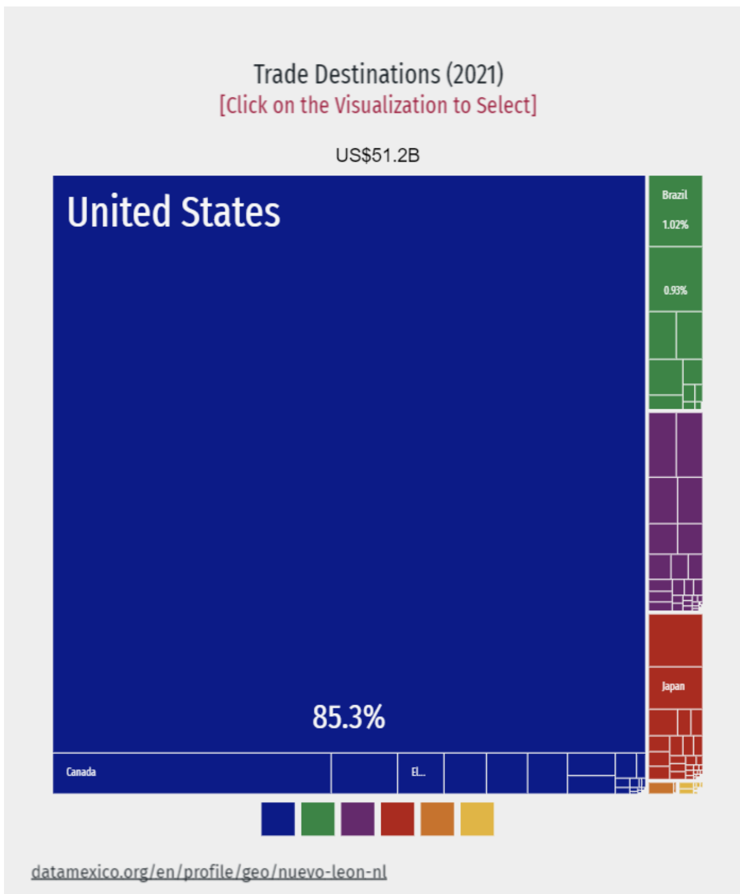


Source: DataMÉXICO (2022r)

In 2021, Nuevo León made a total of sells worth $51.2 billion dollars (DataMÉXICO, 2022d). Figure 27 shows that most of this trade was made with the United States, 85.3%, followed by Canada, Brazil, Colombia, China and Guatemala (DataMÉXICO, 2022d). This proves that Nuevo León trade partners in exports are more diversified than the other states, except for Sonora, as it will be shown in the next subsection.

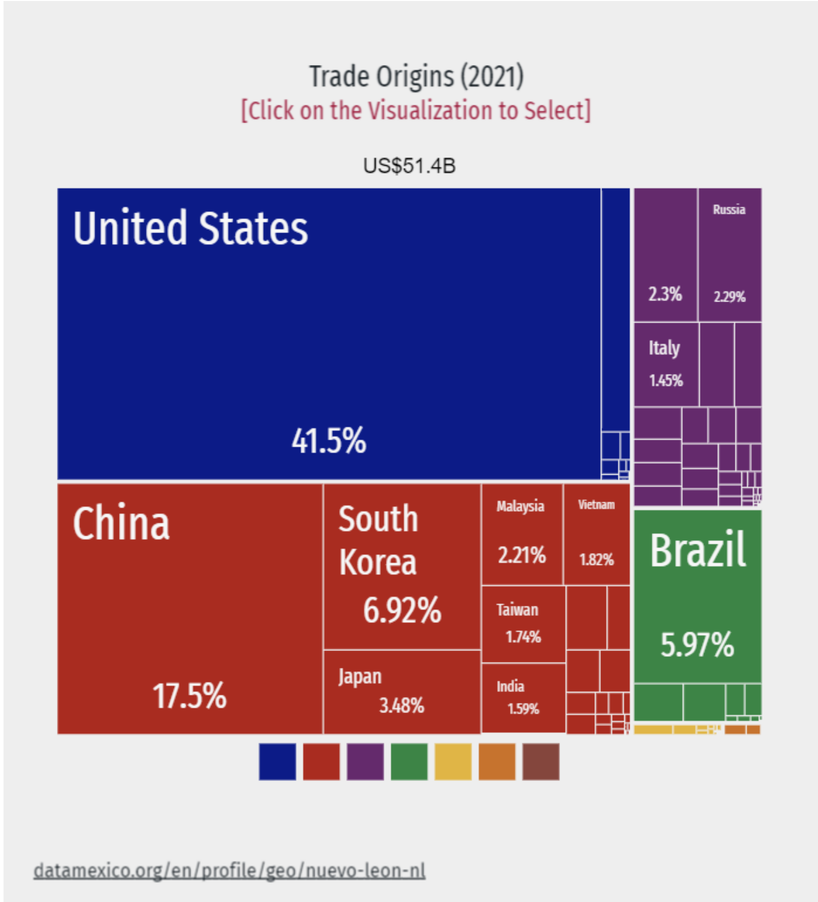
The trade origins of Nuevo León in 2021, however, represents different proportions with their international commerce partners. As shown in figure 28, the United States was still the mayor partner in imports, but by a lesser degree: 41.5% of Nuevo León's trade origin was from this country. The second largest trade origin country was China, with 17.5%, and other Asian countries represented a big rolled too, like South Korea (6.92%), Japan (3.48%), Malaysia (2.21%) and Vietnam (1.82%). Brazil represented 5.97%, which makes it the fourth largest trade origin partner of Nuevo León. Some European countries that stand out are Germany (2.3%) and Russia (2.29%).

Figure 27: Nuevo León trade destinations (2021)



Source: DataMéxico (2022s)

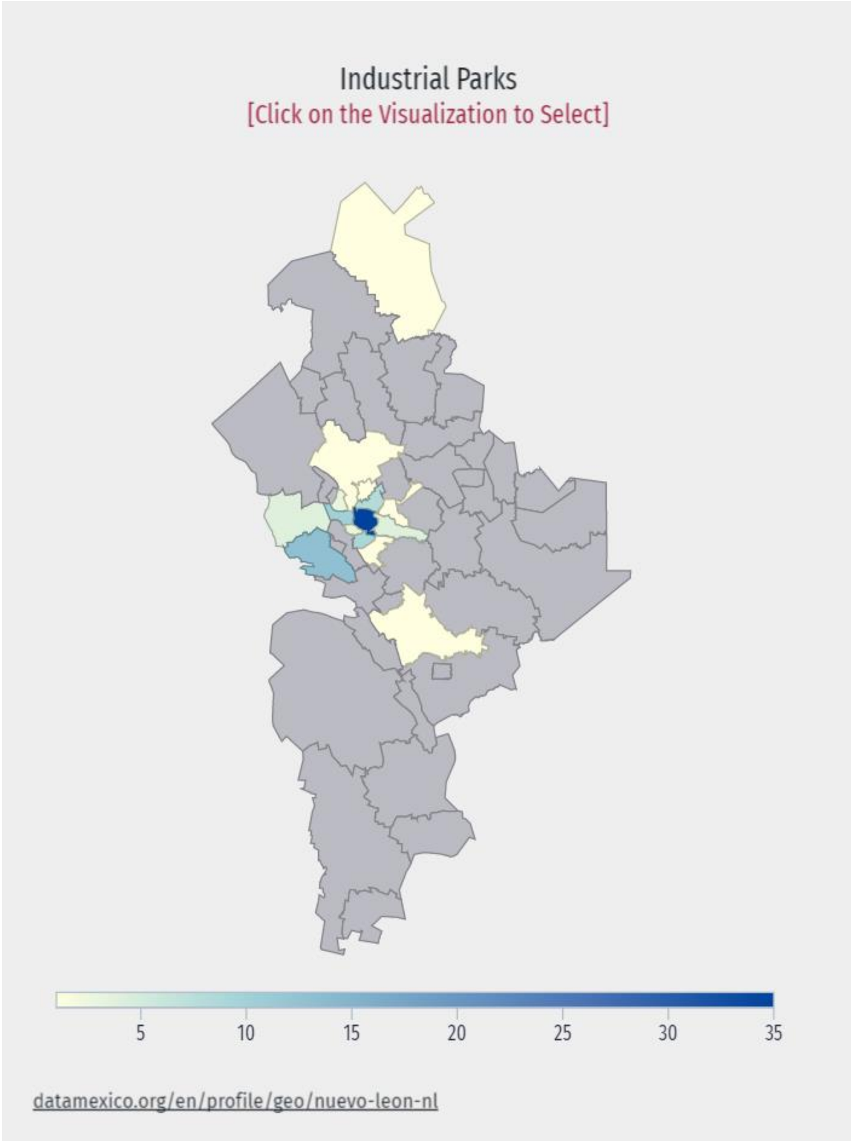
Figure 28: Nuevo León trade origins (2021)



Source: DataMÉXICO (2022t)

In 2021, Nuevo León “registers 78 industrial parks, 3 micro parks and 14 industrial parks under construction” (DataMÉXICO, 2022d). In descending order, they are located in the following municipalities: 35 in Apodaca, 13 in Santa Catarina, 10 in General Escobedo, 9 in Guadalupe, 8 in General Zuazua, 4 in both García and Pesqueira, 3 in both San Nicolás de la Garza and El Carmen, and 1 in Salinas Victoria, Ciénega de Flores, Marín, Juárez, Montemorelos and Anáhuac. Most of them are located within or around the Metropolitan area of Monterrey, as seen in figure 29.

Figure 29: Industrial Parks by municipality in Nuevo León (2021)

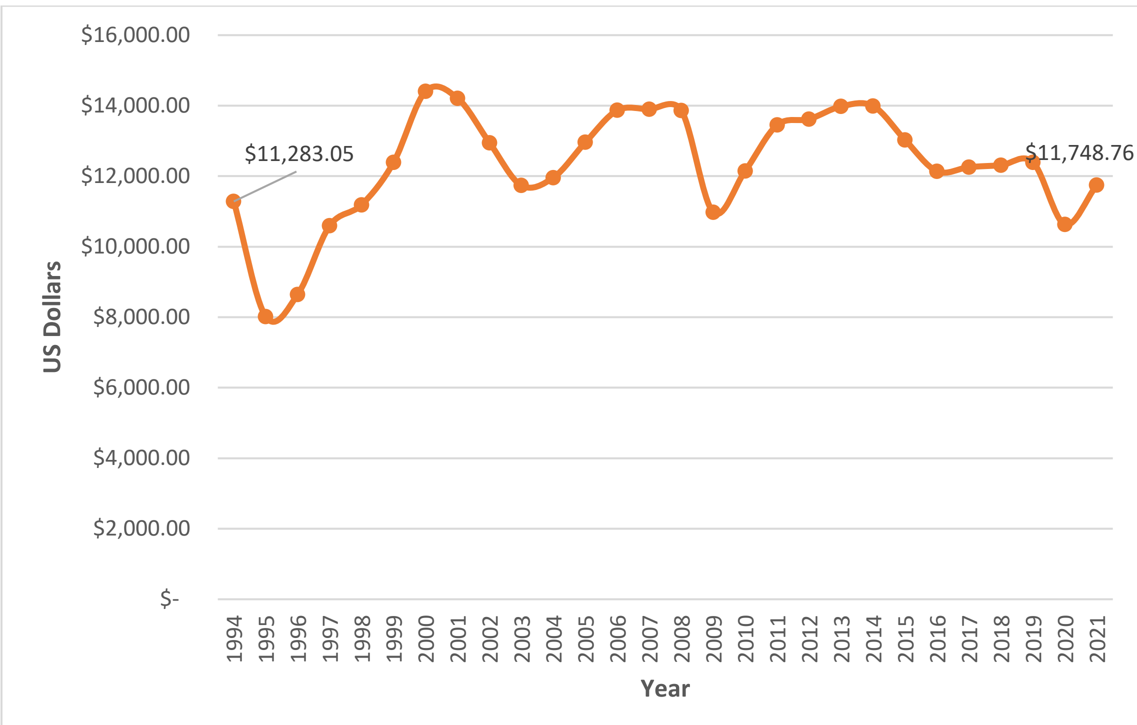


Source: DataMÉXICO (2022u).

2.4.5. Sonora

The northwestern state of Sonora is the second largest in Mexico, with an area of 179,355 km^2. Its norther border collides with the state of Arizona and a fraction of New Mexico in the northeast side. It registered a population of 3,111,119 people in 2021, and it had a GDP of $36,551.79 million dollars. Sonora's GDP per capita at that year was $11,748.75 dollars and maintained a compound annual growth rate of 0.36% from 1993 to 2021, the fourth highest GDP per capita growth rate of all border states on Mexico, below Chihuahua's, Nuevo Leon's and Coahuila's.

Figure 30: Sonora GDP per capita: 1993-2021 (2012 US real dollars)

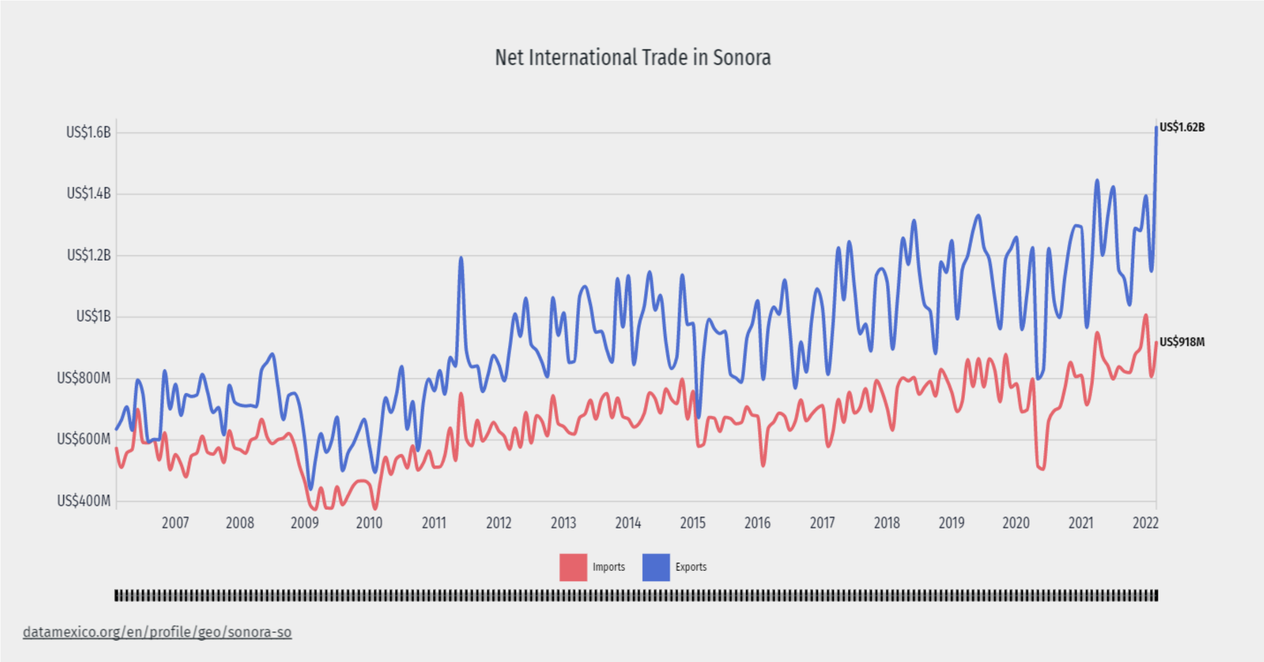


Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis.

Sonora economy is almost even in the secondary and tertiary sectors, each of them representing 43.7% and 49.2%, respectively, of the state's economy in 2021. During that year, in the secondary sector, some highlight activities in proportion of Sonora's GDP were the manufacturing industry (22.2%), non-oil mining (11.3%) and construction (7.8%); inside the manufacturing industry, the most representative branches were fabrication of machinery, computer equipment, communications and others (8.8%) and alimentary industry (5.2%).

In figure 31 there is the international trade of Sonora from 2007 to 2022, measured in millions of dollars. The blue line represents the exports and the red line the imports of goods and services. The international growth of Sonora has maintained a steady growth in the last fourteen years, where commonly the exports are greater than the imports: the annual import compound annual growth rate of Sonora from 2007 to 2021 is 3.06%, while the export compound annual growth rate for the same period is 3.95%.

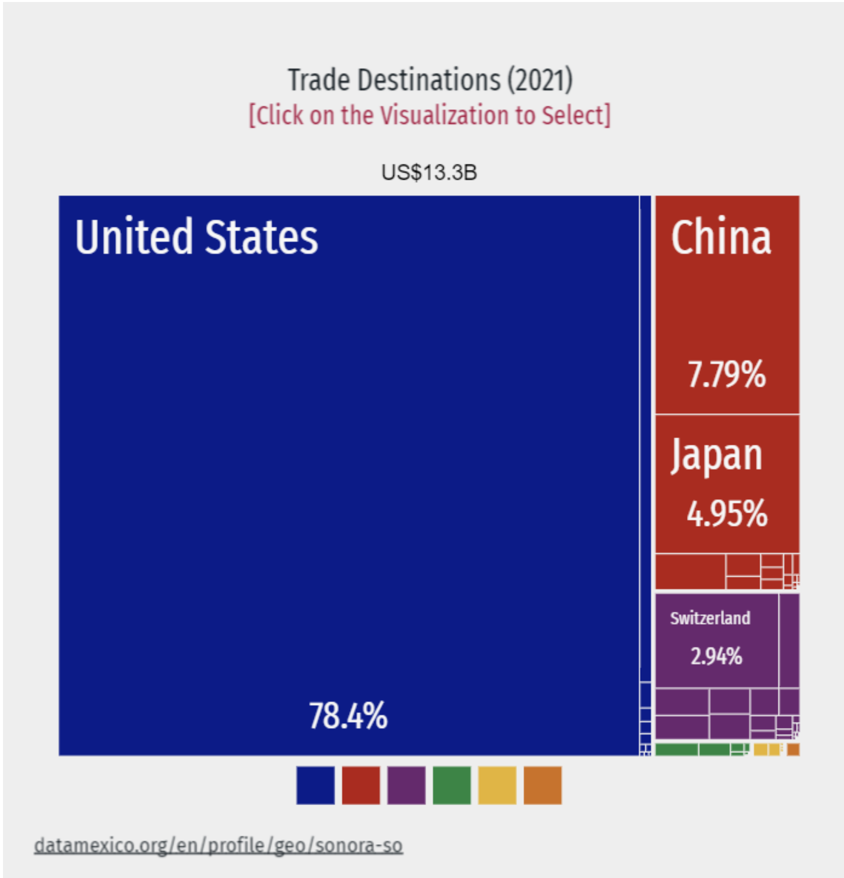
Figure 31: Net International Trade in Sonora: 2006-2022



Source: DataMéxico (2022v)

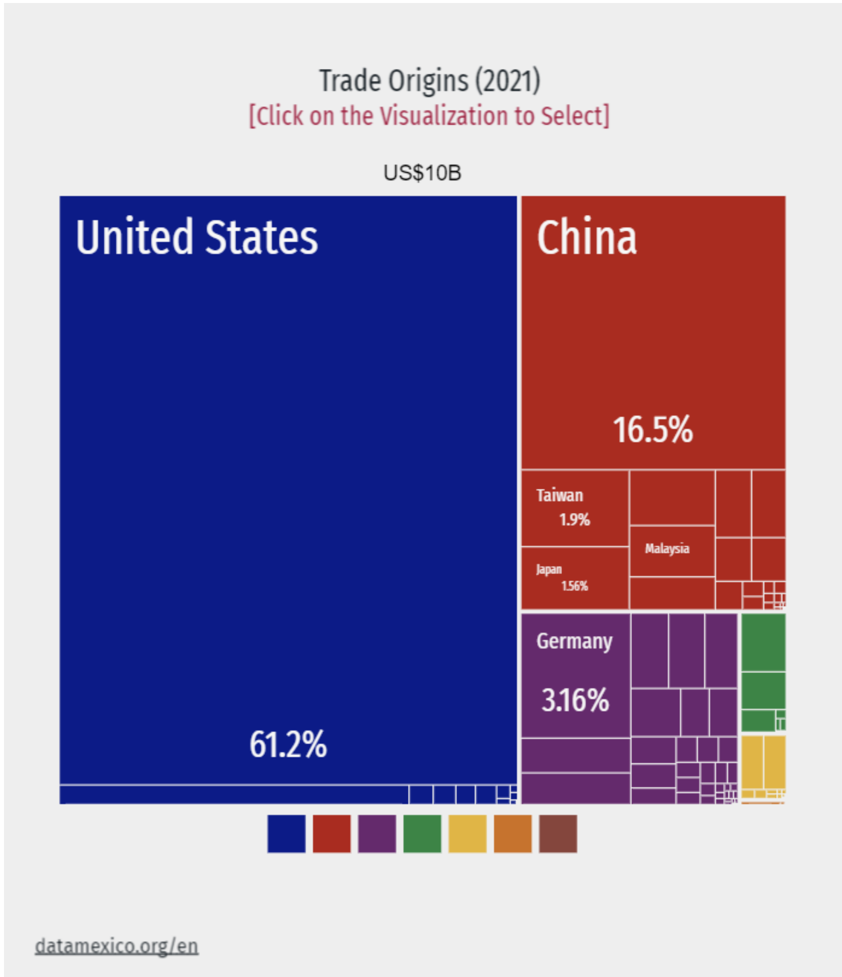
Figure 32 represents the trade destination of the $13.3 billion dollars worth of goods exported by Sonora in 2021. Most of the international sells are destinated to the United Stated, followed by China, Japan and Switzerland. And, similarly, as seen in figure 33, the trade origins of Sonora consist principally of United Stated, followed by China, Germany and Taiwan.

