VERDOORN'S LAW AND THE HETEROGENEITY OF MEXICO'S MANUFACTURING INDUSTRY

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ABSTRACT

This article analyzes structural heterogeneity, low productivity, and the unequal growth of Mexico's regional manufacturing industry during the period of economic liberalization. Verdoorn's law is estimated using a panel data model with cross-section and period fixed effects, in which labor productivity is a function of the specialization index and value-added growth rates. The results show that heterogeneity stems from regional and sectoral differences in capital accumulation and varying degrees of specialization. In general, capital accumulation rates were low, while specialization levels were high, which constrained labor productivity and produced uneven growth across states. These disparities characterized Mexico's 32 federal entities during the 1999-2019 period.

Keywords: Verdoorn's law, economic stagnation, specialization index, labor productivity, capital accumulation.
JEL Classification: C23, O47, R11, L60.

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LA LEY DE VERDOORN Y LA HETEROGENEIDAD
DE LA INDUSTRIA MANUFACTURERA MEXICANA

RESUMEN

Este artículo analiza la heterogeneidad estructural, la baja productividad y el crecimiento desigual de la industria manufacturera regional de México durante el periodo de liberalización económica. La ley de Verdoorn se estima mediante un modelo de datos de panel con efectos fijos de sección transversal y de periodo, en el cual la productividad laboral se plantea como una función del índice de especialización y de las tasas de crecimiento del valor agregado. Los resultados muestran que la heterogeneidad se deriva de las diferencias regionales y sectoriales en la acumulación de capital, así como de los distintos grados de especialización. En general, las tasas de acumulación de capital fueron bajas, mientras que los niveles de especialización fueron elevados, lo que restringió la productividad laboral y generó un crecimiento desigual entre los estados. Estas disparidades caracterizaron a las 32 entidades federativas de México durante el periodo 1999-2019.

Palabras clave: Ley de Verdoorn, estancamiento económico, índice de especialización, productividad laboral, acumulación de capital.
Clasificación JEL: C23, O47, R11, L60.

1. INTRODUCTION

The literature widely documents that following the 1994 trade opening, Mexico's manufacturing industry underwent deep structural transformations and a shift in its specialization pattern driven by integration with the United States and Canada (Livas and Krugman, 1992; Hanson, 1994; Hiernaux-Nicolás, 1995; Hernández, 2000). Far from producing regional convergence, liberalization reinforced industrial polarization and spurred new manufacturing poles in the northern states (Esquivel, 1999).

It was accompanied by the dismantling and recomposition of the industrial base and by agglomeration diseconomies in the main manufacturing centers of central Mexico —stemming from trade opening, the deregulation of foreign direct investment, and productive restructuring

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(Hernández, 1985, 1991; Brown y Domínguez, 1994)— with visible consequences for macroeconomic stagnation.

Salama (2020) argues that Mexico's slow growth reflects the coexistence of an export-oriented manufacturing sector and a simultaneous deindustrialization of the domestic market: after liberalization, the country specialized in assembled-goods exports, relocating manufacturing toward the north, while external competition closed numerous domestic firms displaced by imports, weakening the internal productive base.

Between 1994 and 2020, liberalization policies and structural reforms reshaped the regional manufacturing landscape, turning Mexico into a peripheral manufacturing economy dependent on the United States. The absence of an active industrial policy encouraged specialization in assembly manufacturing and cheap-labor exports, deepening structural heterogeneity, reducing productivity, and intensifying regional disparities. In this context, Verdoorn's law and cumulative causation approaches emerge as particularly relevant tools for explaining this heterogeneity and the divergent trajectories of regional growth (Calderón y Martínez, 2005).

The objective of this article is to analyze the structural heterogeneity of Mexico's regional manufacturing industry during the period of economic liberalization through the estimation of Verdoorn's law using fixed-effects panel models. The central hypothesis is that states with higher manufacturing growth and greater productive specialization tend to generate cumulative productivity gains associated with increasing returns to scale, while states with weak industrial structures and low capital accumulation remain trapped in processes of stagnation and deindustrialization.

The article contributes to the literature in three ways. First, it estimates both the canonical and conditional versions of Verdoorn's law for the 32 Mexican states during the 1999-2019 period. Second, it incorporates a regional specialization index into the analysis in order to capture the structural characteristics of manufacturing accumulation. Third, it develops a productivity-threshold methodology that allows the classification of states according to their relative manufacturing performance and productive heterogeneity.

This article is organized into five sections, including this introduction. The second documents the main regional transformations of Mexico's

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manufacturing sector between 1999 and 2019 —an unequal redistribution marked by the deindustrialization of historically industrial states and the reindustrialization of the north and the Bajío, giving rise to a dual and heterogeneous structure that underscores the need for an active industrial policy. The third lays out the theoretical foundations of Verdoorn's law. The fourth describes the methodology and presents the econometric results from a fixed-effects panel data model estimated by ordinary least squares. The article closes with the main conclusions.

2. REGIONAL HETEROGENEITY AND UNEQUAL DEVELOPMENT OF THE MANUFACTURING INDUSTRY IN MEXICO, 1999-2019

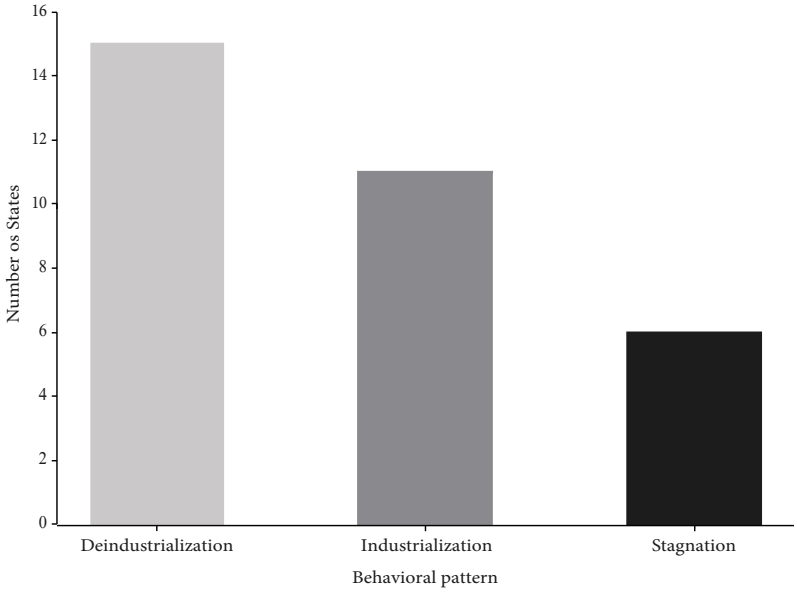
Over 1999-2019, the regional structure of Mexico's manufacturing industry underwent profound transformations. Historically industrialized states —Mexico City, the State of Mexico, Jalisco, and Chihuahua— experienced deindustrialization and stagnation, while new regions emerged as centers of accumulation, as early advantages in infrastructure and location proved insufficient to sustain dynamism under trade opening and productive relocation.

