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Middle income trap and heterogeneities in manufacturing's contribution to development: a comparative analysis between China and Brazil

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Middle income trap and heterogeneities in manufacturing's contribution to development: a comparative analysis between China and Brazil [1]

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Abstract

This paper aims to measure and analyze the contributions of Brazilian and Chinese manufacturing productive structures to development, in the period between 2000 and 2019. This measurement and analysis will be carried out in a comparative perspective to the patterns of industrial contribution to development among the main Middle-Income Countries (MICs), using shift share / structural decomposition techniques. Our analysis focuses on sectoral contributions, aggregated by technological intensity. The measurement of this contribution is analyzed along two dimensions: (i) productivity and (ii) average compensation of employees. Based on the analysis of intersectoral and inrasectoral and components, it is expected that a virtuous development process is associated with the reconfiguration of the productive structure towards activities that increase productivity and average compensation. In this context, the gap identified in the international literature on the subject is as follows*: although it extensively analyzes the definitions and causes of deindustrialization as well as changes in the international organization of manufacturing, the literature still lacks empirical efforts to measure how these phenomena affect the contribution of manufacturing to economic development*. Our paper contributes to this literature by analyzing the limits of the manufacturing's contribution to development, adding an additional perspective to the U-curve framework. This analysis will be based on a reassessment of the model proposed by Rodrik (2016), starting from the sectoral levels of technological intensity as proposed by Tregenna and Andreoni (2020). Thus, the article will seek to econometrically verify whether there is an inverted-U relationship between per capita income growth in MICs and the capacity of the industrial sector to drive development through structural transformation processes and their impact on wage and productivity growth.

Keywords: Middle-Income Trap, Deindustrialization, Structural transformation, Economic development, Technological innovation

Resumo

Armadilha da renda média e heterogeneidades na contribuição da indústria para o desenvolvimento: uma análise comparativa entre a China e o Brasil

Este artigo tem como objetivo mensurar e analisar as contribuições das estruturas produtivas brasileira e chinesa para o desenvolvimento, no período entre 2000 e 2019. Esse esforço será realizado em perspectiva comparada com os padrões de contribuição industrial para o desenvolvimento entre os principais Países de Renda Média (PRMs) e utilizará a metodologia de decomposição estrutural (shift-share). A análise se concentra nas contribuições setoriais, agregadas por intensidade tecnológica. Empiricamente a contribuição da indústria ao desenvolvimento será analisada em duas dimensões: (i) variação da produtividade e (ii) da remuneração média dos funcionários. Com base na análise dos componentes da decomposição estrutural, espera-se que um processo de desenvolvimento virtuoso esteja associado à reconfiguração da estrutura produtiva em direção a atividades que aumentem a produtividade e a remuneração média. Nesse contexto, a lacuna identificada na literatura internacional sobre o assunto é a seguinte: embora esta analise extensivamente as definições e as causas da desindustrialização, bem como as mudanças na organização internacional

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da indústria, a literatura ainda carece de esforços empíricos para mensurar como esses fenômenos afetam a contribuição da indústria para o desenvolvimento econômico. Este artigo contribui para essa literatura ao analisar os limites da contribuição da indústria para o desenvolvimento, acrescentando uma perspectiva adicional à estrutura da curva em U proposta no trabalho seminal de Rowthorn (1995). Esta análise se baseará em uma reavaliação do modelo proposto por Rodrik (2016), a partir dos níveis setoriais de intensidade tecnológica tal qual proposto por Tregenna e Andreoni (2020). Deste modo, para o artigo procurará verificar econometricamente se há uma relação de U invertido entre o crescimento da renda per capita nos MICs e a capacidade do setor industrial impulsionar o desenvolvimento via processos de transformação estrutural e seus impactos no crescimento dos salários e da produtividade.

Palavras-chave: Armadilha da renda média, Desindustrialização, Transformação estrutural, Desenvolvimento econômico, Inovação tecnológica
JEL codes: O11, O57, F43, O47.

1 Introduction

Deindustrialization, marked by a decline in manufacturing's share of employment and GDP, traps economies in the middle-income bracket and highlights varied impacts on development. Many countries are finding themselves caught in a middle-income trap, where growth stagnates as they struggle to transition from labor-intensive to more advanced, technology-driven economies. This study, through a comparative lens, highlights how nations like China and Brazil have navigated the challenges presented by the middle-income trap. By focusing on the nexus between deindustrialization and the middle-income trap, this research aims to contribute to a broader understanding of how targeted industrial strategies can mitigate stagnation risks and chart a course for sustained economic advancement.

Brazil and China represent two distinct paths of industrial development. Brazil's experience with deindustrialization reflects a struggle to move up the value chain since 2000s, while China presents a dynamic counter-example of strategic industrial upgrading. Both countries' experiences offer invaluable insights into the complexities of achieving sustainable economic development through industrial transformation.