Figure 32: Sonora trade destinations (2021)



Source DataMÉXICO (2022w)

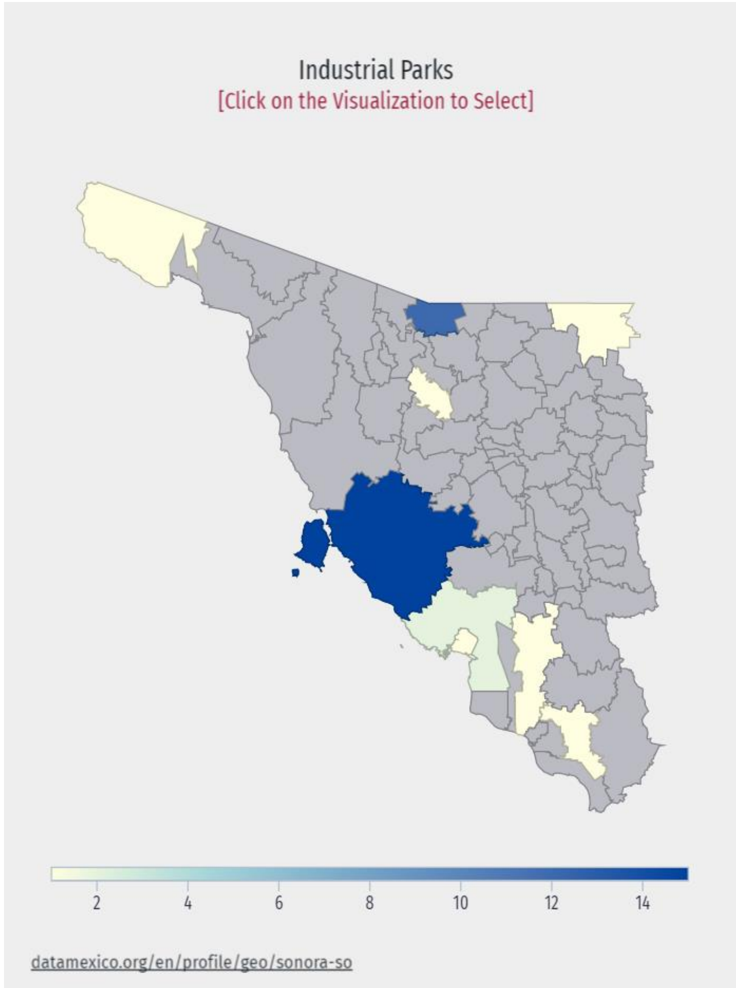
Figure 33: Sonora trade origins (2021)



Source DataMÉXICO (2022x)

In figure 34 there is a map of the industrial parks' location in Sonora, 2020. In the cities of Hermosillo, Nogales and Guaymas, with fifteen, twelve and two industrial parks, respectively. The total number of industrial parks in this state was thirty-three.

Figure 34: Industrial parks by municipality in Sonora: 2020

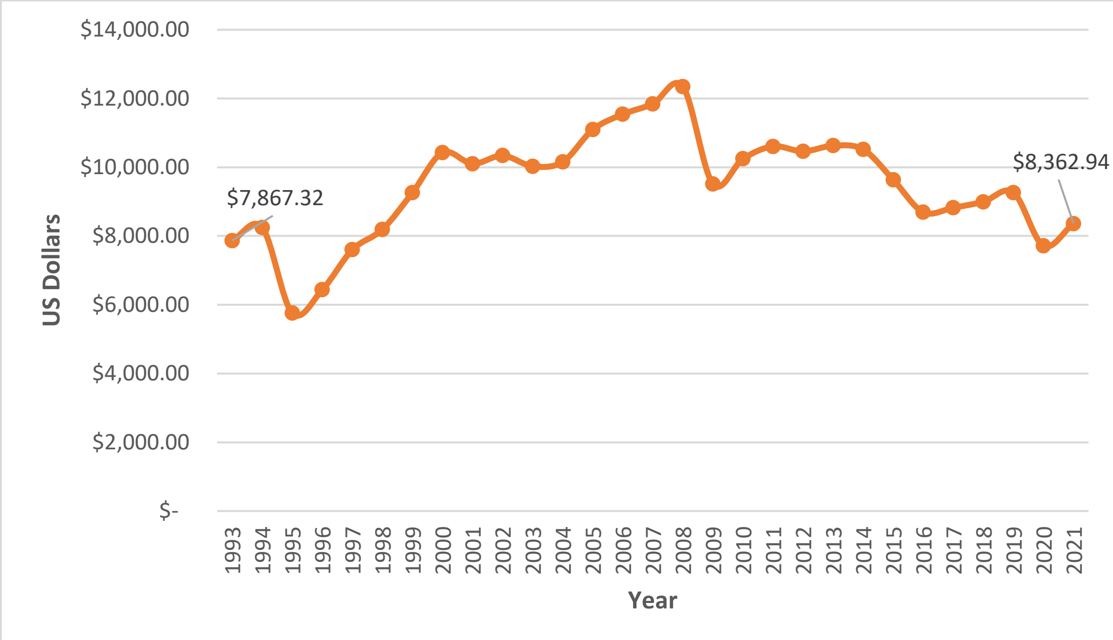


Source: DataMÉXICO (2022y)

2.4.6. Tamaulipas

Tamaulipas is the last of the set of Northern Border Mexican states, with an area of 80,249km^2. In 2021, it registered a population of 3,679,623 people and a GDP of $30,772.47million dollars (INEGI, 2022); it is the state with the lowest GDP in that year in both US and Mexico's set of states. Tamaulipas' GDP per capita compound annual growth rate, from 1993 to 2020, was 0.22%, the second lowest in both sets of states, just above Baja California's.

Figure 35: Tamaulipas GDP per capita: 1993-2021 (2012 US real dollars)

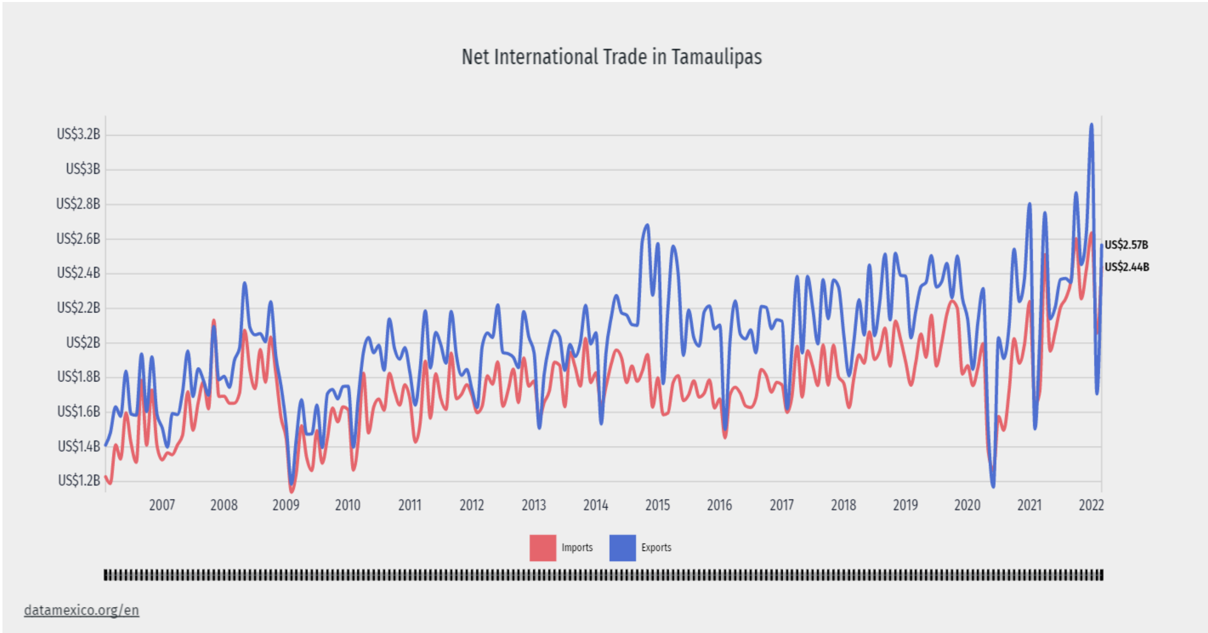


Own elaboration with data from the National Institute of Statistics, Geography and Information (INEGI), Bank of Mexico and the U.S. Bureau of Economic Analysis

In 2021, Tamaulipas economic activities registered the following proportions, according to INEGI (2022). Primary activities just represented 2.6% of Tamaulipas gross added value. Secondary activities, on the other hand, registered a proportion of 33.8%, with highlight activities as the manufacturing industry (23.8%); a highlight in this industry is the fabrication of machinery, equipment, computer equipment and electronic components, with 12.3%. The tertiary sector is the highest, with 63.2% of Tamaulipas gross added value; some activities that stand out are real estate services and rental of movable and intangible assets (13.7%), transport, mailing and storage (11.3%) and retail trade (10.3%).

In international trade, Tamaulipas exports compound annual growth rate from 2007 to 2021 was 2.61%, while the imports compound annual growth rate was 3.33%.

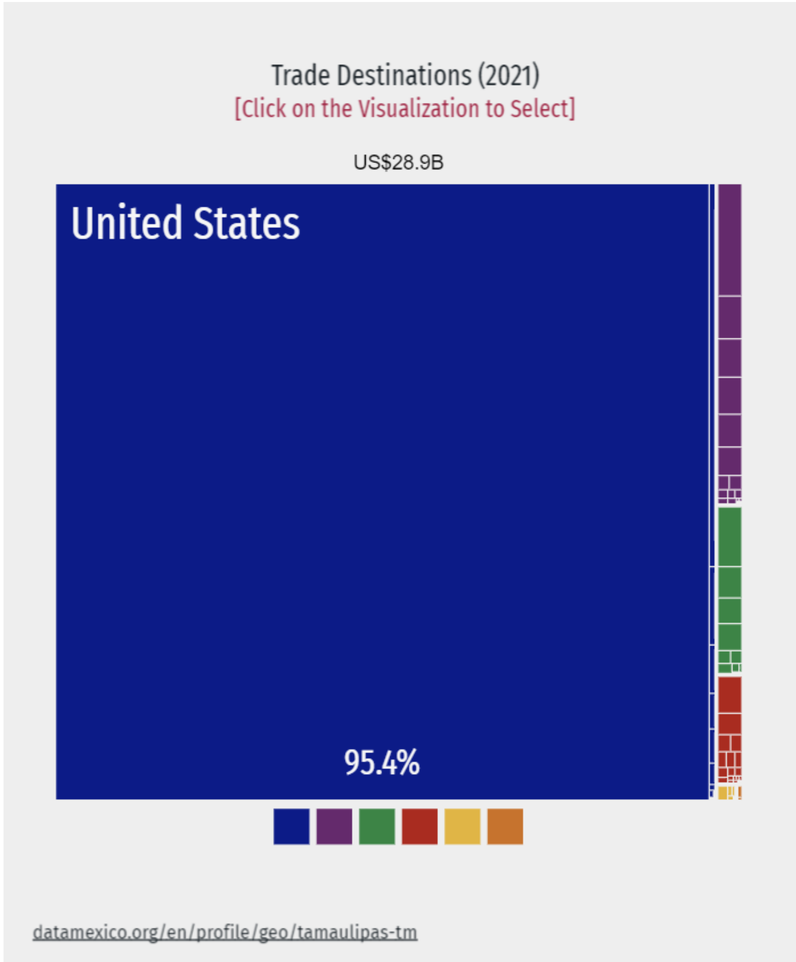
Figure 36: Tamaulipas International Net Trade: 2007-2021



Source DataMÉXICO (2022z)

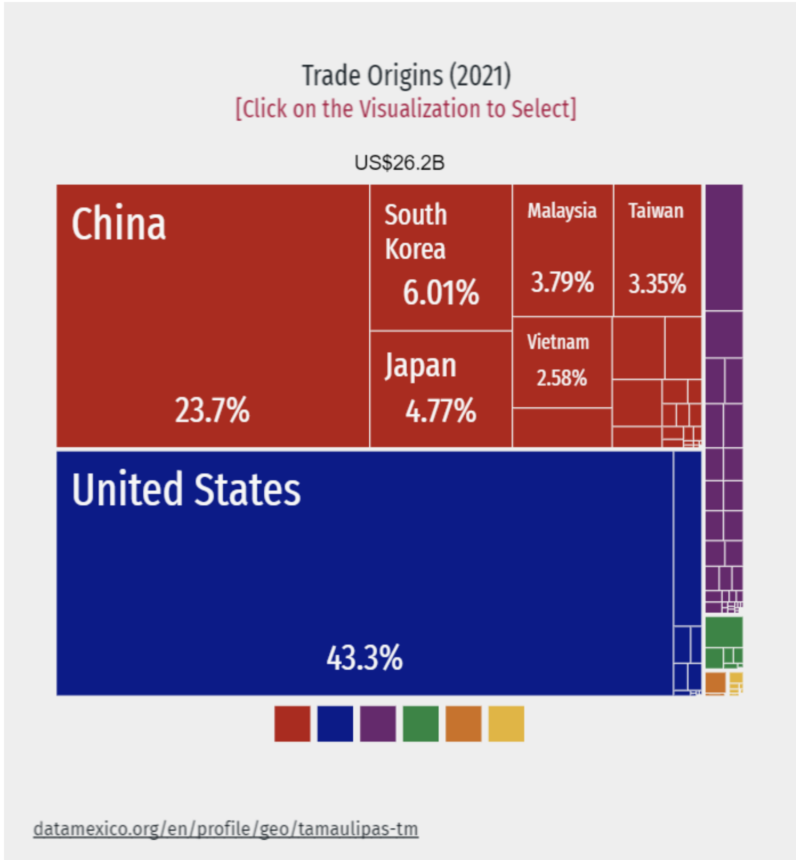
As in the rest of the Northern border Mexican states, Tamaulipas' trade destination, as seen on figure 37, in 2021 registered a mayor proportion for the United States, with 95.4%. In descending order, the next trade destinations were Belgium, Canada and Brazil (DataMÉXICO, 2022f). On trade origins in the same period, as shown on figure 38, the United States was Tamaulipas' number one trade partner too, but in a lesser degree: 43.3%. In descending order, the trade origin countries with higher proportion were all Asian: China (23.3%), South Korea (6.01%), Japan (4.77%) and Malaysia (3.39%).

Figure 37: Tamaulipas trade destinations: 2021



Source: DataMÉXICO (2022a1)

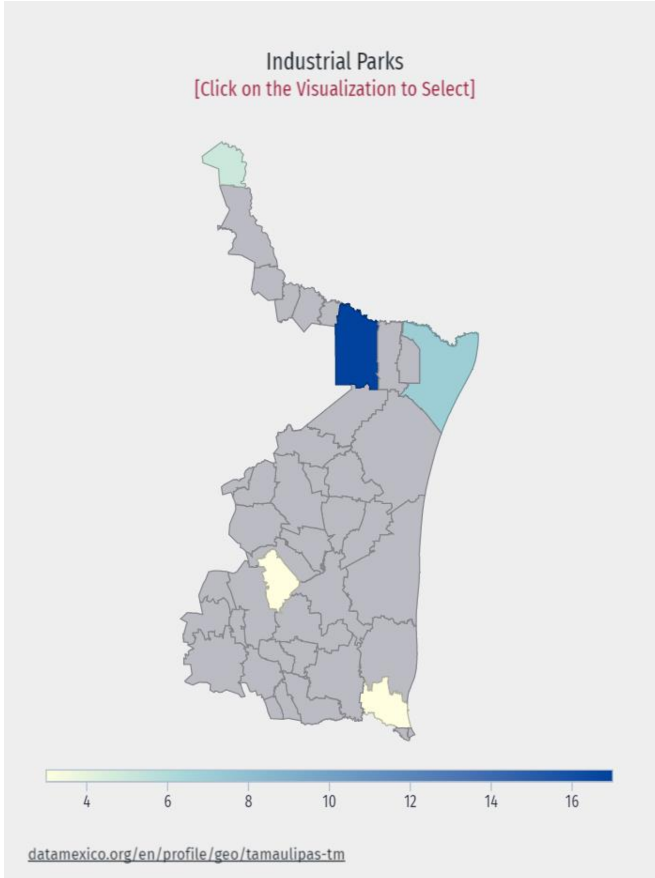
Figure 38: Tamaulipas trade origins: 2021



Source: DataMÉXICO (2022b1)

In 2021, Tamaulipas "registers 25 industrial parks, 1 micro park and 9 industrial parks under construction" (DataMÉXICO, 2022f). In descending order, they were registered in the following cities: 17 in Reynosa, 7 in Matamoros, 5 in Laredo, and three in both Victoria and Altamira.

Figure 39: Industrial Parsk of Tamaulipas: 2021



Source: DataMÉXICO (2022c1)

2.4.7. Mexico's fiscal stimulus for the manufacturing industry and the northern border region

Mexico's tax and fiscal system are very young and centralized compared to the United States'. The Service of Tax Administration (SAT, by its acronym in Spanish), is the federal Mexican institution in charge of federal tax recollection, such as the value added tax, income tax, special tax on products and services, tax on new automobiles, single business tax rate and tax on cash deposits. It was created in 1995, making only 25 years old. Before that, tax recollection was duty of the Secretariat of Finance and Public Credit, making decisions even more centralized. In contrast, the United States Internal Revenue Service (IRS) was established in 1862.

All these different federal taxes named make it only possible for states, that is, at a regional level, to have minor maneuverability in public recollection and spending, turning them severely dependent on federal transactions, despite the known state taxes (property tax, water, transport —driver's license, taxis cards, etc.—, civil registration —birth certificate, marriage certificate, divorces—, payroll tax and notary's office). This also transcends in matter of fiscal stimulus or, as called in the United States, business incentives. The federal fiscal stimulus for the manufacturing industry in Mexico will be described, since there are not exactly at a state level, in contrast with the United States.

2.4.7.1. Fiscal stimulus for the Northern Border Region

According to the Service of Tax Administration of Mexico, it is a tax credit equivalent to the third part of the income tax or provisional payments of the income registered by a company only in the northern border region during a certain period. This region is defined for the municipalities of

> Ensenada, Playas de Rosarito, Tijuana, Tecate and Mexicali of the State of Baja California; San Luis Río Colorado, Puerto Peñasco, General Plutarco Elías Calles, Caborca, Altar, Sáric, Nogales, Santa Cruz, Cananea, Naco and Agua Prieta of the state of Sonora; Janos, Ascensión, Juárez, Praxedis G. Guerrero, Guadalupe, Coyame del Sotol, Ojinaga and Manuel Benavides of the state of Chihuahua; Ocampo, Acuña, Zaragoza, Jiménez, Piedras Negras, Nava, Guerrero e Hidalgo of the state of Coahuila de Zaragoza; Anáhuac of the state of Nuevo León, and Nuevo Laredo; Guerrero, Mier, Miguel Alemán, Camargo, Gustavo Díaz Ordaz, Reynosa, Río Bravo, Valle Hermoso and Matamoros of the state of Tamaulipas (Diario Oficial de la Federación, December 2018).

The Fiscal stimulus for the northern border region is calculated dividing the total income obtained in the preestablished region at a certain period, by the total income registered by the taxpayer in that same period; then, the quotient is multiplied by 100. The third of this proportion is the final fiscal stimulus.

It applies for any national registered taxpayer, as well as foreign residents with permanent residence in Mexico, who perceive income only in the northern frontier region of Mexico related to business activities (Servicio de Administración Tributaria, 2018).

2.4.7.2. Fiscal stimulus for the manufacturing industry and export services

Based on the articles 181 and 182 of the Income Tax Law of Mexico,

> taxpayers referred to this article might apply an additional deduction equivalent to the amount that results of dividing by two the payment for concept of subordinate personal services undertaken to their workers involved in the operation of maquila and that, in its turn, be exempted for such workers and subtract three percent of such exempt payments (Diario Oficial de la Federación, December 2013).

In other word, this fiscal stimulus is the half of the payment for concept of subordinate personal service undertaken to their workers, minus three percent of this half. It applies for any national registered taxpayer, as well as foreign residents with permanent residence in Mexico.

2.4.7.3. Subsidies to the automotive and auto parts industries

In 1982, the subsidies stablished to the automotive and auto parts industries were immensely generous to investors. As described in Mexico's Official Journal of the Federation:

> A subsidy is granted up to 100% of the ad-valorem share specified in General Import Tax Tariff related to raw material and complementary components not produced in the country designated to the fabrication of automobiles, trucks and busses. A 75% subsidy could be granted to raw materials and components of automotive expelled from previous import license, considered indispensable by the Secretary to the fabrication of vehicles. Furthermore, a 75% subsidy to import tariffs could be granted to automotive spare parts not produced in the country destinated to the terminal industry (…) The same subsidy could be granted up to 25% to components considered as national fabrication free from previous license. (…) A 100% subsidy is granted to the ad-valorem quota set in the General Tax Imports Tariff of the raw materials, parts and pieces not fabricated in the country or not in the quantity necessary and that the auto parts industry assigns to the fabrication of components… (Diario Oficial de la Federación, January 1982).

This subsidy applied homogeneously in Mexico to all businesses of automotive and auto parts industry in Mexico.

It is necessary to consider that such subsidies are not the only ones involving the automotive industry. Many others have been approved since 1990, when the liberalization and free trade policies grew exponentially. The application of this subsidies, stimulus and incentives has been on debate recently, as has been called by the actual director of the Service of Tax Administration, Raquel Buenreostro, as of 2021:

> The automotive industry has in Mexico many fiscal benefits compared to other countries. This means that they end up paying a near to cero tax rate or, in some cases, negative, because we return them more than what they paid in taxes… There is a series of incentives that must be revised and we ought to take advantage of international tributary agreements so that in México they pay what is fair (Gonzales, L., June 23, 2021).

On the other hand, the directives of some automobile brands, like Federico Ovejero, vice president of General Motors in Argentina, Paraguay and Uruguay, say, on matter of costs considering the taxrate of Latin American countries:

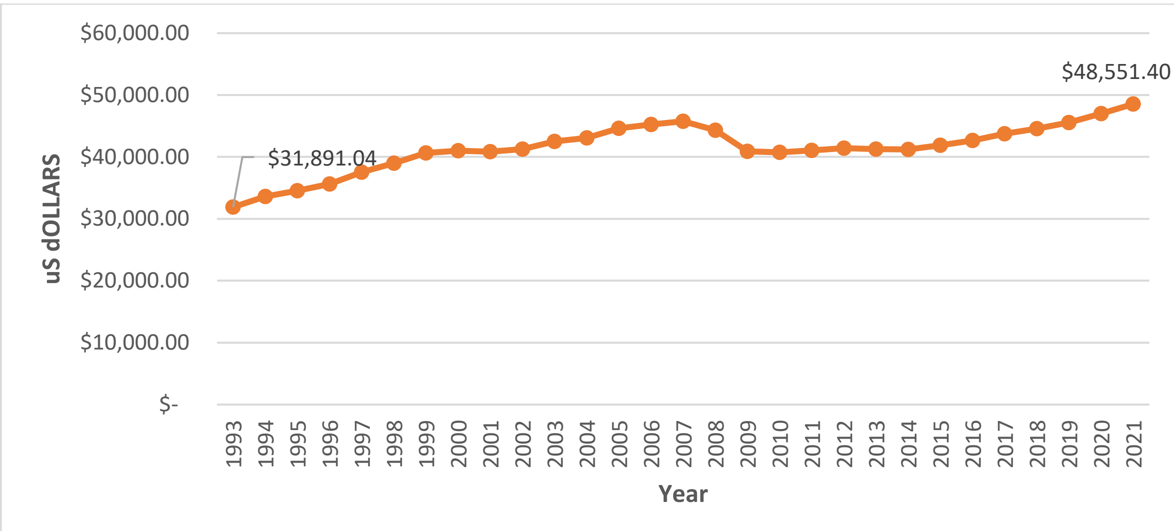
> We did a study three year ago with an international consultant to know the competitiveness of our vehicles in Brazil, Mexico and Argentina. Brazil is 30% more expensive than México to manufacture a car, and Argentina is 60% more expensive than Mexico to manufacture a car (Cluster Industrial, 2021 June 22).