This polarization is evident in the behavior of value added (Graph 1). Eleven states achieved reindustrialization —among them Coahuila, Nuevo León, Guanajuato, Querétaro, Puebla, and Aguascalientes— driven by the automotive sector and foreign investment (Table A1), while fifteen experienced deindustrialization (Table A2) and six remained stagnant (Table A3). Disparities widened as northern and Bajío economies consolidated their share of output and much of the center and south lost relative weight.

A key feature was the integration of northern and Bajío states into North American manufacturing chains through NAFTA-linked export industrialization. States such as Nuevo León, Coahuila, Chihuahua, Guanajuato, Querétaro, Aguascalientes, and San Luis Potosí specialized in transportation equipment, automotive production, electronics, plastics, and metal-mechanical industries tied to foreign direct investment and export markets. This reinforced maquila-type assembly production dependent on imported inputs and external demand, particularly from the United States; although it generated growth and export dynamism, its articulation with domestic suppliers remained limited, operating

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Graph 1. Behavioral patterns of manufacturing value added, 1998-2019



through enclave structures with low domestic technological content and weak backward linkages.

The territorial effects were highly uneven: northern and Bajío regions benefited from economies of scale, productive concentration, and cumulative growth, while much of central and southern Mexico experienced relative industrial decline, weak diversification, and lower productivity growth. Trade liberalization thus relocated activity and consolidated a structurally heterogeneous regional economy.

Deindustrialization was associated with the rising predominance of primary and service activities, which exhibit constant or decreasing returns. In Mexico City, the State of Mexico, and Jalisco, plant closures and relocation toward lower-wage regions produced a sustained decline in manufacturing value added, undermining the industrial base oriented toward the domestic market. Reindustrialized states —notably Coahuila, Nuevo León, Guanajuato, Querétaro, and San Luis Potosí— instead diversified and upgraded their structures around the automotive industry, metalworking, and plastics, generating supply-chain linkages and scale economies as they integrated into North American supply chains.

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This restructuring was closely linked to the increasing returns and cumulative causation processes described by Kaldorian theory: regions integrated into dynamic sectors —particularly automotive and transportation equipment— generated productivity gains through clustering, technological learning, and scale economies. Yet the benefits were distributed asymmetrically: while the north and Bajío built modern platforms integrated into global value chains, many southern states remained specialized in low-productivity activities with weak technological capabilities. States in dynamic sectors exhibited stronger Verdoorn effects and greater capacity to convert growth into sustained productivity, whereas weak industrial structures faced stagnation and diminishing returns, consolidating persistent regional productivity gaps.

Analysis using the Regional Specialization Index (Location Quotient, LQ) confirms this polarization. States with LQ ≥ 1 are highly specialized in key subsectors such as textiles, chemicals, transportation equipment, plastics, and food processing (Table A4), while those with LQ < 1 are less diversified, limiting competitiveness (Table A5). Subsectors 336 (transportation equipment) and 326 (plastics and rubber) emerge as growth drivers in reindustrialized states, particularly Coahuila, Guanajuato, and Querétaro (Table A6).

This specialization concentrated in a few strategic subsectors — transportation equipment (NAICS 336), plastics and rubber (NAICS 326), electronics, and metalworking— benefiting from foreign direct investment, export orientation, and integration into North American production networks. It also revealed structural weaknesses: a large share of exports depended on imported intermediate goods and foreign technology, limiting domestic innovation and the diffusion of technological spillovers, so that localized productivity gains failed to produce broad-based industrial convergence at the national level.

By contrast, states with low specialization indices remained concentrated in traditional manufacturing, primary production, or low-productivity services, limiting their capacity to generate increasing returns. Although export-oriented manufacturing expanded, its capacity to stimulate endogenous development was limited: growth concentrated in assembly activities with low domestic value added and weak local integration, so modernization coexisted with fragmentation of the do-

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mestic industrial base. The sector thus evolved toward a dual, segmented structure —dynamic export enclaves in the north and Bajío alongside stagnation and productive lag in much of the center and south— reinforcing structural heterogeneity and constraining national productivity convergence.

In short, Mexico's manufacturing industry is undergoing a dual process: concentration and modernization in a handful of regions alongside stagnation and deindustrialization in most of the country. Although some northern and Bajío states have built dynamic economies grounded in increasing returns, these gains have been insufficient to reverse the broader decline in national industrial dynamism —confirming a structurally heterogeneous manufacturing sector marked by persistent regional inequality.

2.1. Empirical literature review

The empirical literature on Kaldor's and Verdoorn's laws emphasize manufacturing as the sector with the greatest capacity to generate increasing returns to scale, technological learning, productive linkages, and cumulative causation. This is especially relevant for Mexico, where trade liberalization and export-oriented industrialization have not produced sustained convergence among regions but have deepened structural heterogeneity across states.

Borgoglio and Odisio (2015) provide a long-run comparison of manufacturing productivity in Argentina, Brazil, and Mexico (1950-2010), testing Kaldor-Verdoorn's law from a Latin American perspective with instrumental variables and fixed-effects panels. They confirm the relationship's statistical relevance but find that the Verdoorn coefficient declined after liberalization, suggesting manufacturing growth became less capable of generating productivity gains under the open-economy regime. This supports the view that Mexico retains some increasing returns, but under weaker structural conditions and with more limited cumulative effects.

Loría *et al.* (2019) offer a Kaldorian explanation of Mexico's low growth (1980-2017), arguing it stems from insufficient manufacturing dynamism. Using the GMM (Generalized Method of Moments) and rolling regressions, they show that the coefficient linking manufacturing

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growth to aggregate output weakened under liberalization, reinforcing the interpretation of deindustrialization and an enclave-type pattern. Their work provides the macroeconomic foundation for analyzing, at the state level, why manufacturing growth has been insufficient to produce generalized productivity gains and regional convergence.

Avendaño and Perrotini (2015) approach Mexico's low growth through dynamic insufficiency, capital accumulation, employment, and productivity, integrating Prebisch's dynamic insufficiency, Harrod's growth theory, Kaldor-Verdoorn's law, and Thirlwall's approach. Using a bounds-testing (Pesaran) and error-correction framework for 1974-2012, they find that low capital accumulation reduces labor absorption, weakens labor productivity, and constrains long-run growth —strengthening the argument that productivity problems are not only a matter of scale but of structurally weak capital accumulation.

Quintana, Rosales, and Mun (2013) extend the Kaldorian framework to a comparison of Mexico and South Korea (1998-2008), estimating Kaldor's laws with ordinary least squares and spatial econometric models (spatial lag and spatial error). They show that South Korea developed a virtuous pattern in which manufacturing leads output and labor-productivity growth and generates positive spatial spillovers, whereas Mexican manufacturing has not become a robust source of regional growth —highlighting the spatial externalities and productive linkages behind Mexico's localized dynamism without broad convergence.

Aroche (2021) reinterprets Kaldor-Verdoorn's law from a multisectoral perspective, linking it to input-output analysis and comparative statics. He shows that productivity growth depends on the structure of intersectoral relations and unevenly adopted technical change, not only on the growth rate of manufacturing output —suggesting that Mexico's weak productivity growth may reflect limited domestic linkages, asymmetric technical change, and an incomplete articulation of manufacturing with the rest of the economy.