Therefore, the main goal of this paper is to measure and analyze the contributions of Brazilian and Chinese manufacturing productive structures to development, in the period between 2000 and 2019. This measurement and analysis will be carried out in a comparative perspective to the patterns of industrial contribution to development among the main Middle-Income Countries (MICs). Our analysis focuses on sectoral contributions, aggregated by technological intensity, as suggested by works with high impact in the international literature, such as Tregenna and Andreoni (2020) and OECD (1987).

To this end, development is defined as surplus generation and accumulation, coupled with investment and technical progress into the productive dimension in order to promote the structural transformation of the economy. Since investment is an important instrument for the incorporation of technical progress into productive activities, structural transformation is inextricably linked to the dynamics of creative destruction (Schumpeter, 1934). One of the main results of this development process would be the reconfiguration of the productive structure, with the consequent flourishing, consolidation and increase in the relative participation in the economy of activities with greater productivity, higher wage levels and that promote greater export sophistication.

The hypotheses of the paper are derived from the conclusions of the international literature, that the transformations in industrial activities in the last 2 decades such as the emergence of global value chains, servitization and the increasing digitalization have brought new determinants to explain the relationship between industrialization and development (Chang; Andreoni, 2021; Andreoni; Chang, 2017; 2019, Tregenna; Andreoni, 2020 and Andreoni, 2020).Thus, the hypotheses are:

(i) There has been a tendency for the capacity of manufacturing to contribute to development to diminish in both high-income countries and MICs over the last two decades;

(ii) The heterogeneity of this contribution across sectors and countries (whether emerging or high-income) is increasing.

In this context, this paper specifically aims to measure the contribution of Brazilian and Chinese manufacturing to the development brought about by the process of structural transformation through comparative analysis. In order to achieve these objectives, this research project uses the methodology of structural decomposition through the shift-share technique, as expressed in the works of McMillan and Rodrik (2011), Unctad (2016), Timmer and de Vries (2009) and De Vries, Timmer and De Vries (2015) (see Section 3).The measurement of this contribution is analyzed along two dimensions: (i) productivity and (ii) average compensation of employees. Based on the analysis of intersectoral and inrasectoral and components, it is expected that a virtuous development process is associated with the reconfiguration of the productive structure towards activities that increase productivity and average compensation.

A review of recent international literature on manufacturing and development reveals a concentration of papers on the deindustrialization debate. Among the different dimensions of this literature, notable debates include the causes of deindustrialization (Tregenna, 2009; Andreoni; Tregenna, 2019; Andreoni; Chang, 2019; Chang; Andreoni, 2021; Dosi; Riccio; Virgillito, 2021), its definitions (Tregenna, 2016; Rodrik, 2016; 2017; Özçelik; Özmen, 2023) and the relationship between deindustrialization and the level of per capita income (Castillo; Martins, 2016; Felipe; Mehta; Rhee, 2018; Vu; Haraguchi; Amann, 2021).

In this context, the gap identified in the international literature on the subject is as follows*: although it extensively analyzes the definitions and causes of deindustrialization as well as changes in the international organization of manufacturing, the literature still lacks empirical efforts to measure how these phenomena affect the contribution of manufacturing to economic development*. This capacity to contribute to long-term development is the fundamental pillar that justifies the extensive literature on recent transformations in global industry, as well as the widespread revival of industrial policy. (Cherif; Hasanov, 2019; Aiginger; Rodrik, 2020; Chang; Andreoni, 2020; Mazzucato; Kattel; Ryan-Collins, 2020; Mazzucato; Rodrik, 2023).

This article is structured into four sections. Section 2 reviews the literature on the relationship between manufacturing and development, premature deindustrialization and middle-income trap. Section 3 describes the methodology used in the article. Section 4 presents the results. This is followed by the concluding remarks.

2 Literature review: manufacturing contribution to development, deindustrialization and middle-income trap

The understanding of development as a process involving accumulation, investment driven by technological progress towards activities with higher levels of productivity and structural transformation has historically and theoretically assigned a central role to manufacturing in the economic discussion (Mcmillan; Rodrik, 2011; Unctad, 2016, De Vries; Timmer; De Vries, 2015). This perspective, dating back to Hamilton (1791) and List (1841), underscores the interdependence between industrialization and development.

Classical development economists since the mid-20th century argued that the industrial sector possesses characteristics that elevate its role in economic development. Subsequently synthesized in what is conventionally called Kaldor's Laws (1966; 1967), such characteristics would generally result from the higher value added and productivity of industrial activities, from their high capacity to allow for positive returns to scale and to transmit the gains from technical progress, and finally from their ability to alleviate external constraints on development, given the greater income elasticity of demand for their products compared to non-manufactured goods.