The debate of whether fiscal incentives in industries such as the automotive and manufacturing industry as a whole is a delicate debate in México, because two thigs are crucial to consider: first, the subsidies and fiscal incentives were meant to attract foreign direct investment for the creation of jobs, which, they have; but, second, the companies that initially settled in Mexico due to this incentives have recovered their investment and it is necessary to check, as Raquel Buenrostro said, the actual state of this incentives, especially in an unequal and with poor tax recollection as Mexico.

2.4.8. Arizona

The Grand Canyon State has an area of 295,254 km^2, a population of 7,276,316 people and a GDP of $353,275.32million dollars, as of 2021. Arizona has kept a steady growth in its GDP per capita, like California, but in smaller figures: California GDP per capita is more than $20 thousand dollars higher than Arizona's in 2021. Its compound annual GDP per capital growth rate from 1993 to 2021 is 1.51%. And, in 2021, all total industry of the state represented 1.8% of national production.

Figure 40: Arizona GDP per capita: 1993-2021 (2012 US real dollars)



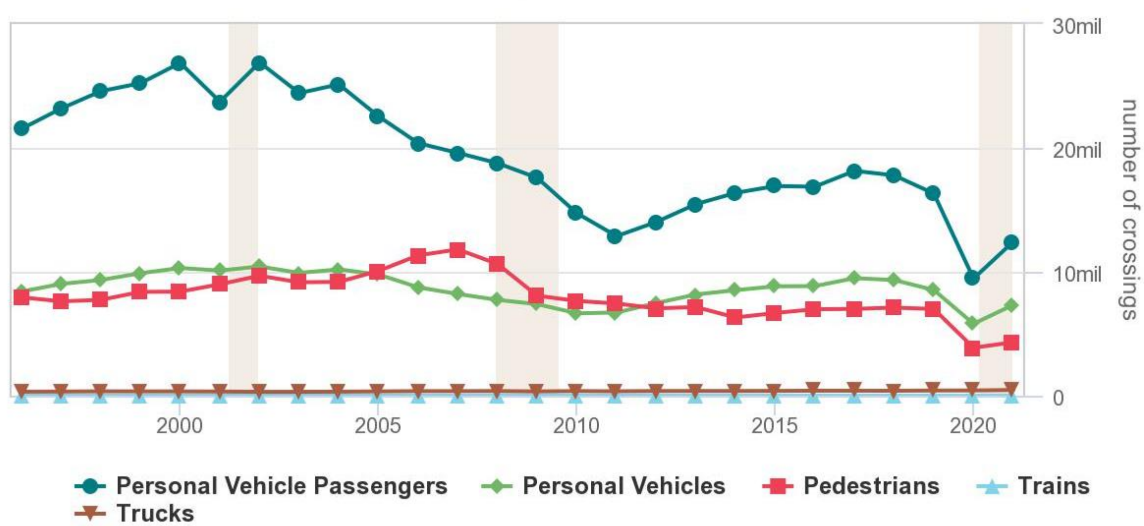
Own elaboration with data from the Bureau of Economic Analysis.

Arizona economic profile highlights for manufacturing (particularly aerospace, electronics and semiconductors), mining (except for oil and gas) and agriculture. In manufacturing, Arizona represented 1.4% of national total U.S. production within this industry, with two highlighted branches: computer and electronic product manufacturing, with 3.4%, and other transport and equipment manufacturing, with 4.4%. In 2019, Arizona percent of total gross state product was 8.37%; the number of firms in 2017 was 4058, and the manufacturing employment in 2020 was 172 thousand workers, which is 5.93% of the share of nonfarm employment (National Association of Manufacturers, 2022).

Mining (except oil and gas), “which is extraction, quarrying, and beneficiating (e.g., crushing, screening, washing, sizing, concentrating, and flotation) (…) for metallic minerals and nonmetallic minerals” (Bureau of Economic Analysis, 2022), represented 7.7% of the US total production. In agriculture, Arizona stands out in its cotton and lettuce production, in which is the second national producer (Arizona Commerce Authority).

About the industrial structure of Arizona, the manufacturing sector represented 8.95% of its GDP in 2021, equivalent to $ 44,707.49 million dollars. From this, 7.41% were durable goods and 1.54% were nondurable goods, relative to the state GDP. On the first subbranch, the most relevant activities were computer and electronic product manufacturing, with 2.77%; transportation equipment, 1.62%; and fabricated metal products, 0.77%. On the second subbranch, the highlighted activities were food and beverage and tobacco products, 0.66%; and chemical manufacturing, 0.38% (Bureau of Economic Analysis, 2022).

Figure 41: Total Border Crossing at Nogales District Ports by Type of Transport (Annual)



Source: Arizona-Mexico Economic Indicators, Ellen College of Management of The University of Arizona.

Arizona holds a tight economic partnership with the Mexican state of Sonora, particularly because of the importance of the Nogales Ports for international trade and tourism. According to the Arizona-Mexico Economic Indicators of the University of Arizona, as seen in figure 41, the total crossing number of personal vehicle passengers, personal vehicles, pedestrians, trains and trucks at the Nogales District Ports has maintained steady levels in the last decades, aside from the effects of the Covid-19 pandemic; from 2019 to 2020, numbers in all crossing border categories dropped, except for trucks, who raised 1.6% (Eller College of Management, The University of Arizona, 2022).

One of the most common ways that states in the U.S. compete for the settlement of investor and capital is through the application of business incentives. Arizona has business incentives for the attraction of capital in its manufacturing industry. The Arizona Commerce Authority describes three manufacturing opportunities. The firs one is *the Qualify Facility Tax Credit*, first stablished in 2012, "to promote the location and expansion of headquarters facilities or manufacturing facilities, including manufacturing-related research & development" (Arizona Commerce Authority, 2022), though the authorization of a $125 million dollars —that is the 2022 maximum available found—per calendar year to qualifying companies. This tax credit offers three options:

> 10% of the qualifying capital investment, or $20,000 per net new job at the facility if the total qualifying investment is less than $2,000 million, or $30,000 per net new full-time employment position associated with the facility if the total qualifying investment is more than $2,000 million, or $30 million per taxpayer per year (Arizona Commerce Authority, 2022).

The second manufacturing opportunity is the partnership that holds the Arizona Commerce Authority with the *Manufacturing Extension Partnership network*, a national public-private association based on Maryland that provides any U.S. manufacturer access to resources they would need, in which "federal appropriations pay one-half, with the balance for each Center funded by state / local governments and/or private entities, plus client fees" (National Institute of Standards and Technology. U.S. Department of Commerce, 2022). Nevertheless, this is not exactly a unique Arizona characteristic, but one that share every other state in the United States, since the MEP is a national network linked to the U.S. Department of Commerce.

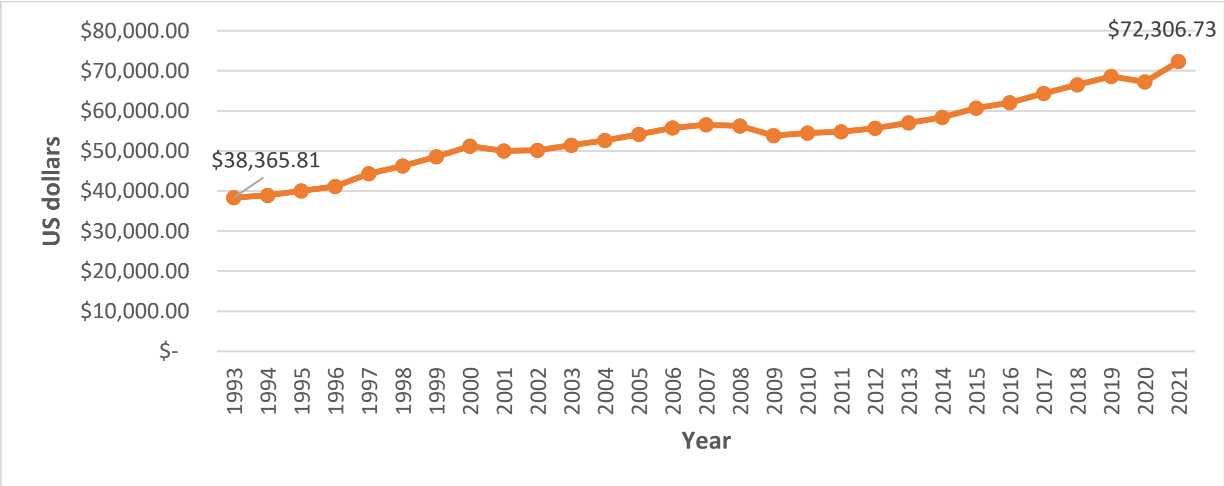
Other business incentives for the manufacturing industry in Arizona include tax exemptions for machinery or equipment used directly in manufacturing, particularly

> machinery, equipment or transmission lines used directly in producing or transmitting electrical power, but not including distribution; machinery or equipment used in research and development; and electricity or natural gas for businesses that are principally engaged in manufacturing or smelting operations (Arizona Commerce Authority, 2022).

2.4.9. California

California is the second largest state in the United States, with an area of 423,970km². In its southern border, it edges with the Mexican states of Baja California and Sonora. It is also one of the most populated states in the United States, with 39,237,836 people and a GDP of $2.8 trillion dollars in 2021 (United States Census Bureau, 2022). Its compound annual growth rate of GDP per capita, from 1993 to 2021, is 2.28%; it has maintained a steady growth in per capita terms in most of the years, except from the 2008-2009 financial crisis.

Figure 42: California GDP per capita: 1993-2021 (2012 US real dollars)



Own elaboration with data from the Bureau of Economic Analysis.

California’s economy is very particular, rich and diversified. In 2020, it represented 14.4/% of all industry total in the United States. Because of its area, climate and universities and research centers, California stands out in agriculture, manufacturing, technology and entertainment. According to the US Bureau of Economic Analysis, California’s agriculture, forestry, fishing and hunting represented 23.4% of the total of the United States in 2020, and about 10% of the state’s labor force works in agriculture.

Some of other remarkable economic activities of California are the tech industry, with Silicon Valley enterprises such as the FAANG group (which stands for Facebook, Apple, Amazon, Netflix and Google); the energy sector stands up as one of the largest in renewable energy sources, such as wind farms; the entertainment industry is a key historical focal point in California, particularly because of the big Hollywood studies, like Warner Brothers, Paramount, MGM, Walt Disney Studios.

In manufacturing, California represented 15.7% of the national production in 2020; the subbranches of manufacturing, computer and electronic product manufacturing, and Apparel, leather, and allied product manufacturing, are more impressive: 41.1% and 35.1% of national production, respectively, in the same year. At a state level, in 2019, manufacturing output represented 10.36% of California’s GDP, with 35 thousand and 321 firms (National Association of Manufacturers, 2022). In 2020, the manufacturing employment in California was 1 million 220 thousand workers.

About the industrial structure of California, the manufacturing sector represented 11.7% of its GDP in 2021, equivalent to $469,430.39 million dollars. From this, 7.18% were durable goods and 4.52% were nondurable goods, relative to the state GDP. On the first branch, the most relevant activities were computer and electronic product manufacturing, with 4.40%; transportation equipment, 0.53%; and machinery products, 0.47%. On the second branch, the highlighted subbranches were chemical manufacturing, 2.59%; and food and beverage and tobacco products, 0.94% (Bureau of Economic Analysis, 2022).

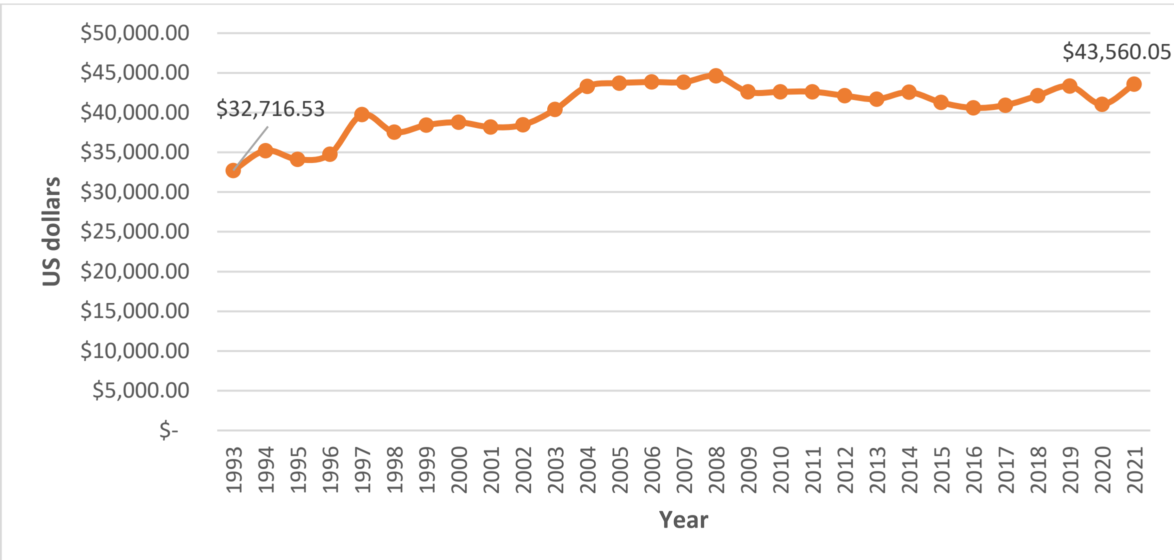
On business incentives, California's manufacturing sector is no exception. In advanced manufacturing, there are two business incentive. The first one, *Sale and Use Tax Exclusion (STE) Program*, "excludes from sales and use taxes purchases of Qualified property if its use is (…) to process Recycled feedstock (…), or that is used in an Advanced Manufacturing process, or that is used to manufacture Alternative Source products or Advanced Transportation Technologies" (California State Treasurer's Office, 2022); applicants are limited to $10 million of STE pear year, and the California State gives a total of $100 million in STE per year. The second one is the *California Lending for Energy and Environmental Needs (CLEEN)* from the California infrastructure and Economic Development Bank (IBank). The CLEEN provides public financing to help the reduction of green-house emissions through two programs: Statewide Energy Efficiency Program (SWEEP) and the Light Emitting Diode Street Lighting Program (LED); companies that apply can receive a loan for IBank from $500 thousand to $30 million dollars (California Infrastructure and Economic Development Bank, 2022).

In less technologically advanced branched of manufacturing, there are two other business incentives. The *Sales and Use Tax Exemption for Manufacturing*, arrange for partial exemption of "sales and use tax on the purchase or lease of qualified machinery and equipment primarily used in manufacturing, research and development, and electric power generation or production, storage or distribution" (California Department of Tax and Fee Administration, n.d.). The second business incentive is also the *California Lending for Energy and Environmental Needs (CLEEN)* from the California infrastructure and Economic Development Bank (IBank), previously explained.

2.4.10 New Mexico

New México is the fifth largest state in the United States, above Arizona and below Montana, measuring an area of 315,194 km^2. It registered a population of 2.115 million people and a GDP of $92,167.71 million dollars in 2021. Even though it's the smallest GPD of the US southern border states, it's almost two or three times the size of the Mexican border states, apart from Nuevo Leon. It has maintained a steady growth in its GDP per capita; its compound annual growth rate from 1993 to 2021 is 1.02%, below Arizona's, California's. and Texas'.

Figure 43: New Mexico GDP per capita: 1993-2021 (2012 US real dollars)



Own elaboration with data from the Bureau of Economic Analysis.

New Mexico's economy pillars are the mining, crude oil production, natural resources and tourist sectors. In 2020, the mining sector in New Mexico represented the following percentages of the US total production: 3.4% in Mining, quarrying, and oil and gas extraction; 3.9% in oil and gas extraction; 4% in support activities in mining (support services of private enterprises on mining). Natural resources production in New Mexico represented 2.1% of all US production in 2020. In the tourism sector, in 2019 "visitors spend $7.4 billion dollars, which generated an income of $2.8 billion dollars for tourism sustained jobs, a 4.8% increase over the prior year" (Tourism Economics, 2020).

New Mexico is the only state in which the manufacturing sector is not as relevant as all other border states on both sides. In 2020, the manufacturing sector just represented 0.2% of the total manufacturing production in the US, and 0.3% in Nonmetallic mineral product manufacturing (Bureau of Economic Analysis, 2022). During 2019, as well, the percent of total gross manufacturing state product just represented 4.39% and, in 2017, it registered 1281 firms in the industry. Speaking of employment, in 2020 there were 26,000 employees; 3.31% share of nonfarm employment (National Association of Manufacturing, 2022).

In New Mexico's industrial structure, the manufacturing sector represented 3.89% of its GDP in 2021, equivalent to $5070.39 million dollars. From this, 1.94% were durable goods and 1.96% were nondurable goods, relative to the state GDP. On the first subbranch, the most relevant activity was computer and electronic product manufacturing, with 1%. On the second subbranch, the highlighted activities were food and beverage and tobacco products, 0.68%; and petroleum and coal products, 0.63% (Bureau of Economic Analysis, 2022).

Even though the manufacturing sector does not represent a role as big as in the other border states, the New Mexico Economic Development Department has seven business incentives for advanced manufacturing. This may be due to a necessity of attraction of investor considering such competitive states near it, like Texas or California. The business incentives are:

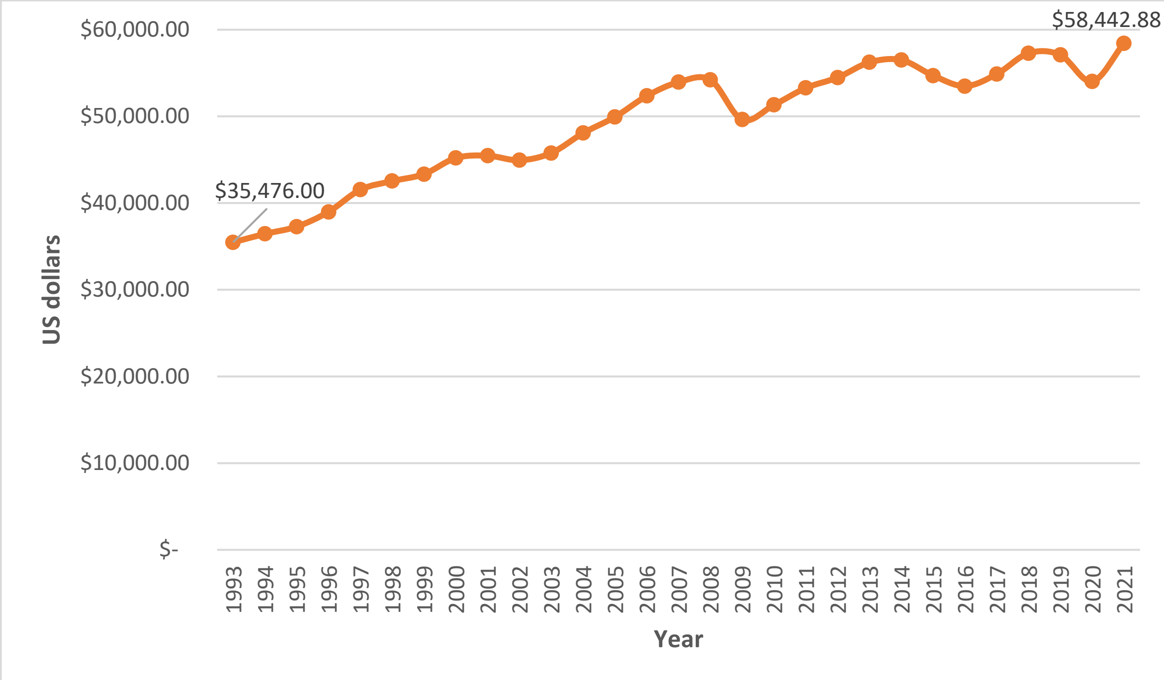
- The *Angel investment credit* is "a tax credit of up to $62,500 (25% of a qualified investment) for an investment made in each of up to five New Mexico companies that are engaging in qualified research (…) or manufacturing" (New Mexico Economic Development Department, 2021).
- The *Consumables Gross Receipts Tax Deduction for Manufacturers*, in which "a seller may deduct receipts from sales to a manufacturer of tangible personal property that becomes an ingredient or component part of a manufactured product" (New Mexico Economic Development Department, 2021).

- The *High Wage Jobs Tax Credit*, in which "a taxpayer (…) may apply for and receive a tax credit for each new high-wage economic-base job. The credit amount equals 8.5% of the wages and benefits paid for each new economic-base job created, up to $12,750 per job" (New Mexico Economic Development Department, 2021).
- The *Investment Tax Credit for Manufacturers*. This consist of compensating or withholding tax equals to 5.125% of the value of qualify equipment, only if "for every $500 thousand dollars, a new employee is added up to $30 million, and for more than $30 million, one employee must be added for each $1 million of equipment" (New Mexico Economic Development Department, 2021).
- The *Rural Jobs Tax Credit*. A tax credit that applies for gross receipts, corporate income or personal income cates, in two levels: 25% of the first $16 thousand in wages on a rural area, or 12.5% of the fist $16 thousand in wages on non-metro areas whose population exceeds 15,000 people.
- *Sigle sales factor*. This business incentive is based on the idea that "manufacturing" excludes construction, farming, power generation and other activities, so there is only one methodology in tax payments for manufacturing instead of several.
- *Trade Support Company in a Border Zone* is a special case, considering its relationship with the Mexican border. This business incentive deduce receipts from customs brokerage or freight forwarder from gross receipts if they are located within 20 miles from a port of entry of New Mexico and Mexico.

2.4.11. Texas

The Lone Star State, Texas, is the second largest state in the United States, below Alaska and above California, with an area of 695,662 km^2, a population of 29.52 million people and a GDP of $1.7 trillion dollars, which is 8.5% of total US production in 2021. On the set of US border states, is the second with the highest GDP per capita in 2021, with $58,442.88 dollars, below California. Its GDP per capita compound annual growth rate, from 1993 to 2021, is 1.8% (again, just below California's).

Figure 44: Texas GDP per capita: 1993-2021 (2012 U.S. real dollars)



Own elaboration with data from the Bureau of Economic Analysis.

The Texas economy is the nineth largest economy in the world if it were a country. The principal economic activities of the state, enlisted in function of target industry clusters, according to the Office of the Texas Governor (2022), are:

- Advance manufacturing: “Texas has been a top high-tech exporting state for nine consecutive years with goods valued at more than $50 billion dollars in 2021” (Office of the Texas Governor, 2022). In the last decade, Texas has attracted a diversified amount of manufacturing businesses and corporations, what makes it today the manufacturer capital of the United States. Some of its most relevant manufacturing companies with a strong presence in the state are Texas instruments, Samsung, Toyota, Caterpillar, Tyson Foods, Navistar, Tesla, Apple, NXP Semiconductor.