Quintana, Mendoza, and Valdivia (2024) analyze regional economic growth using the Kaldor-Dixon-Thirlwall model, estimating Durbin spatial panel models with fixed effects for 2008-2019 and 2008-2023. They find the direct relationship between state export growth and regional growth statistically null, while trade openness has positive, significant effects, interpreting this as evidence of weakened national productive

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linkages —supporting the argument that export manufacturing based on imported inputs and weak domestic linkages does not necessarily generate cumulative regional productivity growth.

Pacheco-López and Thirlwall (2025) place regional disparities in Mexican per capita income at the center of analysis, linking inequality to the uneven territorial distribution of manufacturing. From a Kaldorian perspective they reinforce manufacturing's role in explaining why some regions grow faster than others, situating Verdoorn's law within the broader debate on regional income divergence, structural heterogeneity, and the uneven capacity of Mexican states to benefit from manufacturing growth.

Taken together, this literature shows that Mexico's low growth and regional divergence reflect a deeper structural problem: the weakening of manufacturing as an engine of cumulative growth, the limited domestic content of export production, the deterioration of productive linkages, and the persistence of regional heterogeneity. Methodologically, the analysis has evolved from national time-series estimations toward panel models, spatial econometrics, input-output analysis, and long-run dynamic models.

The present article contributes in three ways. First, unlike studies focused on aggregate growth or national manufacturing performance, it estimates Verdoorn's law for Mexico's 32 federal entities (1999-2019). Second, it incorporates a regional specialization index into the Verdoorn equation, distinguishing manufacturing growth in general from growth associated with specific patterns of specialization. Third, it develops a productivity-threshold approach comparing observed state productivity with that expected from the estimated Verdoorn relationship, classifying states by relative performance and identifying differentiated trajectories of industrialization, stagnation, and deindustrialization.

The relevance of the article thus lies in showing that Verdoorn's law is not homogeneous across the national territory: manufacturing growth generates productivity gains only when associated with productive specialization, increasing returns, and sufficient regional capabilities. Where manufacturing is weakly articulated, dependent on imported inputs, or concentrated in low-value-added activities, growth does not translate into cumulative gains. Since few studies combine Verdoorn's law with regional specialization indicators and productivity-threshold

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analysis at the state level, this article fills that gap by integrating manufacturing specialization, increasing returns, and regional heterogeneity into a unified panel-data framework.

3. THEORETICAL MODEL: VERDOORN'S LAW

Kaldor's three laws (1984) establish that manufacturing is the fundamental engine of economic growth, generating stronger productive linkages, economies of scale, and productivity gains than other sectors. Within this framework, Verdoorn's law (1949) explains structural heterogeneity across countries, states, and regions by proposing that those economies that expand manufacturing output more rapidly also tend to achieve higher rates of labor productivity growth, thereby generating cumulative and self-reinforcing growth processes. The Kaldor-Verdoorn relationship is based on an endogenous mechanism of technical progress in which productivity growth depends on the expansion of industrial output through increasing returns to scale, learning-by-doing effects, technological diffusion, and cumulative causation.

The Verdoorn law can be expressed as:

$$p_{ij} = \delta q_{ij} \quad [1]$$

where p_{ij} is the growth rate of labor productivity in manufacturing, $\Delta p_{ij}/p_{ij}$; $q_{ij} = \Delta q_{ij}/q_{ij}$ is the growth rate of industrial output, specifically of the manufacturing sector j; δ is the Verdoorn coefficient, *i.e.*, the average elasticity of productivity with respect to output, its theoretical value is approximately 0.45; e_{ij} is the employment growth rate, $\Delta e_{ij}/e_{ij}$.

The output growth rate (q_{ij}) is the sum of the productivity growth rate (p_{ij}) and the employment growth rate (e_{ij}), so that:

$$q_{ij} \equiv p_{ij} + e_{ij} \quad [2]$$

From relationship [1] and definition [2], the Kaldor-Verdoorn relationship is established as a function of the employment growth rate, as shown in the following equation:

$$e_{ij} = \delta_1 + (1 - \delta_2)q_{ij} \quad [3]$$

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Equation [3] establishes a linear relationship between the employment growth rate (e_{ij}) and the manufacturing output growth rate (q_{ij}). The parameter δ_1 represents the autonomous rate of employment growth when output growth is zero.

The term $(1 - \delta_2)q_{ij}$ represents the additional contribution to the employment growth rate, proportional to the manufacturing output growth rate. As manufacturing output growth (q_{ij}), the employment growth rate (e_{ij}) is expected to increase in proportion to $(1 - \delta_2)q_{ij}$:

$$\frac{de_{ij}}{dq_{ij}} = (1 - \delta_2) \qquad [4]$$

Ceteris paribus, derivative [4] represents the rate of change —or sensitivity— of the employment growth rate (e_{ij}) to changes in the manufacturing output growth rate (q_{ij}). It indicates that for each unit change in q_{ij} the employment growth rate changes in proportion to $(1 - \delta_2)$.

Following Kaldor (1984), equation [3] mirrors equation [1] and *vice versa*, such that the sum of the coefficients of both equations must equal unity: $[\delta + (1 - \delta_2) = 1]$.

However, the applicability of Verdoorn's law in emerging economies integrated into global value chains has important limitations. In peripheral economies such as Mexico, manufacturing expansion does not necessarily generate strong domestic technological spillovers or broad productivity gains when production is concentrated in assembly activities with low domestic value added, weak backward linkages, and high dependence on imported inputs. Under such conditions, export growth may coexist with structural heterogeneity, stagnant wages, and limited endogenous technological development.

Therefore, the relationship between manufacturing growth and productivity should not be interpreted only as a scale effect. As Avendaño and Perrotini (2015) emphasize, productivity growth also depends on capital accumulation, the capacity to absorb labor, and the generation of technological progress; likewise, Salama (2020) shows that export-oriented expansion may coexist with deindustrialization of the domestic base and weak domestic linkages. The validity and intensity of the Verdoorn effect are thus conditioned by the ability of regional productive structures to generate learning, technological diffusion, industrial linkages, and

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cumulative externalities. This is particularly relevant in Mexico, where liberalization strengthened export manufacturing while reinforcing regional polarization and dependence on foreign capital. Manufacturing growth can generate increasing returns, but only when accompanied by sufficient productive integration, technological upgrading, and sustained capital accumulation.

4. ECONOMETRIC METHODOLOGY: STATIC FIXED-EFFECTS PANEL MODELS

Because the Kaldor-Verdoorn law aims to explain the structural heterogeneity of economic growth, this section estimates it to identify the variables accounting for differences in growth rates associated with manufacturing dynamism across Mexico's federal entities. The hypothesis is that entities expanding industrial output more rapidly also raise labor productivity, generating a cumulative, self-sustaining process.

To measure these differences, deviations from the Verdoorn regression line are calculated, comparing each entity's actual performance with the level expected given its output expansion. Positive deviations identify regions with increasing returns and virtuous industrialization; negative deviations point to scale diseconomies, stagnation, or deindustrialization. The model thus quantifies growth gaps and provides evidence on productive specialization dynamics and regional inequality.