  According to the Bureau of Economic Analysis, in 2020, Texas manufacturing represented 9.3% of U.S. total; petroleum and coal products manufacturing, 23.3%; nonmetallic mineral product manufacturing, 10%; machinery manufacturing, 10.4%. Among the many branches of the manufacturing industry in which Texas stands out, it is surpassed almost five times by California in computer and electronic product manufacturing, since Texas only represents 8.7%. Texas is, then, compare to the rest of the border region, a state whose manufactures are primarily based on its oil, mining and aerospace industries.

At a state level, in 2019 the percentage of total gross state product for the manufacturing industry was 13.07%, with 17,552 firms registered in 2017. As for employment, there were 881,000 employees registered in 2020, which is 7.04% of Texas nonfarm employment (National Association of Manufacturers, 2022).

- Aerospace, aviation and defense: “The broad range of aerospace activities in Texas includes fighter planes and helicopter assembly, navigation instrument development, advanced space-flight research, military pilot training and commercial space travel” (Office of the Texas Governor, 2022). Some of the aerospace activities in Texas are fighter planes and helicopter assembly, navigation instruments development, advanced space-flight research, military pilot training and commercial space travel. And companies with a strong presence include Lockheed Martin, American Airlines, Southwest Airlines, Raytheon, General Electric, BAE Systems, Bell Helicopter, Blue Origin, SpaceX and Boeing.
- Biotechnology and Life Sciences: Texas counts with some of the top research institutions and medical centers in the United States, like the Texas Medical Center and MD Anderson Cancer Center, and an annual budget of $5.6 billion dollars. Some biotechnology companies with strong presence in the state include McKesson, Tenet Healthcare, Luminex, Fujifilm Diosynth, Taysha Gene Therapies, Alcon, Medtronic, Abbott, Galderna and Novartis.

In 2020, Texas’ educational services, health care, and social assistance represented 6.8% of the US production in that branch; health care and social assistance, and ambulatory health care services, represented 7% and 8.3%, respectively (Bureau of Economic Analysis, 2022).

- Energy: “Texas leads the U.S. as the top producer of both crude oil and natural gas, with nearly 480,000 miles of pipelines running throughout the state" (Office of the Texas Governor, 2022). Not only in oil Texas has historically stood out, but in renewable energy, reaching number one producer on wind generation capacity and number two in biodiesel production. Some of the principal companies that reside in Texas are Exxon Mobil, Plains GP Holdings, Phillips 66, Baker Hughes, Valero Energy, ConocoPhillips, Energy Transfer, Occidental Petroleum, Enterprise Product and Partners Halliburton.

In 2020, Texas represented 40.9% of national mining, quarrying and oil and gas extraction in the United States; 58% of oil and gas extraction, and 24.9% of pipeline transportation (Bureau of Economic Analysis, 2022).

- Information technology (IT): The research and development invested by both the public and private sector in Texas' research institutes and universities have gained the state a national focus on its IT. Such as, that the US Army selected Texas as the place where to develop science and technology for the army. Also, Texas strong academic institutions have made it among the top two states for number of technology-related patent assignees for fourteen years. Some of the companies of this branch with a strong presence in the state are AT&T, Cisco, Dell, Google, HPE, Microsoft, Apple and IBM.
- Petroleum refining and chemical products: As in the energy sector, Texas petroleum industry has worldwide recognition. "Texas refineries process almost 5.9 million barrels of crude oil per day, which is 31% of the nation's refining capacity (…) more than 50% of the total U.S. chemical production is produced and processed by Texas chemical manufacturers" (Office of the Texas Governor, 2022). This cluster holds 75,000 workers, the majority located in the city of Houston. Some of the best Texas companies in petroleum refining are Holly Frontier, Westlake Chemical, Valero Energy, Par Pacific Holdings, Tesoro, Celanese, Chevron Phillips Chemical Company and Huntsman.
- Creative industry: The production of music festivals, films, TV shows, commercial and video games has taken a growing role in Texas during recent years. In 2020, "the Texas music industry contributed $10.8 billion in annual

economic activity" (Office of the Texas Governor, 2022). In film, there are 250 production companies based in the state. During 2020, in arts, entertainment, recreation, accommodation, and food services, Texas represented 7.8% of the US total.

Texas' industrial structure, speaking of the manufacturing sector, represented 11.06% of its GDP in 2021, equivalent to $269,835.88 million dollars. From this, 5.66% were durable goods and 5.40% were nondurable goods, relative to the state GDP. On the first subbranch, the most relevant activity was computer and electronic product manufacturing, with 1.43%; transportation equipment, 0.98%; machinery, 0.79%; and motor vehicles, bodies and trailers, and parts manufacturing, 0.68%. On the second subbranch, the highlighted activities were chemical manufacturing, 2.35%; petroleum and coal products, 1.6%; and food and beverage and tobacco products, 0.93% (Bureau of Economic Analysis, 2022).

The principal motive that explains the settlement of companies in Texas is its low corporate taxes. Beginning by acknowledging that the Texas State Constitution abolished personal income tax in 2019, and that municipalities, counties and school districts only rely on property taxes for founding, the Lone Star State government has increasingly push for tax business incentives. For example, on matters of manufacturing and R&D

> The state offers a number of other advantages for businesses, including a sales tax exemption for manufacturing machinery and equipment and R&D-related materials, software, and equipment, as well as a franchise tax exemption to manufacturers, sellers or installers of solar energy devices. Property tax abatements, permit fee waivers, local cash grants and local funding are also available to assist companies looking to relocate or expand in the state (Texas Economic Development Corporation, 2022).

More specifically, there a number of Texas business incentives and programs that involve the manufacturing industry. The *State Sales and Use Tax Exemptions* declares that "leased or purchased machinery (…) that are used or consumed in the manufacturing (…) of tangible personal property for ultimate sale, are exempt from state and local sales and use tax" (The State of Texas Governor, 2019); this also applies on exception of taxes for the use of natural gas and energy by manufacturing companies. On bonds, the *Tax-Exempt Industrial Revenue Bonds* "are designed to provide tax-exempt financing to finance land and depreciable property for eligible industrial or manufacturing projects" (The State of Texas Governor, 2019) for up to 20 million dollars since 2007. In Ad-valorem tax exemption, the *Freeport tas exemption* "qualifies for an exemption from ad valorem taxation of goods only if they has been detained in the state for 175 days or less for the purpose of assembly, storage, manufacturing, processing, or fabricating" (The State of Texas Governor, 2019); similarly, the *Good-in-Transit Incentive* adds an exemption to ad-valorem tax if the personal property used for assembling or manufacturing has been acquired in Texas or imported into the state. And, finally, on the Renewable energy incentive, the *Wind and Solar Energy Tax Exemption and Deductions* gives a tax exemption to manufacturers or installer of solar energy, by a deduction of a state's franchise tax on renewable energy.

2.5. Analysis and conclusions of the section

First, the frontier region of the United States and Mexico, considering the colliding states of both sides of the border, is an immensely rich and large region that includes such wealthy states as California and Texas, and an international bilateral trade that operates via highways and railroads worth of billions of dollars annually. And, as rich as it is, it's also one of the most unequal regions of the world: in 2021, the GDP per capita of the Mexican set of states was, on average, $15,556.24 dollars, with a standard deviation of $3217.02 dollars. In the set of states of the Unites States, the average GDP per capita value in that year was $78,759.22 dollars, with a standard deviation of $17,914.05 —the inequality on the southern border states of the U.S. is very high, making the inequality broader as the scales diminishes, as Yamamoto (2008) pointed out—.

On international trade and economic integration, all Mexico's border states shared that the United States is its principal exports destination. From a national perspective, the manufacturing productive branches with a mayor participation of Mexico's exports to the United State's entities are *transport equipment,* and *computer equipment and electronics*: “these productive branches are the principals in international trade between Mexico and the United States, which reflect a participation of 53.3% of Mexican origin exports destinated to the United States in 2018” (García, 2021: 98). Nevertheless, the set of Mexican states has more diversified international import trade partners, with most of them having a great proportion of input from Asian countries, particularly China and South Korea.

From a regional perspective, the global Foreign Direct Investment destinated to the manufacturing industry in the northern border states of Mexico, from 2008 to 2013, shows that Nuevo Leon held 11.50% of the national FDI in manufacturing during that period, followed by Chihuahua (8.25%), Baja California (6.13%), Coahuila de Zaragoza (5.28%), Tamaulipas (4.32%) and Sonora (2.46%) (García, 2021: 107). And the global FDI destinated to the subbranch production of computer equipment and electronics in the northern border states of Mexico, as proportion of national FDI in that subbranch from 2003 to 2018, was 21.25% in Baja California, 14.83% in Tamaulipas, 11.82% in Chihuahua, 4.45% in Nuevo León, 3.49% in Sonora, and 0.64% in Coahuila de Zaragoza, which makes it 56.48% of the FDI destinated in this subbranch in the North Zone of Mexico. In that same period, the FDI destinated to production of transport equipment in Mexico, as a proportion of the national FDI in that subbranch, was 17.2% in Chihuahua, 9.57% in Coahuila de Zaragoza, 7.23% in Nuevo León, 4.40% in Baja California, 3.84% in Sonora, and 2.90% in Tamaulipas; these sum up to 45.14% for the northern border states of Mexico (García, 2021: 109-110).

These proportions show the national importance of the manufacturing industry in the northern border sites of Mexico in recent years. On the U.S. set of states, California and Texas represent a huge part of the manufacturing industry in the United States, making 15.7 and 9.3% of its national production in 2021, respectively.

To have a clearer perspective of the quantitative differences in area, population, GDP and manufacturing GDP among both set of border stares, these measures are organized in table 1. In size, all U.S. southern border states are larger than Mexico's; only Chihuahua compares to the state in the U.S. set of states, being 47,799 km^2 smaller. On population, the U.S. states hold larger number too, except for New Mexico, whose population is roughly 1 million people less than Chihuahua, Coahuila de Zaragoza, Sonora and Tamaulipas, and 4 million less than Nuevo León. California and Texas stand out: even adding up the number of people in all Northern Border Mexican states —22,990,575 people—, its approximately 16 million and 6.1 million people less than California and Texas, respectively. But, on compound annual population growth rate, Mexican states present higher values than North American southern border states: Baja California's population grew the fastest, while New Mexico and California grew the smallest; Arizona had the second biggest compound annual population growth rate.

Table 1 Comparative framework of the border states of Mexico and the United States

State	Area in km2	Population (2021)	Population growth rate: 1993-2021	GPD in millions of 2012 dollars (2021)	GDP Compound Annual Growth Rate: 1993-2021	GDP per capita in 2012 dollars (2021)	GDP pc Compound Annual Growth Rate: 1993-2021	Manufacturing GDP in milions of 2012 dollars (2021)	Manufacturing GDP Compound Annual Growth Rate: 1993-2021
Mexico's Northern border States									
Baja California	71,450.00	3,690,160.00	2.30%	$ 38,291.26	2.07%	$ 10,376.58	-0.22%	$ 12,246.21	4.20%
Coahuila de Zaragoza	151,571.00	3,261,259.00	1.54%	$ 36,258.13	2.00%	$ 11,117.83	0.46%	$ 16,366.72	3.58%
Chihuahua	247,455.00	3,836,506.00	1.26%	$ 36,181.32	2.38%	$ 9,430.80	1.10%	$ 11,248.98	3.97%
Nuevo León	64,924.00	5,685,888.00	1.84%	$ 85,944.44	2.81%	$ 15,115.39	0.96%	$ 23,902.09	3.15%
Sonora	179,355.00	3,111,119.00	1.57%	$ 36,551.79	1.94%	$ 11,748.76	0.36%	$ 8,692.15	3.32%
Tamaulipas	80,249.00	3,679,623.00	1.46%	$ 30,772.48	1.68%	$ 8,362.94	0.22%	$ 8,168.72	2.93%
TOTAL	795,004.00	23,264,555.00		$ 263,999.42				$ 80,624.86	
U.S.A Southern border States									
Arizona	295,254.00	7,276,316.00	2.10%	$ 353,275.33	3.64%	$ 48,551.40	1.51%	$ 31,626.65	2.25%
Califonia	423,970.00	39,237,836.00	0.81%	$ 2,837,159.43	3.12%	$ 72,306.73	2.29%	$ 332,081.00	2.50%
New Mexico	315,194.00	2,115,877.00	0.92%	$ 92,167.71	1.96%	$ 43,560.05	1.03%	$ 3,586.86	-3.18%
Texas	695,662.00	29,527,941.00	1.75%	$ 1,725,697.97	3.58%	$ 58,442.88	1.80%	$ 190,885.32	2.70%
TOTAL	1,730,080.00	78,157,970.00		$ 5,008,300.43				$ 558,179.82	

Own elaboration with data from I.N.E.G.I., B.E.A and U.S. Census Bureau.

The production of California and Texas is hardly comparable not even with Mexico Northern border, but with its North American border peers, Arizona and New Mexico. California's GDP is 8 times Arizona's and 30 times New Mexico's, while Texas' is 4.75 times Arizona's and 18 times New Mexico's. Compared Nuevo León, the Mexican border states with highest GDP, California's and Texas' GDP is 33 and 20 times Nuevo León's, respectively. As for compound annual GDP growth rates, all border states from both sets reached levels beyond 4%, in which stands out Arizona, Texas and California on the U.S., and Nuevo León and Chihuahua on Mexico

In GDP per capita, despite their large populations, California and Texas protrude again, but with smaller differences against Arizona and New Mexico. This last state had the lowest GDP per capita in the U.S. set of states. On the Mexican set, Nuevo León registered the greatest levels in this variable, while Tamaulipas registered the lowest in both border state sets. The states with largest compound annual GDP per capita growth rate were, in descending order, California, Texas, Arizona and Chihuahua.

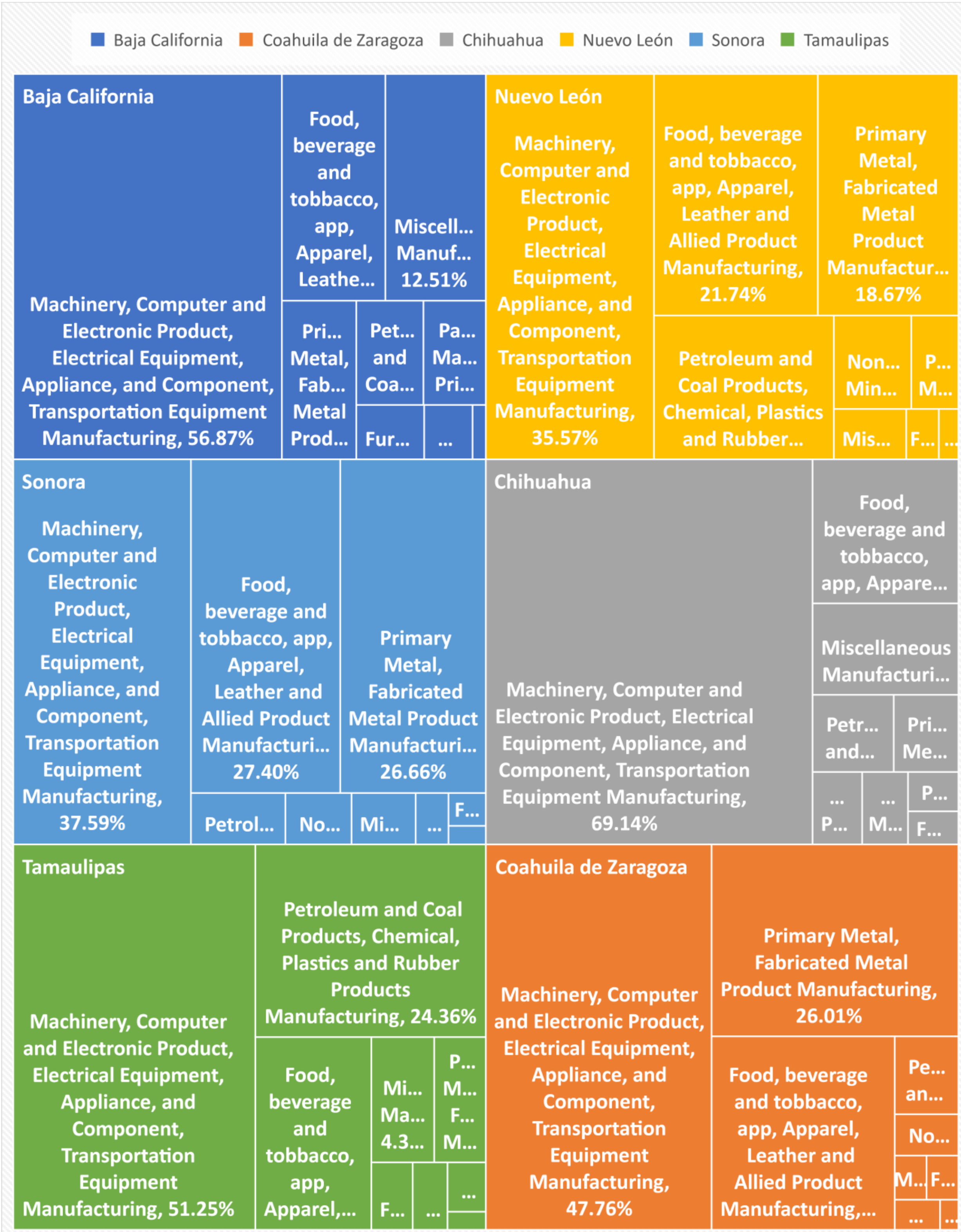
At last, California and Texas again stand out as principal states on manufacturing production, not only on both sets of border states, but in the whole United States if compared with the rest of the nation. As well as containing the states with higher number in this measure, the U.S. border states also has the one with lower manufacturing GDP compared to all others in Mexico and the U.S.: New Mexico. On the Mexican states, Nuevo Leon stand out, again, being the one with highest manufacturing GDP; the rest of the Mexican border states registered values from $8,000 million to $16,000 million dollars. The largest compound annual growth rates on this variable were registered all in Mexican states, particularly Baja California and Chihuahua, with 4.3% and 3.97%, respectively. Texas and California registered the highest growth rates on this matter in the U.S. states set, and New Mexico just registered a rate of -3.18%, the lowest in all the region.

To have a time comparative framework between years 1993 and 2021, and not only analyzed 2021 digits, figures 45 and 46 illustrate the economic structure of the Mexican set of states in that pair of years, while figures 47 and 48 show it for the U.S. set of states for the same periods. Since both countries share the same National Income and Product Accounts system through the North America Industry Classification System (NAICS) —along with Canada—, classifications were summed up into nine categories, each of them consisting of three digits of the NAICS classifications, to have a parallel view between the USA and Mexico border state's industrial structure through time.

Figure 45 Manufacturing industry structure on the northern border states of Mexico: 1993

Own elaboration with data from I.N.E.G.I.

Figure 46 Manufacturing industry structure on the northern border states of Mexico: 2021



Own elaboration with data from I.N.E.G.I.

All the Mexican northern border states had a turn to the production of Machinery, Computer and Electronic product, Electrical Equipment, Appliance and Component, Transportation Equipment Manufacturing, in proportion to the overall Manufacturing Sector, in the last three decades. While in 1993 four out of six of them carried a major role in this branch, by 2021 the six of them base most of their manufacturing industry in it.

In 1993, Baja California's manufacturing industry was based 43.7% in Machinery, Computer and Electronic product, Electrical Equipment, Appliance and Component, Transportation Equipment Manufacturing**,** while Chihuahua it was 46.95%; Coahuila, 39.42%; Nuevo León, 24.99%; Sonora, 33.1% and Tamaulipas 43.8%. In 2021, that same category represented 56.8% of Baja California Manufacturing Industry, 69.14% of Chihuahua's, 47.76% of Coahuila's, 35.57% of Nuevo León's, 37.59% of Sonora's and 51.25% of Tamaulipas'.

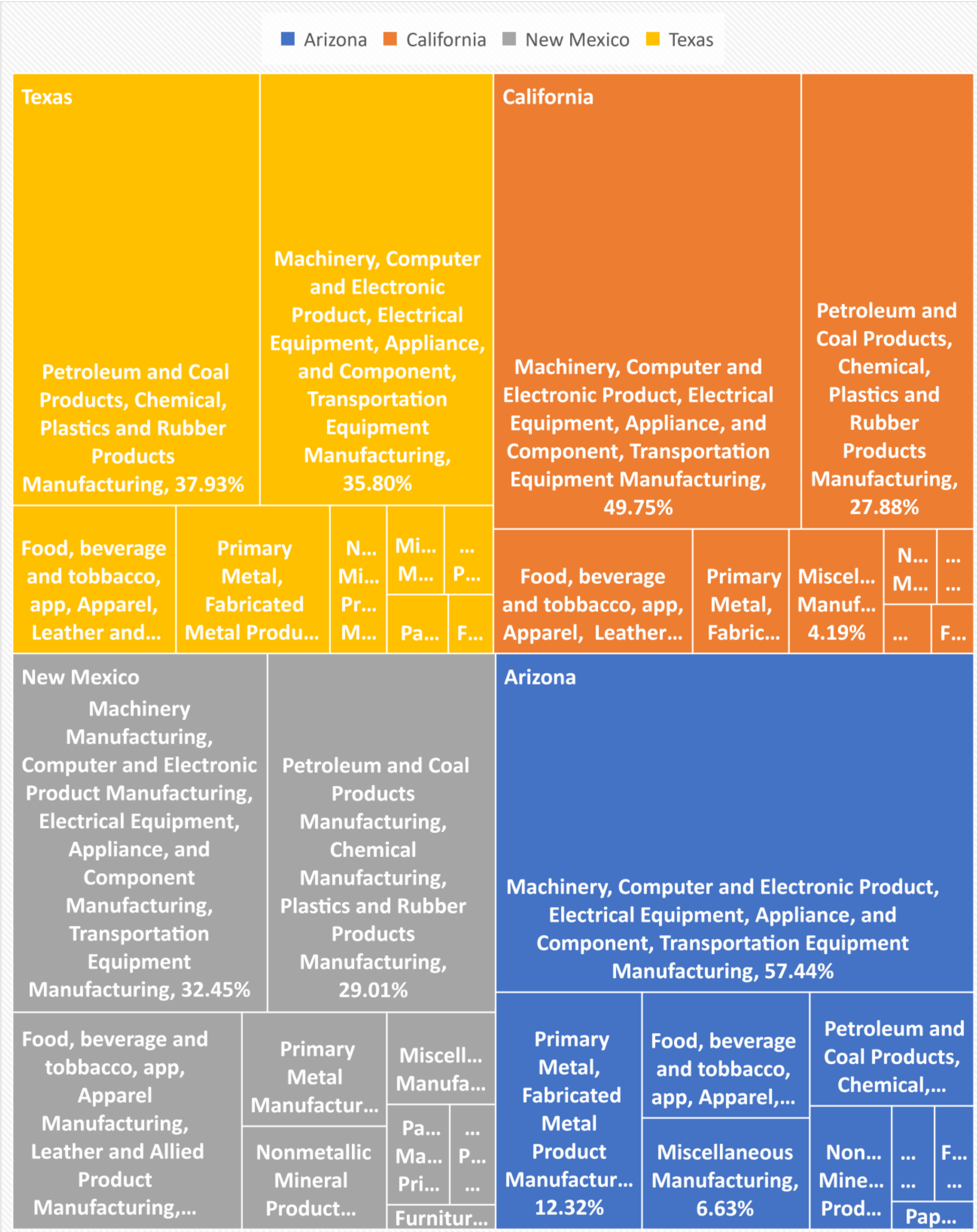
In Baja California, Chihuahua, Sonora and Tamaulipas, the trade-off in proportion from one category to another was mainly from Food, beverage, tobacco, app., Apparel, Leather and Allied product Manufacturing, to Machinery, Computer and Electronic product, Electrical Equipment, Appliance and Component, Transportation Equipment Manufacturing. In Coahuila and Nuevo León this trade-off was from two categories: Primary Metal, Fabricated Metal Product Manufacturing, and Nonmetallic Mineral Product Manufacturing, to Machinery, Computer and Electronic product, etc. Manufacturing.