4.1. Data and variables

We draw on Mexico's *Censos Económicos* compiled by the Instituto Nacional de Estadística y Geografía (INEGI), which classify economic activities according to the North American Industry Classification System (NAICS). The 1999, 2004, 2009, 2014, and 2019 censuses cover all 32 states, yielding a panel with four periods and 32 cross-sections. The analysis focuses on manufacturing sectors 31-32, from which Value Added (VA) and Total Output (TO) were used to derive labor productivity and the specialization index. All variables were transformed into exponential growth rates, $\dot{x} = \left(\frac{Valor\ final}{Valor\ inicial}\right)^{1/n} - 1$, following Kaldor's (1984) methodology, computed for the intervals 1999-2004, 2004-2009, 2009-2014, and 2014-2019.

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Variables used

	Variable name	Source
$\dot{Pr}$	Labor productivity growth rate	INEGI *Censos Económicos* from 1994, 1999, 2004, 2009, and 2014, based on the North American Industry Classification System (NAICS)
$\dot{VA}$	Value added growth rate	
$\dot{LQ}$	Specialization index growth rate	

4.2. Estimating Verdoorn's law

This section estimates Verdoorn's law in two stages. The first estimates the simple Verdoorn relationship using a static panel data model; the second estimates the conditional Verdoorn Law by incorporating the growth rate of the specialization index as an additional regressor.

4.2.1. The canonical Kaldor-Verdoorn relationship

Following the canonical specification of Kaldor (1984), the labor productivity growth rate is modeled as a function of the value-added growth rate.

Table 1 presents the results of a fixed-effects model estimated on panel data spanning 32 cross-sections (states) and four time periods. The results indicate a good fit and confirm that the value-added growth rate ($\dot{VA}_{it}$) is a statistically significant predictor, positively associated with the estimated productivity growth rate ($\dot{Pr}_{it}$). The model includes both cross-section and period fixed effects, controlling for time-invariant unobserved state characteristics as well as common shocks affecting all entities within a given period.

Since both the dependent and independent variables are expressed as growth rates, the coefficient estimates reveal important information about the productivity-value added nexus. The constant term is negative (–0.018863), implying a decline in productivity growth when value added does not grow. The coefficient on the value-added growth rate is positive (0.895874), indicating that a 1% increase in value added is associated with a 0.896% increase in productivity. This result is highly significant (p = 0.0000), underscoring the role of value added as a key driver of productivity growth.

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Table 1. Dependent variable: $\dot{Pr}_{it}$

Method: Panel Least Squares Sample (adjusted): 1999-2019 Periods included: 4 Cross-sections included: 32 Total panel observations (unbalanced): 127				
Variable	**Coefficients**	**Standard error**	**t-Statistic**	**Probability**
C	–0.018863	0.003422	–5.512592	0.0000
$\dot{VA}_{it}$	0.895874	0.026500	33.80649	0.0000
Specification effects Cross-section fixed (dummy variables) Period fixed (dummy variables)				
R-squared	0.944034	Mean dependent var		0.063963
Adjusted R-squared	0.922508	S.D. dependent var		0.096704
S.E. of regression	0.026920	Akaike info criterion		–4.158301
Sum squared resid	0.065946	Schwarz criterion		–3.352075
Log likelihood	300.0521	Hannan-Quinn criterion		–3.830741
F-statistic	43.85650	Durbin-Watson stat		2.452083
Probability (F-statistic)	0.000000			

This is consistent with Verdoorn's law, which holds that value-added growth —stemming from increasing returns to scale, efficiency gains, innovation, and technical progress— drives productivity. The positive relationship reinforces the view that value-added growth raises productivity by improving resource use and capital accumulation, confirming value added as a central determinant of productivity performance across the entities analyzed.

4.2.2. Conditional Kaldor-Verdoorn law

This section presents the results of estimating the conditional Verdoorn law, which incorporates both the value-added growth rate ($\dot{VA}_{it}$) and the growth rate of the specialization index.

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Table 2. Dependent variable: $\dot{Pr}_{it}$

Method: Panel Least Squares Sample (adjusted): 1999-2019 Periods included: 4 Cross-sections included: 32 Total panel observations (unbalanced): 127				
Variable	**Coefficients**	**Standard error**	**t-Statistic**	**Probability**
C	–0.020699	0.002943	–7.034072	0.0000
$\dot{VA}_{it}$	0.908416	0.022761	39.91117	0.0000
$\dot{LQ}$	0.643938	0.109709	5.869512	0.0000
Specification effects Cross-section fixed (dummy variables) Period fixed (dummy variables)				
R-squared	0.959527	Mean dependent var		0.063963
Adjusted R-squared	0.943337	S.D. dependent var		0.096704
S.E. of regression	0.023019	Akaike info criterion		–4.466657
Sum squared resid	0.047690	Schwarz criterion		–3.638036
Log likelihood	320.6327	Hannan-Quinn criterion		–4.129998
F-statistic	59.26886	Durbin-Watson stat		2.432836
Probability (F-statistic)	0.000000			

Table 2 presents the results of the Panel Least Squares estimation with cross-section and period fixed effects. The model evaluates the impact of the value-added growth rate $\dot{VA}_{it}$ and the specialization index growth rate $\dot{LQ}$ on productivity $\dot{Pr}_{it}$. The intercept is –0.020699, indicating that if both independent variables were zero, productivity would decline by 0.020699%. This result is highly significant ($p = 0.0000$).

The coefficient on the value-added growth rate ($\dot{VA}_{it}$) is 0.908416, indicating that a 1% increase in value added is associated with a 0.908% gain in productivity. Likewise, the coefficient on the specialization index growth rate $\dot{LQ}$ is 0.643938, showing that a 1% increase in specialization is associated with a 0.643% rise in productivity. Both coefficients are

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statistically significant at the 0.0000 level, confirming a strong positive relationship between these variables and productivity.

The model —including cross-section and period fixed effects— explains 95.95% of the variation in productivity ($R^2 = 0.9595$), indicating a robust fit. The adjusted R^2 of 0.9433 confirms the model's soundness across multiple predictors. The overall significance ($F = 59.269$; $p = 0.0000$) confirms that value added and the specialization index are key determinants of productivity, underscoring the importance of incorporating both factors into productivity-oriented industrial policy.

The estimated coefficients are broadly consistent with the empirical literature on manufacturing growth and productivity in Mexico and Latin America. The positive, significant relationship between value-added growth and labor productivity supports the Kaldorian interpretation that manufacturing expansion generates increasing returns and cumulative growth —evidence reported by Loría, Mendoza, and Quintana (2019), who tie Mexico's slow growth to weak manufacturing dynamism, and by Quintana, Mendoza, and Valdivia (2024), who explain regional disparities through Kaldor-Verdoorn mechanisms linked to uneven industrial development.

The results are also consistent with Borgoglio and Odisio (2015), who estimate significant Verdoorn effects for Mexico, Argentina, and Brazil. Our findings reinforce these conclusions while showing that productive specialization is a key structural factor: states integrated into dynamic manufacturing sectors transform output growth into cumulative productivity gains, whereas regions specialized in low-value-added activities exhibit weaker increasing returns and greater structural lag.

4.2.3. Labor productivity thresholds in state manufacturing during the study period

Having estimated both the simple and conditional Verdoorn relationships using fixed-effects panel econometrics, and drawing on the resulting Kaldor-Verdoorn coefficients, we find that differences in manufacturing productivity growth rates across states are not especially pronounced on their own. A more informative perspective emerges by defining a labor-productivity efficiency threshold for each of the 32 states.