The United States southern border states manufacturing industry had a different change. In 1993, Arizona, California, New Mexico and Texas held 63%, 48%, 83% and 40% of their Manufacturing Industry in Machinery, Computer and Electronic products, Transportation Equipment, etc. respectively; in 2021, in the same category, Arizona held 57.44%, California 49.75%, New Mexico 32.45% and Texas 37.93%. That is to say, while the Mexican set of states specialized in Machinery, Computer and Electronic products, Transportation Equipment, etc., the US set of states didn't have such a big trade-off in that branch, except for New

Figure 47 Manufacturing industry structure on the southern border states of the U.S.: 1993

Own elaboration with data from B.E.A.

Figure 48 Manufacturing industry structure on the southern border states of the U.S.: 2021



Own elaboration with data from B.E.A.

Mexico, whose 83% in Machinery, Computer and Electronic products, Transportation Equipment, etc. in 1993, trade-off to 32.45% in such brand, while 29.01% in Petroleum and Coal, Chemical, Plastic and Rubber, and Rubber Products Manufacturing, and 17.68% to Food, Beverage and Tobacco, and Apparel Manufacturing. Other trade-offs include a decrease in Paper and Printing Industries for and increase in Primary Metal and Fabricated Metal Products, and Petroleum, Coal, Chemical and Rubber Products in Arizona and California.

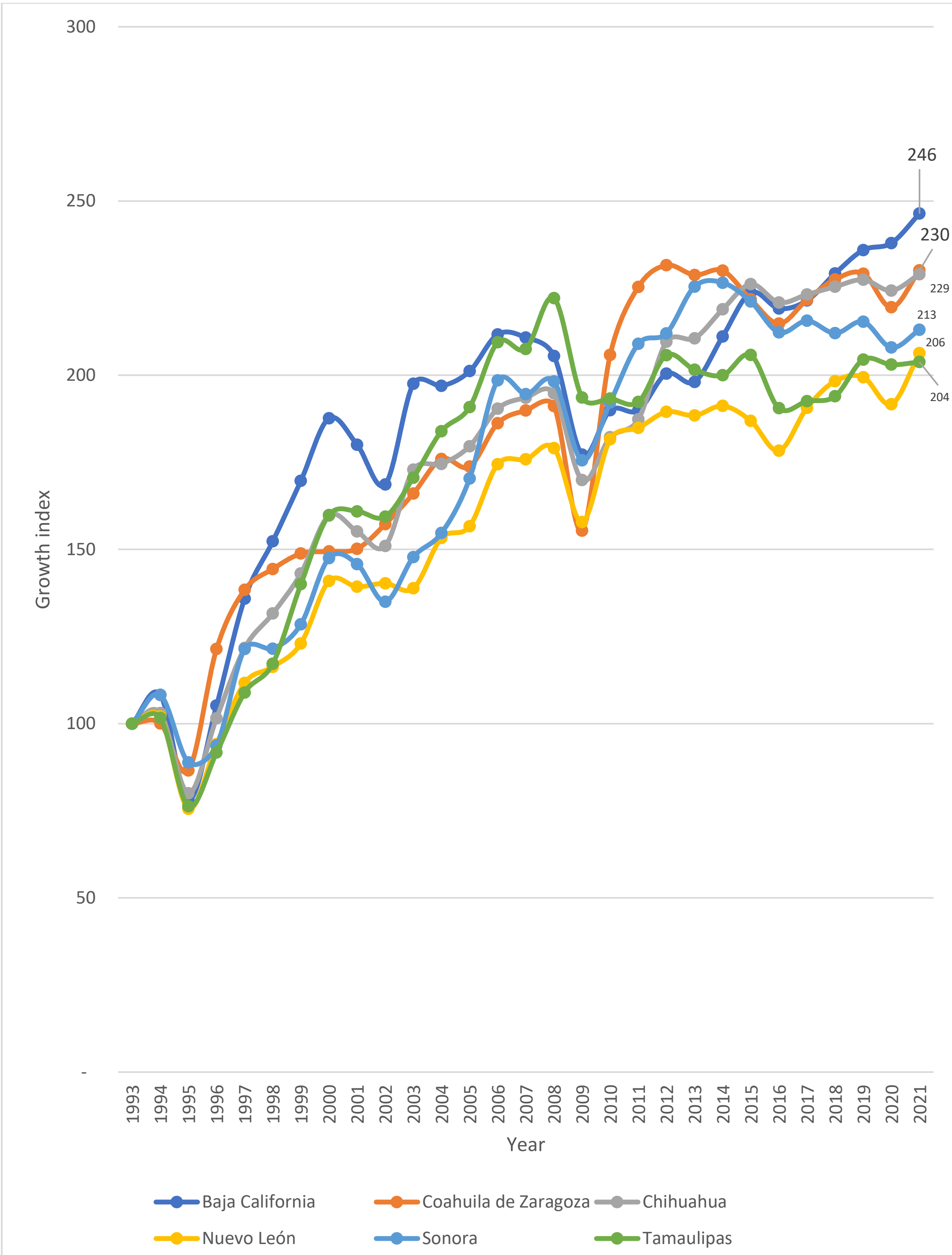
These changes in the industrial structure of the border region, on both sides of the border, concur with Fuentes, Gaytan and Brugés (2023) research: through the estimations and analysis of value-added chains embedded in the bilateral commerce of intermediate and final goods in California-Mexico and Texas-Mexico for 2013, they found that:

> The bilateral-sectoral trade balance shows that Texas (TX) and California (CA) specialize in exports of intermediate goods. In contrast, Mexico (MX) specializes in final goods, resulting in low export multipliers for the latter. MX maintains high dependence on intermediate goods from TX, CA, and third places, resulting in lower foreign exchange earnings per dollar exported. Finally, TX-MX has an energy-technology trade pattern, while CA-MX has a technology-energy trade pattern (Fuentes, Gaytan and Brugés. 2023: 101).

This is represented on figures 48 and 46, since most of the Mexican set of States in 2021 focused their manufacturing production on Machinery, Computer and Electronic product, Electrical Equipment, Appliance and Component, Transportation Equipment Manufacturing, and Food, beverage, tobacco, app., Apparel, Leather and Allied product Manufacturing, while the US set of States in 2021 focus also on Machinery, Computer and Electronic product, Electrical Equipment, Appliance and Component, Transportation Equipment Manufacturing, but —in contrast with Mexico Northen Region— on Petroleum and Coal, Chemical, Plastic and Rubber, and Rubber Products Manufacturing. California and Texas spotlight, since adding both branches represents 73.73 and 77.63% in 2021, respectively; in 1993 they added 61% in California and 62% in Texas.

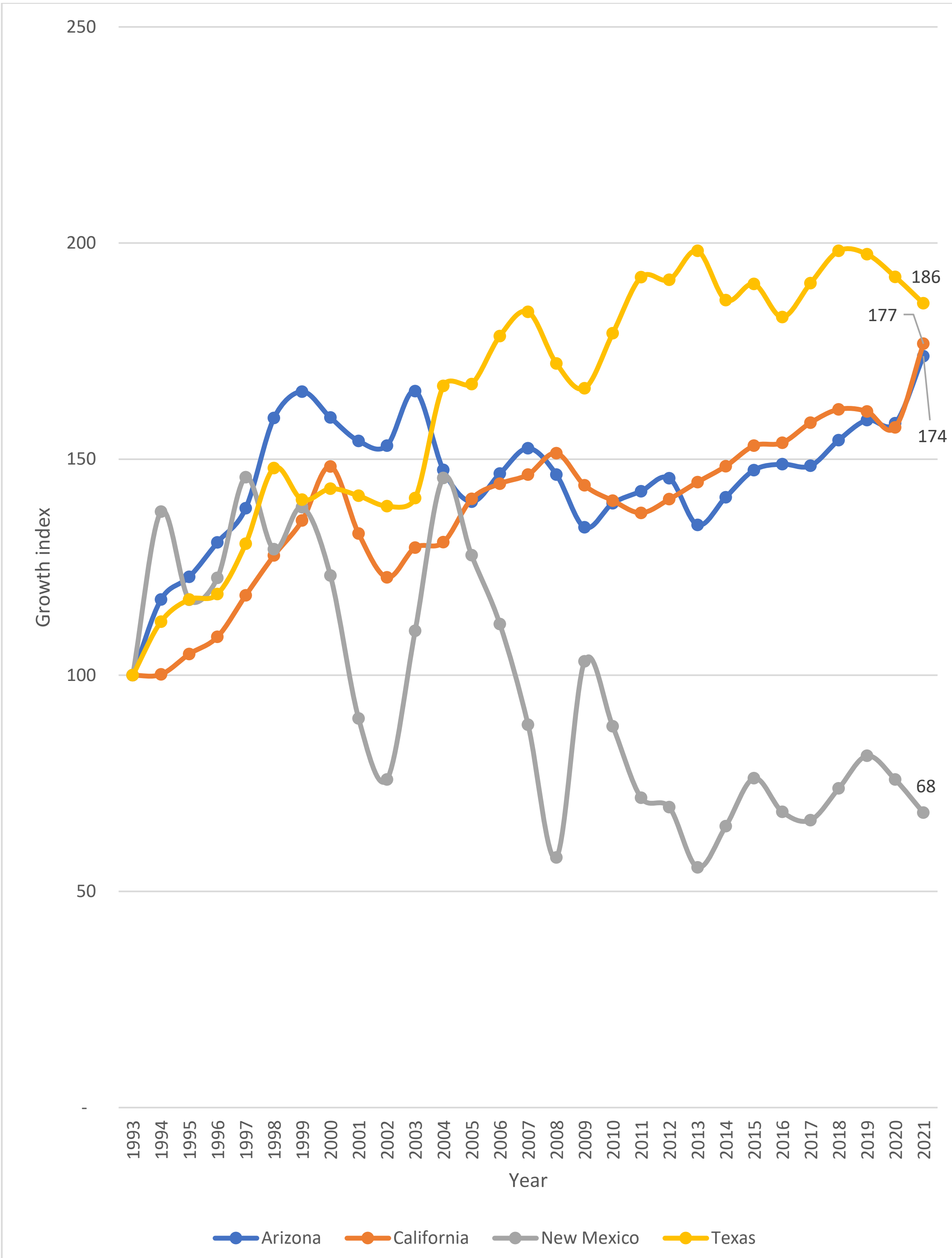
On the growth of the Manufacturing industry by set of States, figures 49 and 50 show the manufacturing GDP growth index of the U.S. and Mexico border states, where 1993=100. All Mexican border states have a similar tendency and greater values than the U.S. border states, except for Texas, who shares the Mexican states tendency and is higher than the other U.S. states. All Mexican states present a prolonged fall in 1995, 2001 and 2008, due to the different financial crisis and recessions. Over all border states, New Mexico presents the lowest levels in the index.

Figure 49 Manufacturing GDP growth index of the Mexico Northern border States: 1993-2021 (1993=100)



Own elaboration with data from I.N.E.G.I., B.E.A and U.S. Census Bureau

Figure 50 Manufacturing GDP growth index of the USA Southern border States: 1993-2021 (1993=100)



Own elaboration with data from I.N.E.G.I., B.E.A and U.S. Census Bureau

Other major difference among the U.S. and Mexican border states manufacturing industries, besides the production and employment, is their business incentives. Arizona has three, California has four (two for advance manufacturing and two for less specialized manufacturing branches), New Mexico has seven for advance manufacturing as well, and Texas has five, along with tax cuts on many affairs, including R&D and manufacturing.

Mexico is behind on regional business incentives. The centralized degree of the Mexican Service of Tax Administration only allows for one regional fiscal stimulus on some Northern border cities, as described before. Besides that, there are national fiscal stimulus and subsidies for the manufacturing industry in general, and the automotive and auto partis industry in particular. Nevertheless, these are not divided by region, rather than by industry or sector, and they are all federal level. Adding this to the poor state level tax recollection in Mexico and the lack of regional political industry planning by state in their State Development Programs, it's hard to picture how exactly companies decide whether to establish in one state or other in Mexico. It seems that the fiscal stimulus of this country, besides the one dedicated to northern border cities, make the nation as a homogeneous place to invest in matter of fiscal policy. In the United Stated there is a tax competitive environment to attract investors; in Mexico, there is almost none.

There are other qualitative differences to consider on industrial location in Mexico: governability, regional security, public and private high education institutions that bring capable and qualified labor force, transport routes. Maybe these elements play a mayor key role in Mexico to decide the settlement of investors at a regional level, rather than fiscal stimulus. However, this concerns further research on the topic of industrial location.

In conclusion, the northern border states of Mexico and southern border states of the United States share a gradually integrated economy, as well as a high degree of income inequality in their bond. California and Texas are the greatest manufacturing states not only in the region of analysis, but in the United States, while Nuevo León is the richest states of the border in the economic branch. However, the income discrepancies seem to mitigate when taking only into consideration the manufacturing GDP, since all Mexican border states grew at a faster rate than their U.S. matches, especially higher than New Mexico. However, Arizona, California, New Mexico and Texas all have several business incentives to compete for the attraction of investments, while these fiscal tools are almost nonexistent in Mexico (besides of the Fiscal Stimulus for the Northern Border Region). On the next section, we'll analyze the historical condition that led to the actual state of the manufacturing industry in Mexico and, particularly, in the northern border.

3. The manufacturing industry in Mexico: history, agglomeration and economic integration with the United States

3.1. Introduction

Section 3 consist of an economic history review of the manufacturing industry in Mexico. First, a short explanation of the economic history of Mexico in the XX century, describing the different political economic models. Then, a description of the beginnings and development of the manufacturing industry in Mexico, starting from the late 1890's to the last decades of the XX century, going through the different programs and policies applied by the Mexican federal government, particularly in the northern border. Next, a review of the work of Mendoza (2002, 2004, 2021), to understand the current state of productivity per regions of manufacturing industry in Mexico in the first decades of the XX century. Afterwards, a critic of the manufacturing project of the nation, focusing on the works of Urquidi (1986), Grunwald (1990) and Crossa and Morales (2021). Finally, conclusion.

3.2. Economic history of Mexico in the XX century

During the end of the XIX and the first decade of the XX century, the three main economic challenges for the reconstruction, national and international integration of the economy, and pacification of Mexico, were, according to Cárdenas (2015): the integration of the national market, because only those areas close to the northern border or the sea had multiple economic growth choices; the building of a national State and the construction of institutions through public investment, lacked by the almost none tax collection due to the poor economic dynamics; and last, related mainly with the first point, the lack of transport infrastructure for the integration of the national and international markets.

Besides the strict militarization and the imposition by the State during the Porfiriato to pacify the country and stabilize the economy after a century of non-stop civil conflicts, the Mexican economy's growth was primarily based on the exports of natural resources to industrialized countries, making the regions with more natural resources and closeness to the sea have comparative advantages among others (such as the mining states, like Coahuila, Durango and Nuevo Leon, or the states with long seashores, such as Veracruz, Jalisco and the Yucatan peninsula). The construction of railways and the train system through FDI and public investment led to the integration of economically marginalized regions, diminished transportation costs and fastened the commerce with the United States; “by 1884, in the end of the administration of Manuel Gonzáles, the railway reached 5,744km, and until then it will grow rapidly: 9,540km in 1890 and 13,300km in 1900; by 1910, the railways reached 20,000km” (Cárdenas, 2015: 190). This increased the national market by the transport of minerals and agricultural goods; the exports would increase too, particularly to the United States, making possible a greater tax collection for the State and push national entrepreneurship. Also, the building of institution and a solid capitalist modern State would increase the FDI and the lading of national and foreign credit.

Still, the economic model was based on the exports of primary goods even during the Revolution Civil War (1910-1917) and the decade after. Even though Aguilar (2016) affirms that the 1910 revolution and subsequent civil conflicts in the 1920’s didn’t “neither cause a general collapse in the economy nor moved it out from the growth trend initiated by the First Globalization” (Aguilar, 2016: 19), Cárdenas (2015) argues that the Revolution Civil War severely affected the national economy. In 1913, the coup attempted by Arturo Huerta began a rise of several armed forced against him. This led to the use of railways, telegraphs and other public infrastructure for military purposes, lacking the already underdeveloped national and international markets. It was between 1917 and 1918, during the end of the civil conflict, that 92% of the national railways were restored. Although, Womack (1987) argues that the revolution did not destroy completely the national production; most of the enterprises could still run with the war, and there were even cases which were not affected at all. This last thesis, as described by López (2018), was confirmed through the works of Cerutti (1983), Cárdenas (1987) and Haber (1989).

After the Revolution Civil War, during the decade of the 1920’s, most of the public policies were oriented to militarization (to maintain peace in the country), reconstruction of infrastructure, and agrarian distribution. The fiscal policy was orthodox, looking for a fiscal equilibrium. The main income source was still the export of commodities, but the national market was beginning to take a bigger proportion of the economy.

The Great Depression represented the shift from development based on the export of commodities and an orthodox fiscal policy, to the industrialization lead by the State and an expanding fiscal policy. The main source of national income shifted from the export of commodities to an industrialization lead by the State, whose focused was to substitute imported good by ones produces in the country. Also, the railways and trains were substituted by roadways and motorized vehicles; they were cheaper to build. This model was called Import Substitution Industrialization (ISI). It took place from 1930 to 1980 in Mexico, and was, according to Bertola and Ocampo (2013), divided in three periods in Latin America as a whole. The first, from 1930 to the Second World War, in which national institutions began the founding and construction of manufacturing activities; in Mexico, particularly though the Bank of Development, created in 1933, the manufacturing industry in textiles, processed foods, cement production, and oil refinery, along with the pharmaceutical industry and agricultural production, were some of the principal industries to burst out after the 1929 crisis. The second, from 1945 to the mid 1960's, was characterized for a more consistent industrialized strategy, built up by protectionist tariffs, multiple currency exchange rates, banks of development and fiscal incentives for national entrepreneurship. The third and last period took place from the mid 1960's to 1980; the import substitution policies intensified and, in the case of Mexico, the discovery of rich oil fields accelerated the GDP growth at the end of the 1970's. There have never been higher GPD growth rates in the history of the country than in the ISI model.

Nevertheless, there were mayor critics and contradictions during the ISI period. Although the manufacturing activity increased, along with migration from rural to urban areas, and this implied the substitution of imported goods, most of them were consumer good: the ISI model achieved the substitution of consumer goods, but the import of capital (machinery) was still necessary, and there was no transition from the substitution of consumer good to substitution of capital. This scenario is still present, particularly, in the manufacturing industry.

The excess of public spending based on debt during the decades of 1960 and 1970, the nation deficit on public expending, the fell of national income due to the fall of oil prices, national inflation and the rise of the interest rate by the Federal Reserve Board of United States to combat the inflation during the 1970's, led to a redefinition of the Mexican economic model. If the Mexican government wanted to redefine their debt with the international banks (most of them American), measured had to be taken. Most of them, imposed by international institutions, like the International Monetary Fund, and though the Washington Consensus. The economic reforms core, as described by Urquidi (2005), consisted of trade and financial liberalization: end of import tariffs, sale of government institution to the private sector, inflation and deficit control, export increase. The Washington Consensus ignored all argument related to the ISI model, considering just the reestablishment of equilibrium of macroeconomic variables, putting aside the income inequality growth that these shocks could lead to. It is during this period in which the manufacturing model, particularly in the northern border of Mexico, began. The geographical advantage, the regional closeness, made the trade liberalization reforms more striking for this sector in this region.

3.3. The manufacturing industry in Mexico in the XX century: beginnings and development

In the last decades of the XIX century, Mexico had been living a first industrialization push. In her doctoral dissertation thesis, López (2018) analyzes the manufacturing industry during the post civil war revolution era, and mentions the foundation of several manufacturing companies in different regions of Mexico during the 1890's, such as Papelera San Rafael y Anexas, Cervecería Cuahutemoc, Compañía Industrial Jabonera de la Laguna, Cervecería Moctezuma, Fundidora de Hierro y Acero de Monterrey, Cemento Cruz Azul, among others.

From 1895 to 1910, the manufacturing sector annual growth rate was 4.6%, where the textiles were the most outstanding industry. Even some products began to be import substituted, as cotton and iron for railroads. López (2018) continues, citing Stephen Haber, describing some issues of the manufacturing industry: most of the companies had machinery unused because they were first designed to attend international demand, not national demand (as it was being used), which elevated their unit costs and implicated low labor productivity; there were high import tariffs, which tended to create a national monopoly. Finally, the manufacturing industry depended from government for its survival.

During the Revolution Civil War, the most affected sectors were agriculture and the national market; the reasons were a scarce of national demand and the destruction or stealing of trains and railroads for military purposes. The impact in the manufacturing sector, on the other hand, was little in comparison: most of the infrastructure was not damaged and the losses were financial since most of the means of distribution (railroads) had been taken by armed forces. López (2018), citing Stephen Haber, describes that some manufacturing plants were used by revolutionaries to finance their warlike activities. It was from 1913 to 1916 that, due to a higher scale in the military conflict, the manufacturing production began to decrease; for example, Cervecería Cuahutemoc and Fundidora Monterrey, both enterprises from Nuevo Leon, diminished their production severely during this period.

Despite the destruction of railroads, along with problems such as depopulation derived from the war and migration of citizen to the United States and a weak national market, a pacifying process, new institutional framework and an increase in exports in consequence of the First Great War, a rapid recover for the industry in Mexico in 1917 occurred, particularly from big companies. The oil industry boomed and kept expanding its production until 1921, when the constitutional reforms on the sovereignty of the land and the nation’s natural resources arise. Still, the main source of growth and development was the export of primary and manufactured goods.

Francisco Madero, Venustiano Carranza, Adolfo de la Huerta and Álvaro Obregón, some of the first presidents during and after the Civil Revolution War, encourage the Mexican bourgeois, businessman and working class to stick to the constitutional rebuilt project that would guarantee social justice for both parties: capital and work. In this sense, although most of Mexico remained an agricultural country, the State did stress the need of stable conditions for the development of a variety of industries to achieve a level of production prior to the Revolution:

> The conciliation of the interests meant that the constitutionalist government would guarantee certain rights to the workers and establish limits to capital in exchange of the protection of capital's property and assure production, since the national reconstruction depended on these two last aspects (López, 2018: 58)

Nevertheless, the achievement of the post revolution industrial project did not happen, because of "difficult in tax recollection, lack of unity and legitimate of the groups in power, pressure from international banks for the debt payment, increasing working class movements and uncertainty generated by the path that would take the new nation project" (López, 2018: 64). And so, the manufacturing sector was involved to in these precarious conditions, at least from 1917 to 1924, based on López research.

Some general characteristics in the manufacturing sector during the beginning of the 1920's were, according to Lopez (2018), citing the national Census of 1921 and the National Labor Department, the following: by that year, the manufacturing sector had 147,487 workers, most of which were employed in the textiles sector, shoemaking and leather products, bricks, chemical products, and hats and clothes (López, 2018). By that same year, the manufacturing sector represented 10.7% of the GDP, being the second most important economic activity besides agriculture, which represented 22.3% of the GDP.

Moving forward, Douglas and Hansen (2003) analyzed the history of the manufacturing industry of Mexico from 1930 to the late 1970's. They affirm that it was until the 1930's, particularly from 1934 to 1940, during the presidential period of Lazaro Cardenas, that the manufacturing industry project began in the northern border states of Mexico, specifically on border cities. Before that, the industry was mainly located in the center of the country, particularly in Mexico City, center states and Nuevo Leon, as noted by López (2018), and was predominantly textiles.

From 1930 to the late 1970's, five programs were a precedent and responsible for the building-up of the manufacturing industry in the northern border states, and for the labor and goods market integration with the United States too: the *Free Exchange Perimeters*, in the 1930's; the *Bracero Program*, from 1942 to 1969; the *National Border Program* (PRONAF, by its acronym in Spanish), from 1961 to 1971; the *Industrialization Border Program* (PIF, by its acronym in Spanish), also known as the Over Supply of Workforce in the Northern Border Program, from 1966 to the end of the 1970's; and the *International Secretary Commission for the Economic Development of the Northern Border Gap and Free-Trade Zones, e*stablished in 1971. Each of them is briefly explained bellow.

The Free Exchange Perimeters was a federal program installed by president Abelardo L. Rodríguez on August 31, 1933. Its objective was to develop the economy and sovereignty of certain areas from the influence of the United Stated economy. The main tool to achieve this was to cancel import tariffs on border cities; Tijuana, Ensenada, Tecate and Mexicali, all in Baja California, were the first ones. The idea was to set up the conditions for the population of these cities so they would encourage to diversify their economies from the usual, which was based on cantinas and casinos, to develop local commerce and entrepreneurship. Nevertheless, this program did not create a new manufacturing industry right away, but paved up the path to it. Years later, during the Second Great War, there were efforts from the local government and businessman of Ciudad Juarez to relocate national industries to this city, but, since most of the factories produced goods for the national market, there was little interest in moving so far to big markets.

It was during the Second Great War that the population in northern border cities increase rapidly, doubling or tripling itself in some cases. The motive was the Bracero Program, a bilateral strategy by the United States and Mexican Governments to supply the agricultural sector of some states of the US (mostly in the southwest) with masculine labor force from Mexico, due to the lack of American men, who were abroad on battlefield. The flow of labor force from Mexico to the United States increased drastically during the 1920's and 1930's, leading up to massive deportations. Durand (2007) enlists the strengths and weaknesses of the program; some of them were:

- Strengths: institutionalization, regularization and legality of Mexican labor force in the United States; recognition by the US of a bilateral job market, making no need of searching for labor force on other nations; long run program, lasting 22 years, mobilizing 5 million Mexican workers; focused on only one sector, the agriculture; improved of wages and labor conditions for Mexican workers while working on the neighbor country.
- Weaknesses: labor supply was greater than demand, making it impossible to address temporal employment for everyone, and so, making the bracero program not a structural solution to Mexican unemployment; most hiring was done directly by businessman, usually addressing bad employment conditions for laborers; big bureaucratic expenses of both labor and businessman, which made it easier and cheaper to still keep hiring undocumented workers; reduction of labor supply in Mexico and excess of it in the USA, making both local governments of the former nation and unions from the later upset.

The Bracero Program has been, until now, the biggest and most ambitious bilateral labor agreement between the two countries. But, unfortunately, even considering it covered a period longer than the situation that initiated it, the Bracero Program ended in 1969. The US government did not demand Mexican labor force no more, but the Mexican government still had, and has, a massive number of workers in the need of jobs. Other programs were required, especially for the manufacturing industry.

A parallel program to the Bracero's was the National Border Program (PRONAF, by its acronym in Spanish), established in 1961. Founded and financed by the Secretary of Finance, and managed by the Development National Bank of

Mexico, the PRONAF objective was to develop the economic and commercial basis in the northern border region to reduce the influence of the United States in it, particularly on Ciudad Juarez and Tijuana. PRONAF also pursued a mayor integration of the north of Mexico with its center region since it was a nationalist proposal.

As Douglas and Hansen (2003) traced, the federal government authorized subsidies for import tariffs that covered commercial goods sold on the border, along with the building of malls where consumers could buy national and American manufactured goods. Most of these places were built in Ciudad Juárez, Matamoros, Piedras Negras, Nogales and Ensenada. Furthermore, despite the construction of several manufacturing factories that required mid to low capital investment, the industrialization in a bigger scale did not happen. The principal reason is the lack of financing to cover most of the border cities since most of the resources focused on Ciudad Juárez. The program was cancelled in 1971 but set the foundations for the next one.

The Industrialization Border Program (PIF, by its acronym in Spanish), first established in 1965, but began operations in 1966, was a unilateral institutional initiative from Mexico, consequence of the decline of the Bracero Program and enlarge of unemployment in the US-Mexico frontier, with bilateral agreements and consequences. Differing from the Pronaf, the PIF implied the beginning in the process of institutionalization of the economic integration among border cities in US and Mexico. This means that, while the former program meant to integrate the northern regional economy of Mexico with its center region, the later based its attention on economic integration with the United States.

Douglas and Hansen, quoting Fernandez (1979), narrate how a visit of the secretary of Industry and Commerce, Octavio Campos Salas, back in 1965, to numerous assembly factories the United States had opened in Hong Kong, Taiwan, Singapore, among other South Asian countries, escorted him to propose the Mexican government the aperture of similar foreign assembly factories in the country. The conditions were accurate for a deal of this nature between both parties, the

Mexican and US government: the geographical closeness, the example of the Asian Export Processing Zones, diminishing transportation costs for capital and input materials due to higher technology, lower wages outside the United States, and an increasingly international fragmentation production process of several goods. Besides, a wear out of the Mexican economic inward development model.

Since the PIF signified a mayor degree of integration between the Mexican and the US economy, at least in an initial frontier range of 20km (Douglas and Hansen, 2003: 1051), American enterprises who set their factories in the border were exempted of import tariffs for both raw materials and capital. Douglas and Hansen consider this frame of operation the birth of the maquiladora industry in Mexico: the assembly of manufactured goods with capital and input from the USA, whose output's destiny was the American market. Only the salaries remained in Mexican soil, and not always, since some of maquiladora workers expended them in the United States, as some critics of the sector have established.

The Mexican government's goal with the PIF was to "create a great amount of jobs, gain vast volumes of dollars and, in last instance, conciliate their own manufacturing industry" (Douglas and Hansen, 2003: 1053; see Sklair, 1989). By 1967, fifty-seven manufacturing factories with 4,257 jobs were established in Matamoros, Nuevo León, Ciudad Juárez, Mexicali, Tijuana, Nogales and Agua Prieta; by 1971, more than 200 factories with 30,000 jobs were established around. Most of these new plants were built in Baja California and Sonora.

The next and last step before 1980 to expand the manufacturing export industry was the International Secretary Commission for the Economic Development of the Northern Border Gap and Free-Trade Zones, founded in 1971 by Luis Echeverria's presidency. The core purpose of the program was to incentive the building of more manufacturing factories. During 1973, constitutional reforms allowed foreign companies to own more than 49% of the Mexican based factories, as well as put in place plants beyond the initial 20km. frontier range. The free-trade and liberalization process kept expanding in manufacturing assembly factories; they were considered a success in the north of Mexico: "as a result of the favorable concessions from the Echeverria presidency to the industry, the number of plants grew from 120 in 1970 to 455 in 1974, and jobs grew up from 20,327 to 75,977" (Douglas and Hansen, 2003: 1055; see Arreola Woog, Programa Mexicano de Maquiladoras, in Sklair, 1989).

One mayor interruption on the development of the maquila project and its programs was the Foreign Dept Crisis of the 1980's in Mexico. It was one of the first sectors in which the postcrisis reforms took place: the public investment in it diminished to pay the external debt. Ironically, even though the manufacturing sector was necessary to increase the balance of trade, because most of the manufacturing goods were exported, the reforms implied to decrease general imports of good and, doing so, diminishing the necessary inputs for this industry at issue. It was a contradiction: if the Mexican government needed an inflow of foreign currency to pay their dept, how would it help to stop the imports of necessary inputs for such industry that would guarantee an income flow via exports?

Urquidi (2005) points out some of the requirement imposed by the economic reforms from 1988 to allow the export of manufactured goods:

1. Previous experience in exporting such goods.
2. To keep a fixed exchange rate for a long period, for which it was necessary an inflation reduction, a safe and trusty foreign exchange market and credit access to the International Monetary Fund.
3. Austerity wage program to stop the costs of manufactured goods over the margins of reasonable competence.
4. Promotion of not only credit for manufacturing businesses, but storage, transport, insurance and services related with market information.
5. Foreign exchange regulation to guarantee export incentives. At the same time, exports income in foreign currency would convert to a fixed exchange rate for the payment of dept and imports of input goods.
6. An infrastructure and management modernization process of the manufacturing factories, to pull of the external demand.

Several statements can be made from the previous conditions. About point number two, on the matters of inflation control, it was supposed that the import of goods would diminish inflation for introducing to the Mexican market foreign competitive merchandise, but this was not the case since importing merchants only changed their prices to the ones set on local market, usually leading to an inertial inflation, because international goods were more competitive than national. On point number three, speaking particularly on wages of the manufacturing industry, Douglas and Hansen (2003) note how the constant peso devaluations kept them low and competitive in contrast to other countries, but reduced the national market potential to grow. About point number four, how would the Mexican government guarantee such requirements while paying the foreign dept and keeping an austerity program? On point number six, the manufacturing factories restructuration to encourage the foreign markets was also a measure to encourage the national market; Latin American economies needed trade opening too. And, as a final remark, a fundamental problem was that many of these strategies were rushed for the need of commercial surplus for the debt payments, which lead to a poor settlement of these maneuvers.

Considering the previous historical review of the manufacturing industry during the XX century in Mexico, what is left to consider are the present conditions of the industry at issue, particularly in the northern border, and some critiques on matter of industrial policy. Such will be the subjects of the next sections.

3.4. Current state of the manufacturing industry in Mexico: the liberalization period

Mendoza (2002) studied the effects of agglomeration economies of the manufacturing industry on the principal northern border cities of Mexico from 1988 to 1998, through a model of urban agglomeration effects with two log-linear econometric specifications. He used data from the Mexican National Institute of Statistics, Geography and Information.

Mendoza begins by describing how before the establishment of the Free trade oriented economic model, manufacturing industry was based mainly in three cities in Mexico: Mexico City, Guadalajara and Monterrey. Furthermore, in the last two decades of the twentieth century, with the reforms oriented to encourage economic openness in the country, one of the most beneficiated regions of Mexico was the northern border states and, particularly, their biggest cities: Tijuana, focused on television assembly; Ciudad Juarez, dedicated to electronic components; Saltillo and Hermosillo, which worked auto parts assembly.

On bigger detail, during the period of 1988 to 1998, "the three industries with the fastest average annual rate of growth were located in the cities of Monterrey, Matamoros and Hermosillo" (Mendoza, 2002: 7), but, from 1988 to 1993, the manufacturing employment grew faster in Tijuana, Nuevo Laredo and Hermosillo. Ciudad Juarez, border city with El Paso, Texas, represents one of the main cases of what the nature of the maquiladora project is:

> the majority of the firms localized Ciudad Juarez have the legal status of maquiladora, which allows them to import duty free all the inputs they require in the manufacturing process and export practically all output back to the country of origin. In that sense, the dynamics of that urban center is largely determined by the strategies of the multinational firms located in that city (Mendoza, 2002: 9).

This means that most of the, if not all, of the output of the maquilas, particularly in the northern border, was exported back to the country from which the factory brand was from; investment and salaries stay in Mexico, but the output is exported back. Nevertheless, the maquiladora regime has also integrated local industries as suppliers of international firms or the domestic market.

Tijuana's role on the national manufacturing industry has grown too. While in 1988 it gathered 1.8% of Mexico's manufacturing employment, by 1998 it reached 3.5%; in a regional level during the same period, it grew from 18 to 30% of Tijuana's total employment (Mendoza, 2002). The main products of this city were radios and televisions of Asian firms. Monterrey, on the other hand, even though is not a border city and had local firms that also faced globalization and opened their markets, had a minor decreased in the manufacturing national employment over the same period, going from 8.06% to 6.74% (Mendoza, 2002).

The results of Mendoza's model showed that the industries with the fastest growth located in the northern cities were electric machinery, equipment and accessories, electronic equipment, radio and television assembly, and textiles. Also, the coefficient of specialization had a direct impact on employment. He concludes that the empirical results suggest that "trade liberalization and the integration of the Mexican with the US economy has shifted the manufacturing employment dynamics from the large cities of Central Mexico towards cities of the northern border states" (Mendoza, 2002: 21-22). Finally, he remarks the necessity of the government to develop the conditions to maintain steady manufacturing growth in the region, so the employment and economic growth are maintained.

Following Mendoza's work, in 2004 he did research the labor productivity convergence in the export maquiladora industry of Mexico, by sectors and states, from 1990 to 1999, comparing the northern border states to the rest of the country, through a conditional convergence analysis. He used data from the Mexican National Institute of Statistics, Geography and Information to develop convergence panel models for both absolute and conditional scenarios through a decomposition of the GPD per capita in two factors: employment per capita and labor productivity (all variables in logarithms).

On the fixed effects panel model by state, the labor productivity by state showed a tendency to divergence, which means that, without conditional variables, inequality among the northern entities of Mexico increases. In the same model, the high skilled labor variable showed a negative and non-significative relation in all states but Coahuila, which indicates that high skilled labor in this state has benefited more local productivity conditions than the others. On the other hand, applying a conditional variable of high skilled labor didn't show sufficient statistical evidence for the impact of this variable. Finally, in matter of the fixed effects, there is a tendency towards convergence in labor productivity by states when salary differences and the index of capital is taken into consideration.

As final considerations, Mendoza (2004) concludes on how center states from Mexico had greater levels of productivity than the ones from the northern border, but the percentual share of the national value of the maquiladora industry is higher in the later than in the former set. By state, Tamaulipas, Nuevo León and Baja California had the highest productivity levels; by sector, it was division VIII (metallic products, machinery and equipment) during the 1990's. The catch-up effect in labor productivity happened mainly due to increments of capital and technology in delayed states, statement that coincides with the narrative of the Neoclassical Theory.

Continuing on the subject of labor productivity in the manufacturing sector in Mexico, Mendoza (2021) keeps up in this line of work, as he researched the labor productivity of the Mexican manufacturing sector during the period 2007-2016, through a panel data model estimated with three spatial models (spatial autoregressive model —SAR—, Spatial Durbin Model —SDM— and Spatial Error Model —SEM—). The data was collected from the Monthly Industrial Survey of Mexico (EMIM, by its acronym in Spanish), National Institute of Statistics, Geography and Information (INEGI) and the Interactive System of Education Statistics.

Before getting into the results, it's important to emphasize that:

> between 2007 and 2016 Jalisco, Aguascalientes, Guanajuato and Puebla showed both the fastest growth of annual average growth and the highest labor productivity index, in the manufacturing sector (…) the central states are exhibiting higher labor productivity than the border region of Mexico, probably because of a higher level of technology and capital endowments in the plants localized in that region (Mendoza, 2021: 22).

Then, it’s remarkable how during the 1990’s productivity of the manufacturing sector was higher in the central states of Mexico than in the northern ones, as labor productivity in the same sector repeats this spatial patter from 2007 to 2016. Baja California and Chihuahua stand out in labor productivity, but still do not weight the total labor productivity of the region as to be greater than in the central states.

Even though Baja California and Chihuahua are among the states with higher labor productivity in Mexico, the results showed the persistency of low labor productivity clusters in these two northern states for both 2007 and 2016 periods, while Hidalgo and Tabasco remained with high labor productivity clusters in both years; the State of Mexico and Tamaulipas were in the high labor productivity cluster in the first year analyzed, but not the following.

The SDM estimations reflected evidence on the importance of technical schooling and public investment in infrastructure as propellers of labor productivity at the regional level. Foreign Direct Investment (FDI), gross capital formation and labor training at the state level were the factors that incentivized productivity of labor at a regional level and the diffusion of regional technological innovation spillovers.

Mendoza (2021) concludes with three remarks on labor productivity in the manufacturing sector:

> labor productivity in the manufacturing sector increased at a slightly faster rate than the national average; second, labor productivity grew faster than wages, probably determined by institutional factors constraining wages expansion; third, (…) at the sectoral level, the subsector of metallic industries exhibited higher labor productivity whereas light industries like food and beverages exhibited lower labor productivity. (Mendoza, 2021: 29-30).

He remarks another interesting point, similar to the ones made by authors mentioned before, such as Baumol (1985) and Combes, P. P, et. al, (2011): labor productivity spillovers among states that are closer together, such as northern states closer to ones in the center, have positively impacted labor productivity. This same pattern could have impacted the northern border states of Mexico due to the closeness to the United Stated southern states, also considering the free trade policies implied in the 1990's, leading up to converge. Nevertheless, it is necessary to take also into consideration Abramovitz's (1986) arguments on how not always spillover effects could lead to convergence from leaders to followers, such as the British-cotton textile industry case.

There have been shifting changes in labor productivity between the central and northern regions of Mexico, as there has been also by states. In the 1980's and 1990's, the government focus on free trade policies began a rapid burgeoning of foreign factories in the north, and so its growth productivity in this region. Nevertheless, that did not mean to marginalize the center of Mexico. A disregarded point by Mendoza, speaking in terms of economic geography, is the closeness to merchant ports in the Atlantic Ocean for states likes Guanajuato, Querétaro and Puebla, calling the attention of foreign brands such as Volkswagen and aerospace sector to enlarge the investment in their factories in the former states, due to the reduction of input and output transportation costs.

Despite the foreign direct investment growing and shifting among regions, one of the mayor critiques remains: why does Mexico keep assembling and exporting vehicles and manufactured goods instead of moving-forward to produce and export their own manufactured goods through a national industrial policy? This will be attended in the next subsection.

3.5. Critiques of the maquiladora project in Mexico: industrial policy or industrial dependence?

The stagnant state of the Mexican manufacturing industry on only assembling imported input to export the output back to industrialized countries is based on its technological and capital dependance. Urquidi (1986) analyses this phenomenon in the long run, focusing in the XX century. First, he describes how Mexico has adopted European technics, technology and abilities since the XVI century, after the Spanish Colonization, while keeping and improving national ones, and how this adoption has not been reciprocal in most cases. Mining technics, textiles and railroads, crucial elements for the development of the economy during the XVIII and XIX centuries, are some examples.

In the last decades of the XIX century and first decades of the XX century, besides foreign direct investment, Mexico's import of technology consisted also in management and industrial organization knowledge applied in new industrial processes from Europe and the United States. Nevertheless, "it wasn't a technology policy, but in essence an indiscriminated and open incorporation of technology, without conditions, which would correspond to incipient capitalist development" (Urquidi, 1986: 318). The capital, technology, and know-how inflows were in function of the enterprises' growth interests rather than an active public policy to locate and center investments. In the oil industry, for example, it was until the 1938 Nationalization of Oil that the government consider to lessen the dependency of foreign capital for the development of technology in this branch, but the Oil Mexican Institute was founded twenty-eight years later, in 1966 (Urquidi, 1986). As seen before, during the Second World War and after, the Import Substitution Industrialization (ISI) model made some advancement in matter of national production, but the imports of capital were still a mayor need for the national factories to operate.

One mayor flaw in mater of technological public policy that Urquidi highlights is the lack of interest by the Mexican government in what he calls Experimental Development Investment —nowadays called Research and Development (R and D) —, which is the public and private financialization to universities and research centers for the development of scientific research to create and own national patents useful for production sovereignty, particularly in the secondary sector. This kind of investment did happen in the 1930's, during the Green Revolution, to attend the scarcity of food. The incentives to follow the same path for heavy industries during the following decades were shadowed by cheaper alternatives, such as keeping importing capital, because of the devaluation of the Mexican peso and the lack of financialization needed for research and development. Also, most universities in the country did not count with enough qualified researchers for this duty.

Despite the constant choice for cheaper options in technology involved issues, there was an institutional response to fund research and development. After meetings held by the government with academic professors, the national congress approved the creation of the National Council of Science and Technology (CONACYT, by its acronym in Spanish) in 1970. Some of its objectives were:

> to incentive and coordinate research (including social sciences), development of information systems, negotiate bilateral and multilateral cooperation programs, increase the number of scholarships for graduate students in Mexico and abroad, carry out technical personal internship to other nations, develop inventories of research personal, diffusion of science and technology, and link the several research institutes to the industry and private sector (Urquidi, 1986: 322).

As Urquidi depicts, this meant a qualitative advance on technological sovereignty, like a lesser degree in the import of technology occurred in some materials. Nevertheless, the author admits that Mexico's technology dependence continued since it was a cheaper alternative. Besides, the debt crisis' consequences in 1982 and 1983, such as federal budget cuts and diminishing of real salaries for the academic personal, backed down the efforts made before.

The last point in the CONACYT objectives is one of, if not, the most difficult. This Council was supposed to be the bridge between the research center and the industry, but the decisions taken on industrial policy did little to favor research and development.