This classifies each state not by raw productivity growth but by the deviation of observed productivity from the Verdoorn regression line

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—relating each state's observed performance to the level implied by its total manufacturing output growth (Kaldor, 1984).

4.2.4. The simple Verdoorn relationship

Table 3 compares each state's observed productivity against a threshold estimated from a fixed-effects panel model using an intercept, the Kaldor-Verdoorn coefficient, and average value added, without the specialization index. Both absolute and relative differences are reported: positive values indicate states performing above the threshold, negative values those that lag behind.

The states in Table 3 are then classified into three groups using a ±5% statistical criterion, defined as follows:

$$\pm 5 = \left(\frac{observed - threshold}{threshold} \right) * 100$$

Expressed as a percentage, it proportionally measures how far each state deviates from its productivity threshold and serves as the basis for classification into the three groups, defined as follows:

- States above the threshold (AT): relative difference > +5%.
- States near the threshold (NT): –5% ≤ relative difference ≤ +5%.
- States below the threshold (BT): relative difference < –5%.

The productivity threshold analysis, with a ±5% proximity band, confirms a high degree of structural heterogeneity across Mexico's 32 states. Eleven entities display observed productivity clearly above the estimated threshold: Mexico City (134.5%), Baja California Sur (48.5%), Veracruz (41.4%), State of Mexico (26.7%), Durango (20.5%), Puebla (20.5%), Tlaxcala (15.4%), Chihuahua (13.9%), Hidalgo (10.3%), Tabasco (9.3%), Morelos (5.6%), and Jalisco (5.6%). These states exhibit high productivity levels, consistent with the presence of increasing returns to scale and more robust growth trajectories.

A second group of seven entities remains near the threshold, with relative differences between –5% and +5%, making them statistically

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Table 3. Estimated labor productivity or 'productivity threshold,' without specialization index

States	Observed productivity	Productivity threshold	Intercept	
09 Mexico City (CDMX)	0.070678	0.030134	–0.01886	
03 Baja California Sur	0.072474	0.048815	–0.01886	
30 Veracruz	0.060387	0.042709	–0.01886	
15 Estado de México	0.058989	0.046573	–0.01886	
10 Durango	0.063813	0.052945	–0.01886	
21 Puebla	0.081947	0.068028	–0.01886	
29 Tlaxcala	0.067703	0.058652	–0.01886	
08 Chihuahua	0.072332	0.063525	–0.01886	
13 Hidalgo	0.065255	0.059141	–0.01886	
27 Tabasco	0.115761	0.105954	–0.01886	
17 Morelos	0.065616	0.062154	–0.01886	
14 Jalisco	0.058952	0.0558459	–0.01886	
31 Yucatán	0.058253	0.0567965	–0.01886	
26 Sonora	0.073617	0.0723764	–0.01886	
19 Nuevo León	0.070888	0.0706020	–0.01886	
02 Baja California	0.070241	0.0704060	–0.01886	
28 Tamaulipas	0.068500	0.069124686	–0.01886	
20 Oaxaca	0.060049	0.062759481	–0.01886	
01 Aguascalientes	0.094303	0.099501445	–0.01886	
16 Michoacán	0.052909	0.057060649	–0.01886	
23 Quintana Roo	0.068705	0.074365033	–0.01886	
32 Zacatecas	0.088008	0.097538875	–0.01886	
12 Guerrero	0.050143	0.056035304	–0.01886	
05 Coahuila	0.073218	0.083567505	–0.01886	
04 Campeche	0.075084	0.087587689	–0.01886	
11 Guanajuato	0.069323	0.081411133	–0.01886	
25 Sinaloa	0.049003	0.059273769	–0.01886	
24 San Luis Potosí	0.082760	0.102221257	–0.01886	
06 Colima	0.038675	0.052687328	–0.01886	
22 Querétaro	0.054054	0.074863103	–0.01886	
18 Nayarit	0.015113	0.024353408	–0.01886	
07 Chiapas	–0.006998	0.010304414	–0.01886	
National	0.064367	0.064291174	–0.01886	

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	Coefficient LKV	Value added	Absolute difference	Relative difference (%)
	0.89587	0.054692	0.040543	134.5
	0.89587	0.075544	0.023658	48.5
	0.89587	0.068729	0.017677	41.4
	0.89587	0.073041	0.012416	26.7
	0.89587	0.080155	0.010867	20.5
	0.8958	0.096990	0.013919	20.5
	0.895874	0.086524	0.009051	15.4
	0.895874	0.091964	0.008807	13.9
	0.895874	0.087070	0.006114	10.3
	0.895874	0.139325	0.009806	9.3
	0.895874	0.090433	0.003462	5.6
	0.895874	0.083392	0.003106	5.6
	0.895874	0.084453	0.001457	2.6
	0.895874	0.101844	0.001241	1.7
	0.895874	0.099863	0.000285	0.4
	0.895874	0.099644	−0.000164	−0.2
	0.895874	0.098214354	−0.000624665	−0.9
	0.895874	0.091109332	−0.002710325	−4.3
	0.895874	0.132121755	−0.005197757	−5.2
	0.895874	0.084748133	−0.004150668	−7.3
	0.895874	0.104063778	−0.005659439	−7.6
	0.895874	0.129931078	−0.009530677	−9.8
	0.895874	0.083603613	−0.005891489	−10.5
	0.895874	0.114335839	−0.010349157	−12.4
	0.895874	0.118823283	−0.012503345	−14.3
	0.895874	0.111928835	−0.012087247	−14.8
	0.895874	0.087218481	−0.010270247	−17.3
	0.895874	0.135157686	−0.019460887	−19.0
	0.895874	0.079866508	−0.014011538	−26.6
	0.895874	0.104619738	−0.020808857	−27.8
	0.895874	0.048239382	−0.009239485	−37.9
	0.895874	0.032557496	−0.017303211	−167.9
	0.895874	0.09281905	7.66226E-05	0.11

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equivalent to the estimated average: Yucatán (2.6%), Sonora (1.7%), Nuevo León (0.4%), Baja California (–0.2%), Tamaulipas (–0.9%), Oaxaca (–4.3%), and the national average (0.11%). These states reflect an intermediate position, with productivities that approximate the threshold without exhibiting a clear advantage or significant lag.

Finally, fourteen entities fall well below the threshold, evidencing deep structural lag: Aguascalientes (–5.2%), Michoacán (–7.3%), Quintana Roo (–7.6%), Zacatecas (–9.8%), Guerrero (–10.5%), Coahuila (–12.4%), Campeche (–14.3%), Guanajuato (–14.8%), Sinaloa (–17.3%), San Luis Potosí (–19.0%), Colima (–26.6%), Querétaro (–27.8%), Nayarit (–37.9%), and Chiapas (–167.9%). In these cases, observed productivity falls far short of the reference threshold, limiting the capacity to sustain a process of increasing returns to scale.

In sum, the threshold-based classification highlights strong regional heterogeneity in labor productivity: while some states consolidate trajectories above the threshold, others remain trapped in persistent underperformance. The Verdoorn relationship—growth drives productivity—thus underscores the importance of directing industrial policy toward development poles in states near (NT) or below (BT) the threshold, where the scope for generating increasing returns and long-run convergence with above-threshold (AT) states is greatest.