Urquidi’s lasts remarks focus on future efforts to make public policies with an emphasis on mayor technology independence, with actual links between the research centers and the industry, using the funds and management needed to reduce the costs of national industrial processes. There have been efforts and accomplishments, such as the development processes of iron manufacturing and construction methods exported to other underdeveloped countries, but the “Mexican income from the transfer of technology abroad is abruptly countered by the payments made by the imports of it” (Urquidi, 1986: 327). Mexico is far behind not only in the development of technology, but the speed in producing it in contrast to industrialized countries and transnational firms.

Other final remark is the relation between technological advance and employment. Mexico cannot ignore the fact that the imports of capital and technology from the United States has a relation with employment, since factories that enlarge their technologic assets usually diminish their labor force. How would it be possible to develop and make a more competitive industrial sector while fighting the tendency of unemployment due to the adoption of more technology in factories? Or also, as Grunwald notes, a tendency to keep wages low.

Grunwald (1990), on his review of Sklair’s book *Assembling for Development: The Maquila Industry in Mexico and the United States*, depicts a critical point of view. While Sklair calls the opening of developed countries’ factories in underdeveloped ones a “reformation of capitalism”, under the view of creation of jobs in the regions which need them more and an easy exit for enterprises to accumulate wealth though cheap labor, Grunwald calls it “a new kind of exploitation of Third World economies by the transnational corporations (TNCs) of the First World” (Grundwald, 1990: 425). He depicts how the Mexican maquila wages are very low in comparison to the USA, but higher than most of other sectors in Mexico and Latin American in general. Also, he concurs with Douglas and Hansen (2003) on how the salaries did not necessarily were spent in Mexican border cities, but across them, in the United States. In this sense, TNC’s and the Mexican government (through devaluation of the Mexican peso) contribute to keep low wages only to generate international competitive business conditions, not looking up in the medium or long run on the construction of a national industry.

Grunwald continues his critique comparing the development of the manufacturing industry in the Four Asian Tiger with Mexico:

> Look at the 'four tiger' experience with assembly operations. When in the 1950's and 1960's US companies shifted assembly production to South Korea, Taiwan, Hong Kong, and Singapore where wages were only a fraction of those in Mexico, firms in those countries quickly absorbed the new technologies for domestic and newly emerging export production (…) The 'four tigers' have used the assembly industries as a springboard for industrialization and the combination of low wage cost plus advanced technology has helped make them the formidable international competitors they now are (Grunwald, 1990: 426).

This may be the mayor, the key counterpoint, to the maquiladora project as a whole. As noted in sections 3.1 and 3.2, since the 1950's, the Mexican government lacked the necessary tax recollection and public spending for the building-up of a national industry who transcended assembling foreign input. There wasn't either a tax reform who would contribute to solve this problem. With such conditions, a proper use and appropriation of foreign technology was not possible.

Crossa and Morales (2021) share Urquidi's and Grundwald's point or view. Starting off from Hopkins and Wallerstain's concept of *global value chains* (GVC) —the fragmentation of the production process across different countries, in which some add more value than other due to structural differences— in a world production system divided by central and peripherical nations, Crossa and Morales thesis bases on the idea that the maquiladora industry in Mexico has set a technological and capital dependency on industrialized countries, particularly in the last 40 years, that has led to wages stagnation and poor national research and development on new technologies.

Crossa and Morales don't believe that *industrial upgrading* —a country's upgrade in their participation in GVC to branches with more capital and value-added linkages— has been achieved in the maquiladora industry in Mexico. On the contrary, for the last 40 years, it seems that the idea of an assembly economy has predominated. Industrial upgrading, in their point of view, seems to be a passive choice on industrial matters, waiting for foreign direct investment to change the current technological state of the country. On *social upgrading*, that is, the capacity of GVC to increase the wellbeing of a region, they also think that is not usually the case.

To support these ideas, Crossa and Morales analyze the evolution and current state of the automobile manufacturing and auto parts industries in Mexico, two of the largest brands in the manufacturing industry in the country and two of the biggest exponents of the maquiladora project.

The car manufacturing-auto parts industries' growth is remarkable, since "it represents 3.3% of the GDP and 20% of manufacturing GDP (…) and from the beginning of the 1980's until 2018, this industrial activity in Mexico has grown its participation from 3% of total manufacturing exports to 36% (…) and around 80% of production of this branch is exported to the US and Canada" (Crossa and Morales, 2021: 347-348). These growth rates could give the impression that the manufacturing car and auto parts industries have gained a mayor roll on technological and knowledge transfers from industrialized countries to Mexico through foreign direct investment; an *spillover* effect, as named previously, that would lead to a *catching-up* effect on unindustrialized and industrialized countries. Nevertheless, for Crossa and Morales, this ignores the economic policies that led to the actual state of the manufacturing car industry: the Mexican State has become a manager of FDI, stablishing up free tariffs zones, low taxes, and cheap labor for transnational corporations, instead of executing laws and reforms for the linkage of foreign firms in national production. They name the case of China as an example of an open economy with limits to transnational corporations, in function of national technological development.

The United States, Mexico and Canada Agreement (formerly known as NAFTA), while institutionally viewed as a process of trade liberalization openness for the expansion of markets and increase of competitiveness, which would lower prices and higher levels of employment, Crossa and Morales affirm Mexico became an "manufacturing appendix for the United Stated to encourage the global competitive pressure" (Crossa and Morales, 2021: 353) with such agreement. Actually, they describe the then NAFTA as a strategy of the United States to make a bigger economic and commercial union to confront the increasing competitiveness of Japanese markets and producers. And so, this new commercial trade deepened a process to dismantle treaties and programs such as the *National Border Program* (PRONAF), that is, nationalist policies linked to lessen the dependence on foreign capital and commodities.

In this context, despite the continuing growth of the automobile assembly industry in Mexico, its levels in research and development are among the lowest in this industry. Germany, South Korea and Mexico have similar number in production during 2018, with 5.1, 4.02 and 4.1 million cars, respectably, but keeping a huge gap among their investment in research and development for the automobile assembly industry: $24.5, $7.2 and $0.4 million dollars in 2018, respectably (Crossa and Morales, 2021: 356). And the case is similar to the manufacturing industry as a whole with $59, $51 and $7 million dollars in research and development investment in the same year for the three countries mentions, in that order (Crossa and Morales, 2021: 356). This resonates with Urquidi (1986): the little to no attention from the Mexican State on technology, patents and production sovereignty in the last decades has maintain in recent years.

About the wage gap in the manufacturing industry between Mexico and the United States, Crossa and Morales mention the tendency of low salaries that Grunwald mention before: there is a wage's ration of 1:20 in the automobile assembly industry and a 1:10 in the manufacturing industry. The wage gap, or wage ration, is a clear manifestation of how most intensive capital and high skilled labor activities remain in USA, while intensive low skilled labor activities —which are usually related with low salaries— remain in the other country.

As a final remark, Crossa and Morales advocate for higher salaries on the manufacturing sector, impulse the public and private investment in research and development for national and international firms in the country and change the idea that the only option is to look up for FDI and linkages to GVC as a way for development. Instead, they back the creation of a national industrial policy to generate a genuine industrial upgrading.

According to Canales and Canales (2022), Mexico did export globally five times more products with higher R&D investment than the rest of Latin America as a whole, worth $71 billion dollars. This makes it a competitive country on a matter of high-tech exports with nations such as the Netherland, France and Malaysia. Both authors continue:

> LatAm is taking the world stage as an emerging technology exporter — with Mexico leading the charge in Latin America and the #12 spot globally. Not only did Mexico top the region in high-tech exports, but it also placed first among LatAm countries with the most patents granted by the US Patent and Trademark Office (USPTO) (…) Mexico shipped $71B in high-tech exports globally last year, representing 81.4% of the LatAm region. Since 78% of total Mexican exports go to its largest trading partner, the US, it's safe to assume that most of this tech ends up there. Data from the US Department of Commerce indicated that Mexico provided 17.8% of the total high-tech products to the US (Canales and Canales, 2022).

The sum of money that represents the high-tech exports of Mexico is amazingly high considering its position as an unindustrialized country. Nevertheless, this also reflects Urquidi's, Grundwald's and, especially, Crossa and Morales' ideas: Mexico's manufacturing industry became a branch whose production growth and economic integration is overwhelming, but this growth does not reflect on national technology, patents and salaries.

3.6. Conclusions of the section

The manufacturing industry in Mexico is almost as old as the foundations of capitalism in the country, during the Porfiriato period, and so are its problems. The constant deficiency on tax collection derived in poor attempts in industrial policy during the XX and XXI centuries. It was, and has been, cheaper to import capital and technology from industrialized countries, particularly from the United States, a country with a set of subsidies and fiscal support that made it very hard for Mexico to compete with. Despite the tries on paths that would lead up to structural industrial policies, such as the PRONAF and the foundation of CONACYT, the public financialization and private national investment have not been enough for an industrial policy plan, along with universities and research centers.

Looking at the manufacturing industry in Mexico, there have been shifting changes in labor productivity between the central and northern regions of Mexico, as there has been also by states. In the 1980's and 1990's, the government focus on free trade policies began a rapid burgeoning of foreign factories in the north, and so its growth productivity in this region. Nevertheless, that did not marginalize the center states of Mexico: the center region was and still is the one with higher productivity in matter of manufacturing. But, at a state scale, the ones with higher productivity remain in the northern border (Tamaulipas, Nuevo León and Baja California).

Mexico has maintained a roll on Global Chained Values as only a manufacturer, with most of its linkages as the lowest in value-added. Urquidi, Grunwald and Crossa and Morales all agree in the necessity of a shifting on Mexico's public policy to link its manufacturing industry to higher value-added links in the GCV, rise wages for workers and incentive an active role of the State to combine efforts from research centers and the private sector.

4. Data and methodology

4.1. Introduction

Section 4 aim is to describe the data used for the research and the methodology applied. First, the sources of the data are named, along with the process of currency homogenization for the study. Then, the methodology and its mathematical foundations are described, based on Allington, McCombie (2007), Wieland (2020) and Barro, Robert J., and Xavier Sala-i-Martin (1992). Finally, conclusions.

4.2. Data

The data consists of Mexican and US sources. The manufacturing GDP in current pesos for the northern border states of Mexico was obtained from the National Institute of Statistics, Geography and Information (INEGI), and the manufacturing GPD in current dollars for the southern borders states of the United States was obtained from the Bureau of Economic Analysis (BEA). Population data for the Mexican states was also obtained from INEGI and, in the case of the US states considered, from the USA Census Bureau.

Since both regions have different currencies and are expressed in current units, homogenization of currencies into real units was necessary. First, GDP in pesos was divided by the exchange rate peso-dollar for the payment of obligations defined in foreign currency, taken from the Bank of Mexico. Second, once the manufacturing GDPs of both regions is in current dollars, the implicit Price Deflators for Gross Domestic Product from the Bureau of Economic Analysis was used to transform the current dollars to real 2012 dollars.

4.3. Methodology

Once the homogenization of currencies was done, the manufacturing GDP in 2012 dollars was divided by the population of its corresponding states to have the manufacturing GDP per capita of each state. For sigma convergence, natural logarithms were applied to all manufacturing GDP per capita data for all states and years. Then, its standard deviation was calculated per year, which results in the standard deviation of the natural logarithm of the manufacturing GPD per capita of all northern border states of Mexico and southern border states of the US. In theory, as mentioned before, a downfall through time in the plotting of these data would mean a lower dispersion of manufacturing production in the region, which translate to reduction of inequality and, so, the achievement of sigma convergence. Similarly, there would be no sigma convergence if the dispersion rises over time.

Sigma and beta absolute convergence regression models were based on the theory of Barro and Sala-i-Martin (1992). Both authors developed a Non Linear Squared (NLS) model, but we choose to develop an Ordinary Least Squared Model (OLS), as done by Allington, McCombie (2007). Sigma and beta convergence models were constructed using the R package REAT —*Regional Economic Analysis* Toolbox— (Wieland, 2020), which has commands to study five different regional economic phenomena: concentration, dispersion and regional disparities; regional convergence; specialization of regions and spatial concentration of industries; proximity and accessibility; and analysis and prognosis of regional growth. We focus only on regional convergence.

For the sigma convergence regression model, a statistically significance value and a negative magnitude in the parameter *time* would describes if there is a downfall in the dispersion of production. For beta convergence, if there is a statistically significant value for the beta parameter and a negative relation when regressing the GDP per capita growth rate between 1993 and 2021, and the initial level of GDP per capita of the set of states considered, it would mean there is absolute beta convergence:

> when testing for beta convergence, the natural logarithms of output growth over *T* time periods in *i* regions is regressed against the natural logarithms of the initial output values at time *t* (…) The estimated parameter of interest is the slope of the model, here denoted β (that is why the modeled process is called beta convergence): If $\beta < 0$ and statistically significant, there is absolute beta convergence (Wieland, 2020; see Allington, McCombie, 2007; Schmidt, 1997).

The mathematical foundations of beta (3) and sigma convergence (4) ordinary least squared regression models, according to Wieland (2020) and Allington, McCombie (2007), are:

$$\frac{1}{T}\sum_{t=1}^{T} ln(\frac{Y_{i,t+1}}{Y_{i,t}}) = \alpha + \beta\, ln\left(Y_{i,t1}\right) + \epsilon \ , \quad (3)$$

$$\sigma_t = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(Y_{i,t} - \overline{Y}_t\right)^2} \quad ó \quad cv_t = \frac{\sigma_t}{|Y_t|} \ , (4)$$

where:

- $\mathbf{Y_{i,t}}$ is the GDP per capita of the region i at time t.
- $\mathbf{\overline{Y}_t}$ is the arithmetic mean of $Y_{i,t}$ for all regions at time t.
- $\mathbf{T}$ is the number of regions
- $\boldsymbol{\alpha}$ and $\boldsymbol{\beta}$ are estimated parameters.
- $\boldsymbol{\epsilon}$ is an error term.
- $\boldsymbol{\sigma_t}$ is the standard deviation of the GDP per capita of all regions.
- $\mathbf{cv_t}$ is the coefficient of variation of $\boldsymbol{\sigma_t}$

There are two other useful parameters derived from beta parameter. The speed of convergence, $\boldsymbol{\lambda} = \frac{-\ln(1+\beta)}{T}$**,** which is interpreted as the annual speed of convergence measured as a percent (Allington and McCombie: 2007; Goecke and Huether: 2016) and *half-life* parameter, “which means the time (measured in the regarded time periods) to reduce the regional disparities by one half” (Wieland, 2020; see Allington, McCombie, 2007; Schmidt, 1997). The *half-life* parameter can be calculated as

$$half.life = \frac{log2}{\lambda}. \qquad (5)$$

In addition, Mendez and Santos-Márquez (2022) point out two warning on equation (3). First, unobserved heterogeneity, considering the existence of unmeasured (unobserved) differences between study participants or samples that are associated with the (observed) variables of interest. Second, the model may suffer from endogeneity, that is, a correlation of the explanatory variable with the errors due to the lack of explanatory variables. Both warnings are related with the absence of more variables. Nevertheless, in this research the case of study is of absolute convergence, in which fixed variables of the neoclassical growth model of Ramsey (1928), Solow (1956), and Koopmans (1966) are considered. Even in this limited scope, the analyses and results are still informative as they may serve as a first benchmark for future studies that use a conditional convergence model to study the manufacturing industry in the U.S.-Mexico border states.

4.4. Conclusion of the section

The data collection was not an obstacle since it was obtained from official government institutions from both countries. The principal obstacle was to define a method for the homogenization of currencies. When comparing different countries, other authors as Yin et al. (2003) used the purchasing power parity (PPP) for this matter. In future work on the topic, it may be useful to use other methods of currency homogenization between the U.S.-Mexico border states and compare results with this research.

The methodology consists of sigma convergence and absolute beta convergence models, along with its graphical representations. The sigma convergence is achieved when the dispersion of the natural logarithm of the GDP per capita diminishes over time, and the beta convergence is achieved when there is a negative value on β, which represents a negative relation between the GDP growth rate of the period and the logarithmic value of time zero, and is statistically significant.

5. Regression analysis

5.1. Introduction

Section 5 presents the results of the trend regression for both sigma and beta convergence ordinary least squares models. Initially, the convergence analysis focuses on the GDP per capita of the US-Mexico border states. Subsequently, the same analysis is extended to the manufacturing GDP per capita within the same region. The section covers the description of the sigma convergence trend regression, accompanied by an analysis of its graphical representation. Following this, the beta convergence trend regression is explained, along with its graphical representation, for both GDP per capita and manufacturing GDP per capita. Concluding this section, there are some key findings and conclusions.

5.2. Sigma convergence

Table 2 presents the results of the sigma convergence trend regression model for the GDP per capita of the US-Mex border States. The existence of sigma convergence depends on a negative value on the Time parameter, and it must be statistically significant (pr < 0.05). Since none of both conditions strike, there is not enough evidence to affirm there is sigma convergence for the GPD per capita of the US-MEX border states, between 1993 and 2021.

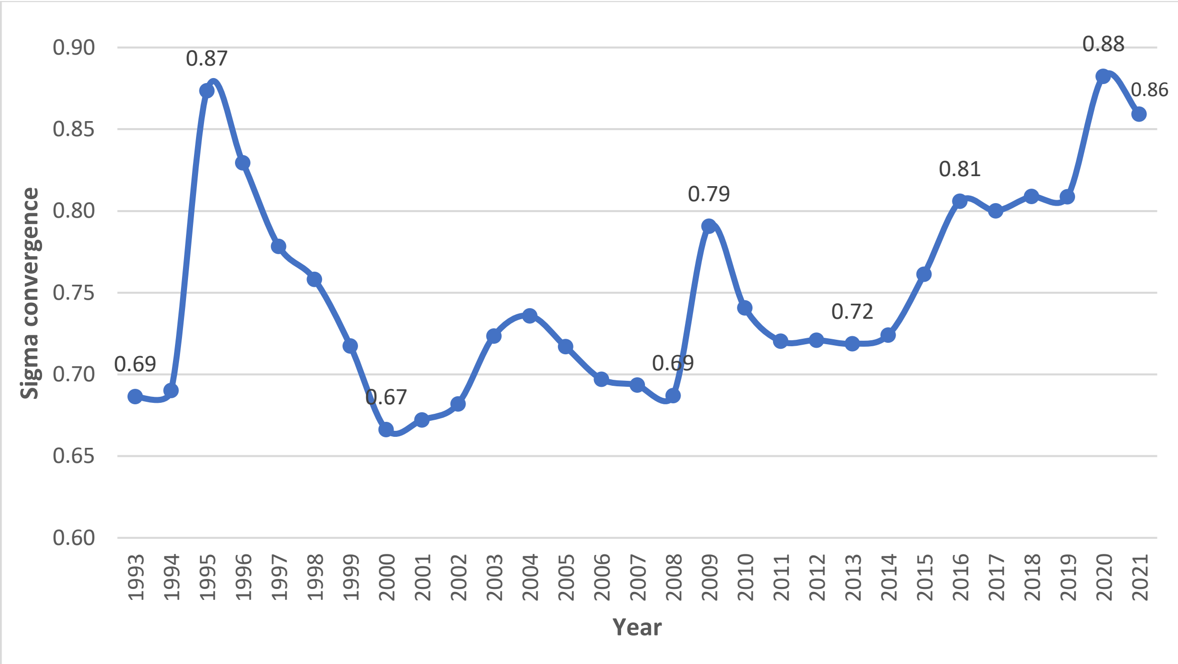
Table 2: Sigma convergence for the US-MEX border States for multiple periods (Trend regression): 1993-2021

	Estimate	Std. error	t value	Pr(>|t|)	
Intercept	-25.19160544	43.4006898	-0.5804425	0.5662588	
Time	0.01299279	0.0217711	0.5967907	0.5554424	
Model Stats					
	Estimate	F value	df 1	df 2	Pr(>F)
R-Squared	0.0125602	0.3561591	1	28	0. 5554424

Own elaboration

Figure 51 shows that sigma convergence has three mayor peaks: in 1995, results of the 1994 Mexican Financial Crises; 2009, as consequence of the 2008 world financial recession; and in 2020, due to the COVID-19 pandemic recession. In the twenty-seven years period, income inequality in 2020, based on the sigma convergence, is just 0.01 points below its highest level, in 1995. This proves a slight tendency toward a mayor dispersion of income among the border states, which means a tendency to divergence, that is, a higher degree of income inequality.

Figure 51 Sigma convergence of the GDP per capita of the Northern border states of Mexico and Southern border states of the U.S.: 1993-2021



Own elaboration with data from the INEGI, BEA and US Census Bureau

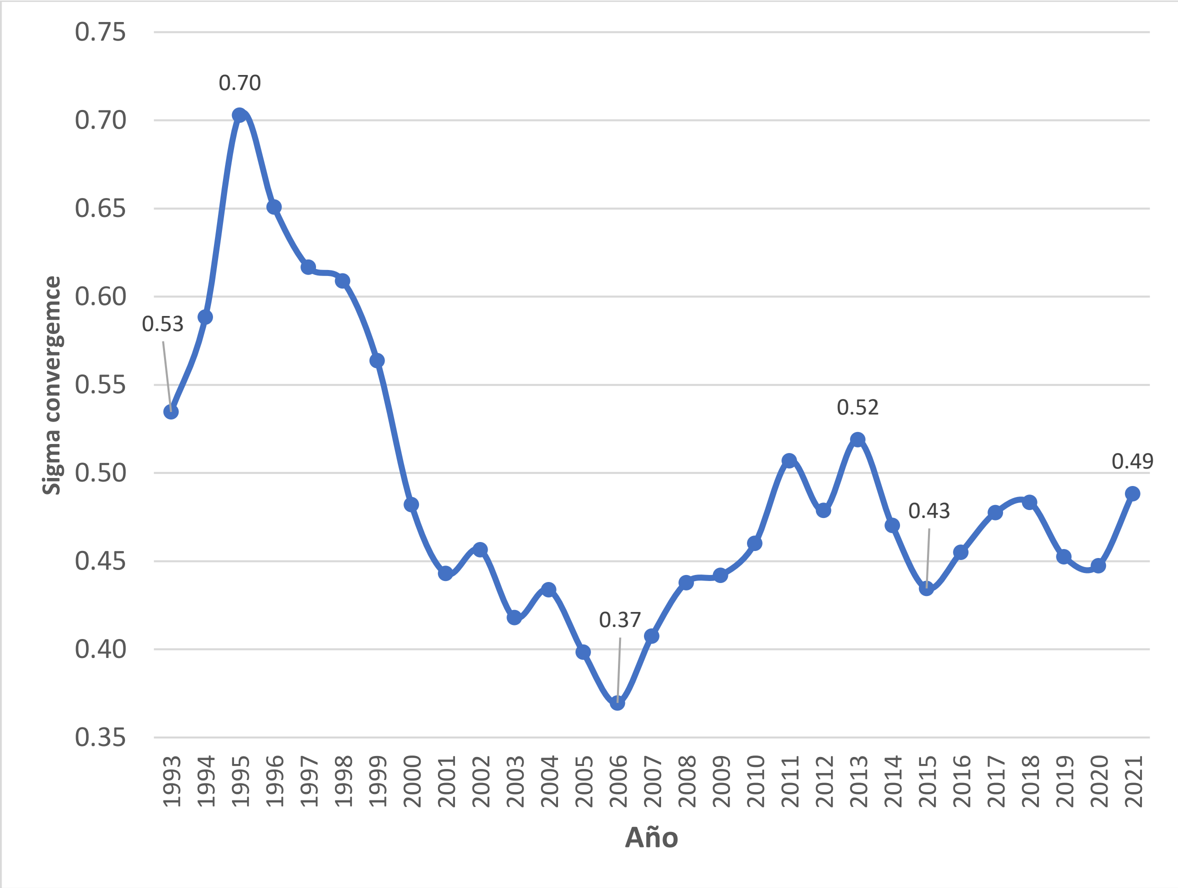
On the next sigma convergence regression for multiple periods, related to manufacturing GDP per capita among the same region and period, table 3 presents values for both the intercept and the variable *time* with a probability greater than 0.05, which makes them both not statistically significant. The variable *time* has a value of 0. 00301387, which means that, by every year that passes, the sigma convergence of the manufacturing GDP per capita —or standard deviation of the natural logarithm of the manufacturing GDP per capita— of the border states that share Mexico and the United States, increases 0.00301387 units. The R-squared has a level of 0. 0004274319, which stand for a not significant model.