Maps 1(a) and 1(b) together illustrate the relative performance of state labor productivity against the estimated threshold.

Map 1(a) uses a continuous gray scale for the relative productivity difference by state: darker shades mark states below the threshold (deeper hues denoting deeper lag) and lighter shades those above it, capturing the full gradation of territorial productivity gaps.

Map 1(b) simplifies this into two categories —above the threshold (light gray) and below it (dark gray)— allowing immediate identification of leading and lagging states, though without conveying the magnitude of the differences.

Based on both maps, we classify the states as follows:

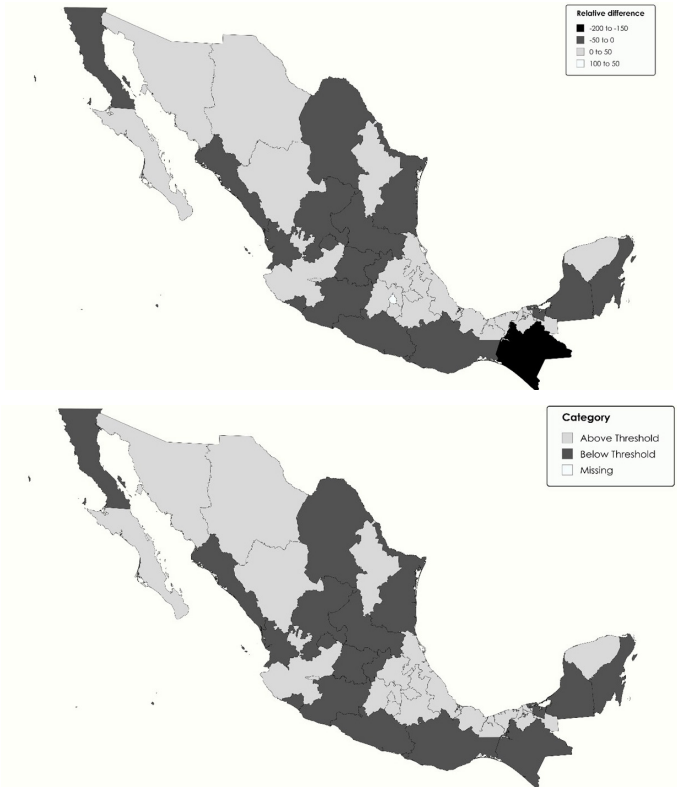
- States with productivity well above the threshold: for example, Mexico City (CDMX), Baja California Sur, and Veracruz, which show substantial positive relative differences.
- States near the threshold: such as Nuevo León and Baja California, whose

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difference (positive or negative) is very small. The national average also approximates the threshold closely.

- States with productivity well below the threshold: cases such as Chiapas, Nayarit, and Querétaro, which show substantial negative differences.

Maps 1(a) and 1(b). Productivity variation without specialization index



4.2.5. The conditional Verdoorn relationship

Table 4 compares the observed labor productivity of each state against an estimated threshold derived from the conditional Verdoorn model, which incorporates value added and the regional specialization index. Observed productivity reflects actual performance, while estimated productivity is the level expected given each state's structural conditions; the comparison is quantified through the absolute and relative differences.

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Table 4. Estimated labor productivity or productivity threshold, with specialization index

States	Observed production	Estimated production/ threshold	Intercept	
09 Mexico City (CDMX)	0.07067	0.029368	–0.02069	
31 Yucatán	0.05825	0.035661	–0.02069	
21 Puebla	0.081947	0.064245	–0.02069	
29 Tlaxcala	0.067703	0.0553039	–0.02069	
10 Durango	0.063813	0.052531	–0.020699	
15 Estado de México	0.058989	0.049621	–0.020699	
30 Veracruz	0.060387	0.050944	–0.020699	
03 Baja California Sur	0.072474	0.064600	–0.020699	
13 Hidalgo	0.065255	0.058244	–0.020699	
27 Tabasco	0.115761	0.103944	–0.020699	
08 Chihuahua	0.072332	0.066708	–0.020699	
14 Jalisco	0.058952	0.056164	–0.020699	
17 Morelos	0.065616	0.0627960	–0.020699	
23 Quintana Roo	0.068705	0.0659298	–0.020699	
28 Tamaulipas	0.068500	0.068139	–0.020699	
16 Michoacán	0.052909	0.054566	–0.020699	
05 Coahuila	0.073218	0.075732	–0.020699	
01 Aguascalientes	0.094303	0.098344	–0.020699	
26 Sonora	0.073617	0.080881	–0.020699	
04 Campeche	0.075084	0.081291	–0.020699	
19 Nuevo León	0.070888	0.07786	–0.020699	
20 Oaxaca	0.060049	0.067031	–0.020699	
24 San Luis Potosí	0.082760	0.098206	–0.020699	
22 Querétaro	0.054054	0.066071	–0.020699	
02 Baja California	0.070241	0.084657	–0.020699	
25 Sinaloa	0.049003	0.059961	–0.020699	
11 Guanajuato	0.069323	0.086447	–0.020699	
12 Guerrero	0.050143	0.064204	–0.020699	
06 Colima	0.038675	0.056854	–0.020699	
18 Nayarit	0.015113	0.022432	–0.020699	
07Chiapas	–0.006998	0.008198	–0.020699	
32 Zacatecas	0.088008	–0.023101	–0.020699	
National	0.064367	0.065591	–0.020699	

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	Kaldor-Verdoorn coefficient	Value added	Specialization coefficient	Absolute difference	Relative difference
	0.908416	0.054692049	0.643938	0.04130967	140.7
	0.908416	0.0844533	0.643938	0.022591621	63.3
	0.908416	0.096990526	0.643938	0.017702124	27.6
	0.908416	0.086524661	0.643938	0.01239986	22.4
	0.908416	0.080155013	0.643938	0.011281708	21.5
	0.908416	0.073041681	0.643938	0.009367902	18.9
	0.908416	0.068729246	0.643938	0.009443088	18.5
	0.908416	0.075544868	0.643938	0.007873335	12.2
	0.908416	0.087070751	0.643938	0.007010881	12.0
	0.908416	0.13932524	0.643938	0.011816989	11.4
	0.908416	0.091964705	0.643938	0.005624142	8.4
	0.908416	0.083392281	0.643938	0.002787944	4.9
	0.908416	0.090433874	0.643938	0.002820333	4.5
	0.908416	0.104063778	0.643938	0.00277578	4.2
	0.908416	0.098214354	0.643938	0.000360313	0.52
	0.908416	0.084748133	0.643938	–0.00165661	–3.0
	0.908416	0.114335839	0.643938	–0.00251436	–3.3
	0.908416	0.132121755	0.643938	–0.00404076	–4.1
	0.908416	0.101844085	0.643938	–0.00726360	–8.9
	0.908416	0.118823283	0.643938	–0.00620764	–7.6
	0.908416	0.099863428	0.643938	–0.00697810	–8.9
	0.908416	0.091109332	0.643938	–0.00698273	–10.4
	0.908416	0.135157686	0.643938	–0.01544563	–15.7
	0.908416	0.104619738	0.643938	–0.01201756	–18.2
	0.908416	0.099644614	0.643938	–0.01441556	–17.0
	0.908416	0.087218481	0.643938	–0.01095804	–18.3
	0.908416	0.111928835	0.643938	–0.01712409	–19.8
	0.908416	0.083603613	0.643938	–0.01406079	–21.9
	0.908416	0.079866508	0.643938	–0.01817861	–31.9
	0.908416	0.048239382	0.643938	–0.00731887	–32.6
	0.908416	0.032557496	0.643938	–0.01519686	–185.4
	0.908416	0.129931078	0.643938	0.111110054	–480.9
	0.908416	0.094048954	0.643938	–0.00122413	–1.9

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As before, states are classified into three groups using the relative difference (observed – threshold)/threshold, with a symmetric ±5% 'proximity zone':

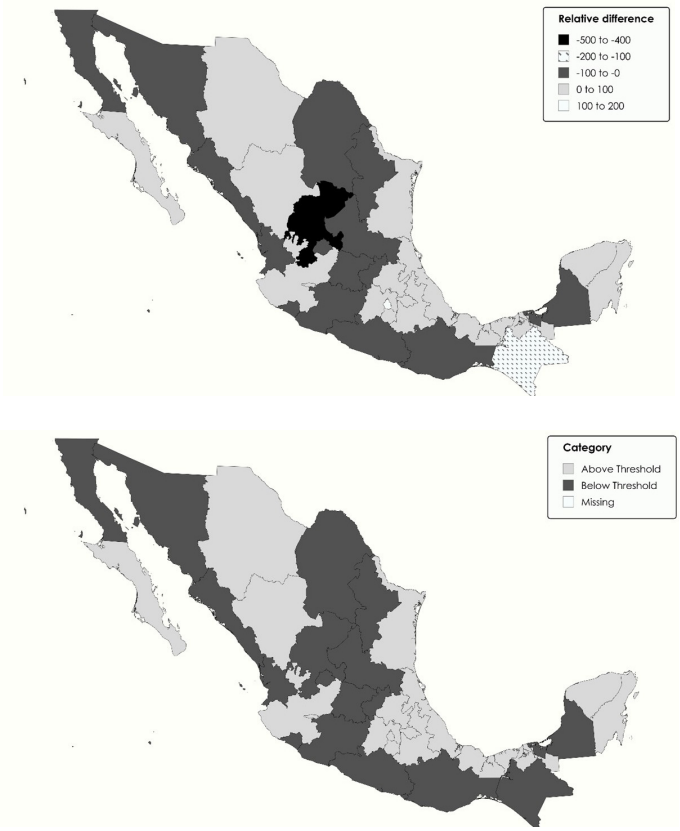
- States with observed productivity well above the threshold (AT), *i.e.*, eleven states with relative difference > +5% (observed productivity clearly exceeding the estimated threshold): Mexico City (140.7%), Yucatán (63.3%), Puebla (27.6%), Tlaxcala (22.4%), Durango (21.5%), State of Mexico (18.9%), Veracruz (18.5%), Baja California Sur (12.2%), Hidalgo (12.0%), Tabasco (11.4%), and Chihuahua (8.4%).

  These states record high productivity, clearly exceeding the threshold. Those with increasing returns —Mexico City, Yucatán, Puebla, and Tlaxcala— generate more value added than the model anticipates, likely owing to economies of scale, better productive organization, dynamic sectors, or local competitive advantages.
- States near the threshold (NT), with relative difference between –5% and +5% (small deviations from estimated productivity, statistically equivalent to the threshold): Jalisco (4.9%), Morelos (4.5%), Quintana Roo (4.2%), Tamaulipas (0.52%), Michoacán (–3.0%), Coahuila (–3.3%), and Aguascalientes (–4.1%). This intermediate group —including Tamaulipas, Morelos, and Jalisco— shows productivity broadly consistent with the structural conditions captured by the model.
- States with observed productivity well below the threshold (BT), with relative difference < –5% (observed productivity significantly lower than estimated): Sonora (–8.9%), Campeche (–7.6%), Nuevo León (–8.9%), Oaxaca (–10.4%), San Luis Potosí (–15.7%), Querétaro (–18.2%), Baja California (–17.0%), Sinaloa (–18.3%), Guanajuato (–19.8%), Guerrero (–21.9%), Colima (–31.9%), Nayarit (–32.6%), Chiapas (–185.4%), and Zacatecas (–480.9%). In this group, observed productivity falls significantly short of the estimated threshold.

A significant group performs below expectations—observed productivity falls short of what their structural characteristics would imply. Extreme cases such as Zacatecas and Chiapas show very large negative gaps, possibly reflecting low diversification, institutional weakness, or insufficient use of human capital. These results offer a diagnostic guide for policy, revealing not only how productive states are but how far they exploit their economic potential.

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Map 2(a) and 2(b). Productivity variation with specialization index



The upper panel of Map 2 shows the relative variation in state productivity associated with the degree of economic specialization: darker shades indicate pronounced productivity declines relative to the reference threshold, while lighter shades indicate significant gains. The lower panel classifies states as above the national threshold (light grey) or below it (dark grey). Read together, the two maps identify which entities effectively leverage their productive specialization and which do not.

States that clearly benefit —posting relative productivity gains and positioning above the threshold— include Nuevo León, Querétaro, Baja California, Coahuila, Chihuahua, and Aguascalientes, which concentrate higher-value industrial activities, reflecting a specialization process that drives productivity and regional competitiveness.

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Conversely, states that fail to benefit and fall below the threshold include Mexico City, State of Mexico, Puebla, Chiapas, Guerrero, Tlaxcala, Oaxaca, and Veracruz, where specialization is oriented toward less dynamic, low-productivity activities that may reinforce structural patterns of low regional growth.

In sum, the cartographic evidence reveals marked territorial divergence: the industrial poles of the north and Bajío capitalize on their specialization to raise productivity, while many central and southern states are specialized in low-value-added sectors, limiting their capacity to generate productive convergence and sustained economic development.

4.2.6. Specialization and increasing returns to scale

The joint analysis of the simple Verdoorn relationship, the specialization index, and the productivity threshold offers a precise picture of regional manufacturing productivity in Mexico between 1994 and 2019. The Verdoorn relationship reveals when growth translates into higher productivity; the specialization index captures sectoral concentration; and the threshold (with a ±5% band) distinguishes states of high, medium, and low relative productivity.

Two versions are estimated: the simple relationship (Table 1), linking growth and productivity directly, and the conditional relationship (Table 2), which incorporates the specialization index to show how productive concentration amplifies or dampens increasing returns. Both confirm marked structural heterogeneity.

Under the simple relationship, twelve states fall clearly above the threshold—including Mexico City, Baja California Sur, Veracruz, State of Mexico, Durango, Puebla, and Tlaxcala—while fourteen remain below, with notable lags in Chiapas, Nayarit, and Zacatecas. The conditional relationship shifts this classification: accounting for specialization in strategic sectors reclassifies some near-threshold states as lagging while consolidating others' above-threshold positions.