Table 3: Sigma convergence for the manufacturing industry in the US-MEX border states, multiple periods (Trend regression): 1993-2021

	Estimate	Std. Error	t value	Pr(>|t|)	
Intercept	-5.54130523	54.9079737	-0.1009199	0. 9203333	
Time	0. 00301387	0. 0275435	0.1094222	0. 9136481	
Model Stats					
	Estimate	F value	df 1	df 2	Pr(>F)
R-Squared	0.0004274319	0. 01197321	1	28	0. 9136481

Own elaboration.

Figure 52: Sigma converge of the manufacturing GDP per capita of the northern border states of Mexico and southern border states of the U.S.: 1993-2021



Own elaboration with data from I.N.E.G.I., BE.A. and U.S. Census Bureau.

Figure 52 shows the evolution of sigma convergence in the manufacturing industry of the border states shared by Mexico and the United States, from 1993 to 2021. The motives of its progress and changes are:

- From 1993 to 1995 there was a high upwards change, going from 0.53 to 0.70, which means a mayor dispersion of manufacturing GPD per capita. In other words, higher inequality in the manufacturing sector among the states of the region of study. The main reason of this raise is the 1994 financial crisis of Mexico, which derived in capital flight, rise in the unemployment rate and overall decrease in Mexican production. In the northern border stares of Mexico, according to Erquizio, Ramírez and García (2021), who studied regional and national economic cycles from 1980 to 2017, the fall of the GDP of the northern border states of Mexico was -6.25% in 1995.
- Since 1995, sigma convergence kept a constant negative tendency in the following years until 2006. According to Chiquiar and Tobar (2019), who studied the Global Value Chains in Mexico from 1993 to 2017 in a historical perspective, from 1995 to 2001 there was an increase in the participation of Mexico in the global value chains because of the firm of the North America Free Trade Agreement. In addition, Erquizio, Ramírez and García (2021), describe an economic expansion for the northern border states of Mexico from 1996 to 2000, and a recession in the same region in 2001, derived from a mayor competition on global value chains with China due to its integration to the World Trade Organization in that year. And, from 2002 to 2008, there was again an expansion period for the northern region of Mexico, with the highest growth rate compared to the other regions of the country: 2.56% at a national level, 2.39% in the center region, 3% in the northern center region, 3.63% in the northern region, 1.47% in the southern region. Also, the foreign direct investment in the northern border states of Mexico maintained a general constant growth rate from 2002 to 2008, as shown in figure 6, along with a constant growth in international trade between Mexico and the United States in this subperiod, with a trade surplus for the former nation, as shown in figure 2.

- In 2006, the manufacturing GDP per capita dispersion among the Mexican and U.S. border states hit 0.37, the lowest in the period of study. From that year until 2013, sigma convergence raised rapidly in 2007 and 2008 due to the lethargy in international trade derived from the 2008 financial crises; fell from 2011 to 2012 and raised again in 2013 to 0.52. Then, from 0.52 in 2013, it fell to 0.43 in 2015, maybe derived from a drop in manufacturing production in Texas in 2014 and 2016, which, even though it seems smaller than the fall of manufacturing production in the northern border states of Mexico during the same period —see figures 5 and 8—, it has a larger representation of production in the border region. In 2018, the dispersion on manufacturing per capita output raised again to 0.48, dropped in the next two years, but raised again to 0.49 in 2021. This last raised is because of the population decreased registered in California in 2021 due to the COVID-19 deceased and, particularly, people moving out as the cost of living in this state soars, according to the Unites States Census Bureau (2022) and Lange (2022). The result of this is an increase in per capita terms of California per capita income and the manufacturing GDP pc coefficient of variation.

5.3. Beta convergence

Table 4 presents the results of the ordinary least squares beta convergence regression model for the US-MEX border States. None of the parameters, α nor β, are statistically significant. And, since the later is positive, it can be affirmed there is no absolute convergence in GDP among the border states of the U.S. and Mexico.

Because the beta parameter is positive on the regression on Table 4, something different happens in this case: since *Lambda* is measured through the equation $\boldsymbol{\lambda} = \frac{-\ln(1+\boldsymbol{\beta})}{\boldsymbol{T}}$**,** β ought to be negative for λ to be positive, considering that a positive value in β would mean a negative speed of convergence. Then, considering the *Halflife* is calculated through $half.life = \frac{log2}{\lambda}$, a negative value in λ would mean a negative number of years to reduces income disparities by half. Thus, *Lambda* and *Halflife* parameters cannot be calculated if β parameter is positive.

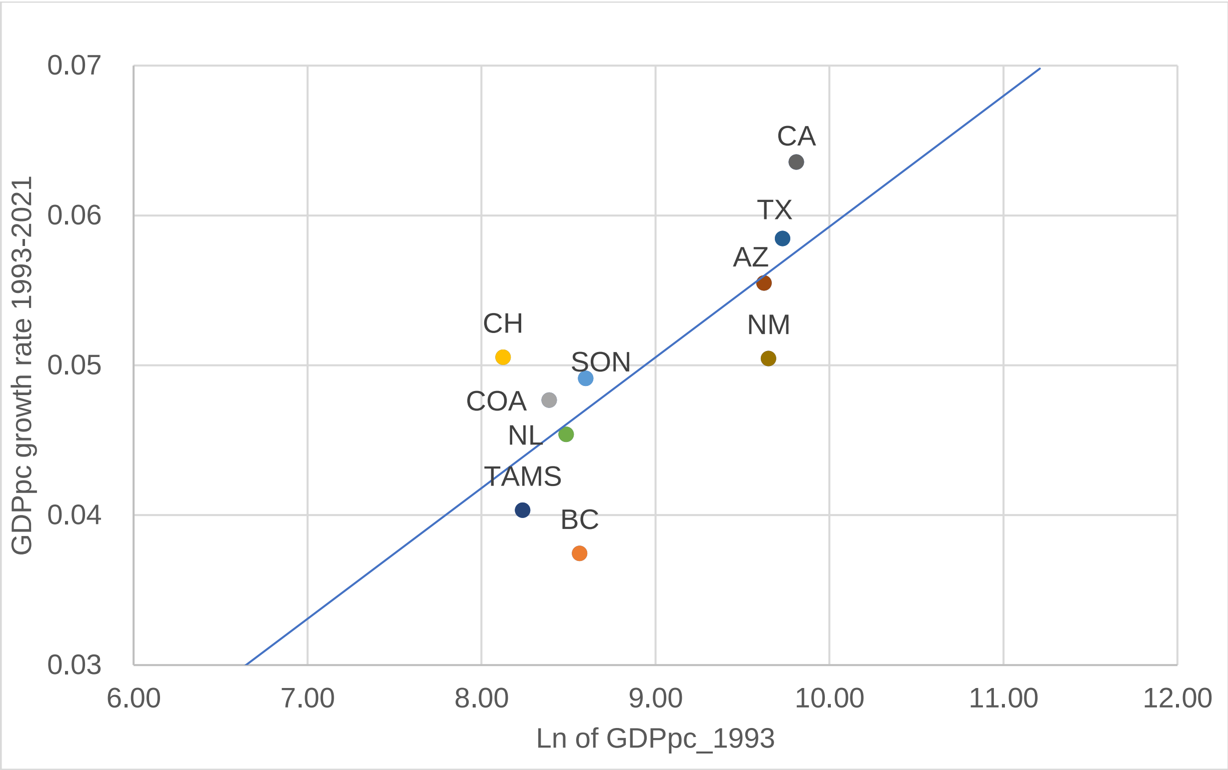
Table 4: Beta convergence of the US-MEX border States, trend regression: 1993-2021

	Estimate	Std. Error	t value	Pr(>|t|)	
Alpha	-0.071730389	0. 0.0250552	-2.862892	0. 02105761	
Beta	0.008389857	0. 00258416	3.246644	0.01176003	
Lambda	NA	NA	NA	NA	
Halflife	NA	NA	NA	NA	
Beta model Stats					
	Estimate	F value	df 1	df 2	Pr(>F)
R-Squared	0.5685167	10.54069	1	8	0.011076003

Own elaboration.

Figure 53 presents the previous regression results of Table 4. The y-axis represents the GPD per capita growth rate from 1993 to 2021, while the x-axis represents the natural logarithm of the GPD per capita on the initial year. Each dot represents a state, where “AZ” is Arizona, “CA” is California, “NM” is New Mexico and “TX” is Texas, for the U.S. set of states; “BC” is Baja California, “CH” is Chihuahua, “COA” is Coahuila de Zaragoza, “NL” is Nuevo León, “Son” is Sonora and “TM” is Tamaulipas, for the Mexican set of states. On the right-upper side of the graph, which corresponds to states with high values on both axis, the set of four dots corresponds to the U.S. Southern border States. Furthermore, on the right lower side of the graph, which corresponds to the states with low values on both axis, the set of ten dots correspond to the Mexican Northern border States. There beta convergence trend regression of the US-MEX border states presents a positive relation, meaning there is no absolute beta convergence in the GDP levels of the region.

Figure 53: Beta convergence of the GDPpc in the US-MEX border States: 1993-2021



Own elaboration.

On Table 5, the beta convergence ordinary least squares regression model for the manufacturing GDP per capita of the U.S.-Mex States, from 1993 to 2021, shows the following results. *Beta* has a negative value, which is a first indication of beta convergence, and *Alpha* is statistically significant. Yet, *Beta* is not, since its p-value is greater than 0.05. In consequence, there is enough evidence to affirm there is no beta absolute convergence in the manufacturing industry among the U.S.-Mex States.

The next estimate, *Lambda*, indicates that convergence in the manufacturing GPD per capita grows at a speed of 0.00075% per year. The last estimate, *Halflife*, can be calculated because the *Beta* parameter is negative, despite not being statistically significant. It shows that it would take 921 years for the disparities of manufacturing GPD per capita to reduce in half among the states that compound the border region of Mexico and the United States.

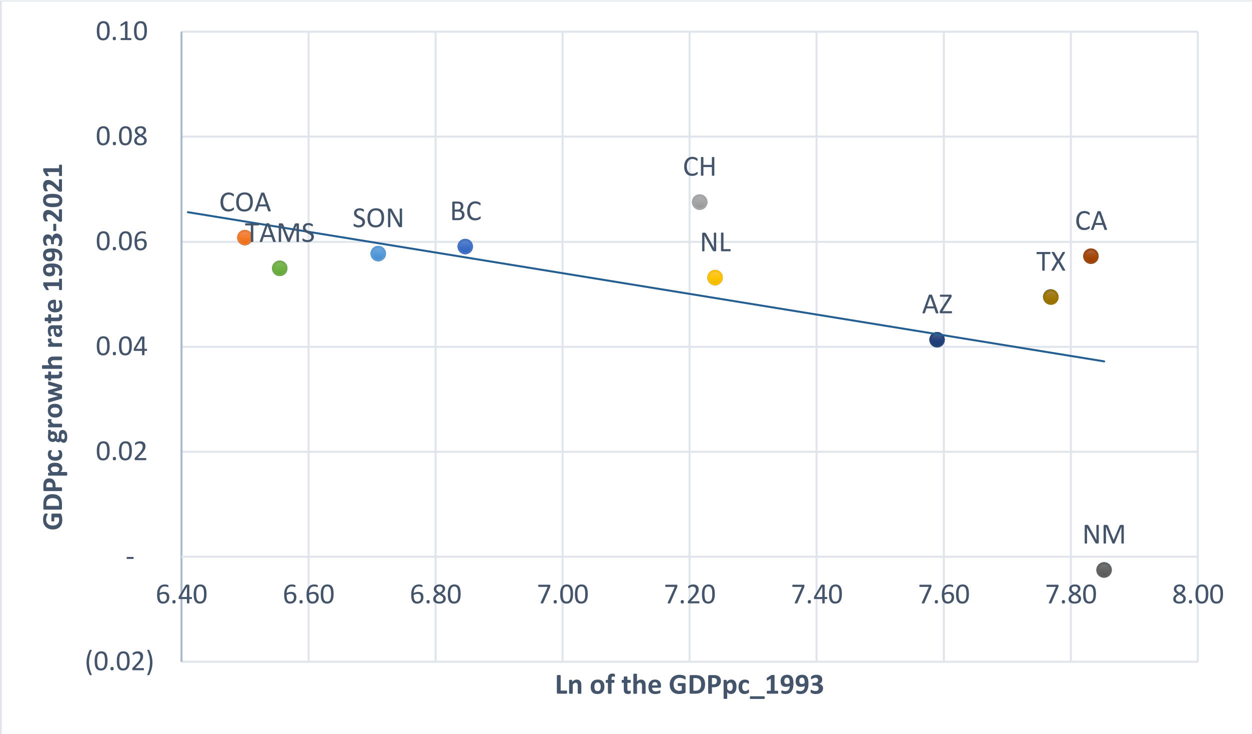
Table 5: Beta convergence of the manufacturing industry in the US-MEX border States, trend regression: 1993-2021

	Estimate	Std. Error	t value	Pr(>|t|)	
Alpha	1.753105e-01	0.08182921	2.142395	0.06453523	
Beta	-2.083981e-02	0. 01026327	-2. 030523	0.07679483	
Lambda	7.521427e-04	NA	NA	NA	
Halflife	9.215634e+02	NA	NA	NA	
Beta model Stats					
	Estimate	F value	df 1	df 2	Pr(>F)
R-Squared	0.3400987	4.123026	1	8	0.07679483

Own elaboration.

Figure 54 shows the graph of Beta convergence for the manufacturing industry GDP per capita. The set of U.S.-Mex border States are separated into the two subsets: from the middle to the upper-left side of the graph, there are the Mexican northern border states, with low initial levels of manufacturing GDP per capita, but higher growth rates; on the right mid-lower side of the graph, there are the U.S. southern border states, with high initial levels of manufacturing GDP per capita, but smaller growth rates than the Mexican states. Then, this is another indicator of higher growth from Mexican Northern States in terms of manufacturing, regardless of the lack of statistically significance beta parameter.

Figure 54: Beta convergence of the manufacturing GDP per capita of the northern border states of Mexico and southern border states of the U.S.: 1993-2021



Own elaboration.

Based on both trend regressions and the graph of beta convergence, there is enough statistical evidence to accept our hypothesis: the manufacturing industry project in the northern border states of Mexico has made possible an absolute convergence phenomenon with the manufacturing industry of the southern borders states of the United States, from 1993 to 2021.

5.4. Conclusions of the section

Both sigma and beta convergence were not achieved for the manufacturing industry in the northern border states of Mexico with the southern border states of the United States. The standard deviation of the natural logarithmic value of the manufacturing GPD per capita raised from 1993 to 1995, due to the financial crisis in Mexico; fell from 1996 to 2006, due to a rise in Mexican national trade with a trade surplus; raised again from 2007 to 2013, fell until 2015, and has maintained similar levels in the last year. In general, from a value of 0.55 in 1993, the sigma convergence diminished to 0.49 in 2021.

The ordinary least square regression model for the beta convergence showed not enough statistically significant results on β for the manufacturing industry among the U.S.-MEX States, despite it being negative, a *Lambda* parameter —the annual speed of convergence measured as a percent— of 0.0075%, and a *Halflife* —the time in which disparities among the region will reduce by half— of 921 years.

Also, there is not enough statistical evidence for beta and sigma convergence for the total GDP by State in the region of study; *Halflife* parameter cannot even be measured since *Beta* is positive in this case.

Conclusions

Considering the statistical results of the trend regressions and graphical information, for both sigma and beta convergence, along with the historic description of the efforts made by several federal Mexican administrations and local governments across the borders states and municipalities, there is not enough evidence to affirm that the manufacturing industry project in the Northern border States of Mexico has made possible an absolute convergence phenomenon with the manufacturing industry of the southern borders states of the United States, from 1993 to 2021. The key reasons for this are:

- The income and production divergencies among the region, but particularly with California and Texas. Their GPD per capita and Manufacturing GPD per capita values are far greater than the ones in Mexico's Northern border States.
- As Fuentes, Gaytan and Brugés (2023) point, the bilateral-sectoral trade balance shows that Texas and California specialize in exports of intermediate goods; Mexico specializes in final goods, resulting in low export multipliers for the latter, maintaining high dependence on intermediate goods from Texas and California, and in lower foreign exchange earnings per dollar exported.
- While the Northern border States of Mexico specializes in final goods through assembly, the US southern border States, particularly Texas and California, not only produce intermediate goods, but technology, knowledge and capital, leaving the Mexican region with low added-value chain activities.
- According to Erquizio, Ramírez and García (2021), whose research focused on regional and national economic cycles from 1980 to 2017, describe that the fall of the GDP of the northern border states of Mexico is greater than any other regions of Mexico during recessive periods (1994, 2008), suggesting harder efforts to recover GDP levels after a recession.

Beyond the answer to the research questions, other attributes of this thesis are the following. In section one, the summary of the first studies and approaches to the concept of economic convergence, going through the idea of *convergence clubs* made by Baumol (1985), Paul Romer's idea of investment in human capital and integrated markets to diminish divergence; Abramovitz' critic on matter that not only follower countries import technology from leader, but the other way around, and the importance of technology imports, knowledge flow, human capital and international trade can lead to followers to catch up to leader nations, something that does not happen only with technology imports. Also, in this section a series of papers involving convergence on national levels were reviewed, as had been done by Baumol (1985), Abramovitz (1986), Romer (1990) and Yin, L., et al. (2003), but also at a subnational level: Barro and Sala-i-Martin (1990) and Yamamoto (2007) on the U.S. states, Martínez-Galarraga and Tirado (2015) on Spain, Combes, P. P, et. al. (2011) in France, and Normand, A., and Quintana, L. (2010), along with Aguilar (2016) in Mexico. The importance in the reviews of these research lays on the contrast in the scale of study —national, subnational— and the different methodologies applied.

On section 2, the US southern border states and Mexico Northern border states were compared in income per capita, manufacturing GDP, population, its respective growth rates, geographical size, and business and fiscal incentives. The U.S. states are larger in area, GDP and manufacturing GDP, and have many subnational business incentives for the attraction of investors in their states; the Mexican states are smaller and have minor figures in all variables compared to the U.S. states, except for the manufacturing GPD growth rate from 1993 to 2021. This resulted in a growing disparity of GPD per capita among both sets of border states in the period of study. Furthermore, despite fiscal stimulus in Mexico for the manufacturing industry and, particularly, for the automotive industry, there are few fiscal stimuluses at a subnational level, unlike the U.S. The most relevant Mexican business incentive, for matters of this investigation, is the Fiscal stimulus for the Northern Border Region, the only one at a regional level. This makes us wonder how investor decides where to locate within Mexico, choosing one region against the other, especially in the manufacturing industry, where the northern states compete with the central states. In the U.S., at least the southern border states have mechanism with which they compete to attract investors, while in Mexico it appears that, in business incentives, there are not so many differences and, so, other motives are taken into consideration for industries and companies to locate —human capital, universities, research institutes in engineering, security, governability, transport routes, closeness to markets and seaports —. This problem may be a future research topic not only of convergence, but industrial location in Mexico.

On section 3, the history of the manufacturing industry in Mexico was described, from its origins in the last decade of the XIX century, during the Porfiriato, to the first decades of the XXI century, in the free trade and economic liberalization period. The constant deficiency on tax collection unleashed poor tries in industrial policy during the XX and XXI centuries. It was, and has been, cheaper to import capital and technology from industrialized countries, particularly from the United States, a country with a set of subsidies and fiscal support that made it very hard for Mexico to compete with. Mexico has maintained a roll on Global Chained Values as only a manufacturer, with most of its linkages as the lowest in value-added. Active federal and regional policies ought to be designed, along with changes in the trade agreements with other countries —particularly with the U.S.— so Mexico transcends from an assembling country to one with higher linkages in value-added in the GCV.

In section 4, as other researchers, the necessity of homogenizing currencies for a real comparison of both sets of states was necessary, since, at the beginning, currencies were expressed in dollars and Mexican pesos. It was done first converting the currencies to nominal dollars and then used the implicit Price Deflators for Gross Domestic Product from the Bureau of Economic Analysis to transform the current dollars to real 2012 dollars. When comparing different countries, other authors as Yin et al. (2003) used the purchasing power parity (PPP) for this matter. In future work on the topic, it may be useful to use other methods of currency homogenization between the U.S.-Mexico border states and compare results.

As a final remark, it may be stated that other key contribution of this research is the not only regional, but transnational character as an absolute convergence analysis. Most convergence studies are usually on a global scale, proving the existence or not of developing countries catching up with developed ones, as done by Baumol (1985), Abramovitz (1986), Barro and Sala-i-Martin (1993), Yin et al. (2003), and Rodríguez, D., Perrotini, I., and Mendoza, M. (2014). At a smaller scale, convergence studies are usually in the same country, comparing the slow growing states or regions with the ones with greater growth, as done by Barro and Sala-i-Martin (1990), Martínez-Galarraga (2015) and Tirado, Combes, P. P, et. al. (2011), Duncan and Fuentes (2006), Normand, A., and Quintana, L. (2010), and Aguilar (2016), without the necessity of currency homogenization. In our case, convergence in a transborder region was studied, composed of states from different countries, studying the evolution in GDP per capita dispersion of one of the most important industries in the U.S. Mexican-Border states.

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