The key lesson is that growth alone is insufficient. States with dynamic sectors (Chihuahua, Nuevo León, Querétaro) convert growth into sustained productivity gains, whereas those with dispersed or primary-sector structures (Chiapas, Oaxaca, Guerrero) face diminishing returns. These results align with Kaldorian and structuralist literature

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on regional divergence: Quintana, Mendoza, and Valdivia (2013) find that Mexican regions with stronger industrial structures grow at rates comparable to successful cases like South Korea, and Pacheco-López and Thirlwall (2025) link regional disparities to manufacturing intensity and productive capacity.

Specialization alone, however, does not guarantee productivity gains—its impact depends on the type of manufacturing activity and its capacity to generate technological spillovers, productive linkages, and economies of scale. Northern and Bajío states specializing in automotive, plastics, and advanced manufacturing show stronger Verdoorn effects, whereas many southern and central states remain locked into low-productivity trajectories despite some specialization. Structural heterogeneity in Mexico is thus not merely a consequence of uneven growth but of asymmetric productive structures and differentiated capacities for technological accumulation.

Prime examples of high productivity and specialization in modern industrial sectors are Nuevo León, Querétaro, Aguascalientes, Baja California, Chihuahua, and Coahuila, all displaying a positive Verdoorn relationship consistent with increasing returns. By contrast, Campeche, Tabasco, Chiapas, Oaxaca, and Tlaxcala remain below the threshold, with low structural productivity and no clear strategic specialization. San Luis Potosí, Sonora, and Guanajuato occupy an intermediate position —near the threshold, with some specialization and signs of increasing returns, but no consolidated growth model.

In summary, the comparative analysis reveals marked regional heterogeneity in Mexican manufacturing, shaped jointly by labor productivity, sectoral specialization, and the presence or absence of increasing returns. This typology points to the need for differentiated regional industrial policies—promoting development poles in states below or near the threshold while consolidating the trajectories of those already exhibiting sustained growth and specialization.

5. CONCLUSIONS

During the economic liberalization period, Mexico's regional manufacturing industry exhibited strong heterogeneity, reflected in low productivity and unequal growth across states. These disparities originated

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in differences in capital accumulation rates —generally low— and in the varying degrees of specialization present in certain regions. The export orientation of manufacturing, combined with the deindustrialization of the domestic market, deepened this divide and allowed the identification of three types of entities: industrialized, stagnant, and deindustrialized.

To account for these differences, Verdoorn's law was estimated in both its canonical and conditional versions using a fixed-effects panel model. The robust coefficients allow measurement of deviations from the Verdoorn line —that is, a comparison of each state's actual performance against the level that would be expected given its output growth.

The analysis reveals clear productive heterogeneity: states such as Nuevo León and Querétaro exceed the national threshold with dynamic industrial structures and increasing returns; others, such as Chiapas and Oaxaca, remain lagging without meaningful improvement; and intermediate cases such as Guanajuato show still-incipient progress. This reinforces the need for differentiated industrial policies tailored to each region's productive profile, aimed at rebuilding industrial capacity, narrowing regional gaps, and promoting balanced national development.

The findings are consistent with previous empirical studies on the Kaldor-Verdoorn relationship in Mexico and Latin America, which emphasize manufacturing's strategic role in generating productivity growth and cumulative causation. Yet they also reveal that manufacturing growth in Mexico has been territorially uneven and structurally fragmented: while some states integrated into dynamic sectors capable of increasing returns, many others remain marked by low productivity, weak linkages, and limited technological diffusion.

The Mexican experience thus suggests that trade liberalization and export-oriented industrialization are insufficient by themselves to guarantee regional convergence or sustained productivity growth. The benefits of manufacturing expansion depend critically on the nature of productive specialization, domestic value added, and the capacity to generate endogenous technological capabilities. Industrial policy should therefore move beyond a purely export-oriented strategy and prioritize productive diversification, technological upgrading, and stronger regional industrial linkages in lagging states. ◄

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ANNEX

We implement standard diagnostic tests to validate the consistency of both our specifications, the Kaldor-Verdoorn canonical and conditional versions. We present the canonical version first and the conditional one subsequently.

A.1 Canonical Kaldor-Verdoorn law

Table A.1.1. Redundant fixed effects tests

Redundant fixed effects tests Test cross-section and period fixed effects			
Effects test	**Statistic**	**d.f.**	**Probability**
Cross-section F	0.940939	(31,91)	0.5622
Cross-section chi-square	35.311151	31	0.2716
Period F	14.928184	(3,91)	0.0000
Period chi-square	50.826665	3	0.0000
Cross-section/Period F	2.193654	(34,91)	0.0017
Cross-section/Period chi-square	76.024805	34	0.0000

The results in Table A.1.1 evaluate the relevance of cross-sectional and period fixed effects. For cross-sectional effects, the F-statistic ($p = 0.5622$) and Chi-square ($p = 0.2716$) do not reject the null that they are redundant. For period effects, however, both p-values (0.0000) indicate they are significant and should be included.

The joint test of cross-section and period fixed effects shows that their combined inclusion significantly improves fit ($F = 2.193654$, $p = 0.0017$;

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χ^2 = 76.024805, p = 0.0000), rejecting redundancy and enhancing model precision.

Table A.1.2. Fixed effects test equations (Cross-section fixed effects test equation)

Effects test equation	R-Squared	F-Statistic
Period fixed effects	0.926094	382.1877
Cross-section fixed effects	0.916491	32.23814
Cross-section and period fixed effects combined	0.898163	1,102.455

Table A.1.2 presents alternative fixed-effects configurations. The period fixed-effects model yields a strong fit (R^2 = 0.926094; F = 382.1877), while the cross-section fixed-effects model is significant but weaker (R^2 = 0.916491; F = 32.238).

The combined cross-section and period specification offers the most robust fit (R^2 = 0.898163; F = 1,102.455), indicating that temporal and cross-sectional differences jointly explain the variation. Although cross-section effects alone are less significant, combining both is essential to capture the data structure and improve accuracy.

A.2. Conditional Kaldor-Verdoorn law

Table A.2.1. Redundant fixed effects tests

Redundant fixed effects tests Test cross-section and period fixed effects			
Effects test	**Statistic**	**d.f.**	**Probability**
Cross-section F	1.217552	(31,90)	0.2347
Cross-section chi-square	44.477860	31	0.0554
Period F	17.146871	(3,90)	0.0000
Period chi-square	57.412925	3	0.0000
Cross-Section/Period F	2.665739	(34,90)	0.0001
Cross-section/Period chi-square	88.477014	34	0.0000

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Table A.2.1 shows that cross-section fixed effects are not individually significant (F: $p = 0.2347$; chi-square borderline at $p = 0.0554$), while period effects are highly significant ($p = 0.0000$). The joint tests ($p < 0.001$) confirm that including both substantially improves fit, capturing temporal and cross-sectional variation.

Table A.2.2. Fixed effects test equations (Cross-section fixed effects test equation)

Effects test equation	R-Squared	F-Statistic
Period fixed effects	0.942553	397.0565
Cross-section fixed effects	0.936393	276.3942
Cross-section and period fixed effects combined	0.918767	701.2409

Table A.2.2 reports alternative fixed-effects configurations. The period equation achieves $R^2 = 0.942553$, with significant coefficients on both the value-added and specialization-index growth rates; the cross-section equation yields a comparable $R^2 = 0.936393$; and the combined specification gives $R^2 = 0.918767$, confirming a robust, well-specified model for productivity dynamics.

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