In line with the guidelines suggested by development strategies based on Kaldor's laws, industrial policy in MICs since the mid-19th century has generally aimed at promoting productive structure density as a way of catching up with High-income Countries (HICs). In other words, an industrial policy would be the more virtuous the greater its capacity to promote and expand the local industrial value-added in a generalized way. Such policies are grounded in competition and accumulation dynamics, where production, value generation, and appropriation coincide territorially, at least to some extent.

In the context of the changes in the international productive structure that have taken place in recent decades, the emergence of global value chains as dominant elements in the dynamics of competition and industrial accumulation entails the need to rethink the way in which the interdependence between the densification of the industrial activities and development is determined.

Since the 2008 great financial crisis, there has been a resumption of the understanding of the centrality of industrial policy in national development strategies. Efforts to advance the technologies associated with what has been agreed to be called Industry 4.0, with the aim of promoting the transition to a new techno-economic paradigm, are illustrative. High-income countries aim to reconfigure the determinants of competitiveness to counter China's technological and innovative catching-up. These efforts seek to restore the historically constructed hierarchy among nations in terms of their productive and technological superiority. For China, strategies like as Made in China 2025 would be instruments to exploit the opportunities arising from the transition between techno-economic paradigms (Perez, 2004) and accelerate the national catch-up process (Nolan, 2014). China's strategic integration into Global Value Chains (GVCs) reflects a sophisticated approach that contrasts with many MICs (Barro, 2016; Agénor, 2017, Glawe and Wagner, 2020). Through initiatives like "Made in China 2025", the country has transitioned from labor-intensive to high-tech industries, targeting dominance in sectors like robotics and biotechnology. This shift underlines a broader structural transformation facilitated by substantial investments in infrastructure, education, and R&D, along with policies attracting foreign direct investment in technologically advanced sectors (Wu et al., 2021; Liu, 2003; Yan; Yudong, 2003; Chen et al., 2011).

The revival of industrial policy debates has also sparked theoretical discussions on rethinking development strategies. These strategies range from enhancing activities with comparative advantages, such as the idea of Lin (2011) of Growth Identification and Facilitation (GIF) framework, to those emphasizing domestic production complexity, as seen in the diversification proposals based on the Product Space, by Hidalgo and Hausmann (2009). Additionally, some strategies focus on analyzing the relationship between the impact of informational externalities on innovation disincentives and the diversification of the productive structure, as proposed by Hausmann and Rodrik (2003; 2006).

While these contributions by international exponents of industrial policy are politically and academically significant, studies including Andreoni and Chang (2019) as well as Andreoni and Gregory (2013) present a critical perspective on the limitations of the current debate. They emphasize the need to refocus on the "productive structure" as a central object of analysis, while also addressing neglected issues and emerging challenges.

The shift from the Fordist/Chandlerian paradigm to microelectronics, the emergence of global value chains, and the advent of Industry 4.0 have introduced new dimensions to the analysis of competitive, innovative, and accumulative industrial dynamics (Brun et al., 2019). They even necessitate, as Andreoni and Chang (2019), O'Sullivan et al. (2013), and Diegues et al. (2023) argue, a reconfiguration of industrial and development policies in conceptual, normative, and institutional terms.

However, despite these numerous transformations, it is understood that the logical relationship between manufacturing and development, understood as the ability of structural transformation to positively influence (i) the increase in productivity and (ii) the increase in average remuneration, persists as a constitutive element of productive development (Mcmillan; Rodrik, 2011; Unctad, 2016; De Vries; Timmer; De Vries, 2015). It is in this context that the debate on premature deindustrialization and its implications for the growth and development trajectories of MICs has emerged in the literature, especially since 2008. The seminal interpretations of the deindustrialization process go back to the work of Rowthorn, including Rowthorn (1995), as well as Rowthorn and Ramaswamy (1997, 1999) whose main objective was to relate this phenomenon to the possibilities of sustainable growth in high-income countries. Based on these contributions, several attempts have been made to estimate a relationship between the level of industrial employment as a share of total employment and the level of per capita income in countries. In general, it has been shown that this relationship is characterized by an inverted U-shape. In other words, a relationship has been estimated which shows that as per capita income increases over time, there is a corresponding increase in industrial employment, with a simultaneous decrease in the share of agricultural employment, up to a certain point. After this point, an inverse phenomenon is observed, with a reduction in the relative importance of industrial employment and value added. This phenomenon would characterize a normal deindustrialization and would result mainly from the fact that productivity growth has been higher in the manufacturing sector than in the services sector.

In developed economies, deindustrialization begins at a high level of per capita income and is considered a “normal” phenomenon because it is the result of a country’s own industrial maturity. It therefore refers to a decline in the share of manufacturing in national GDP without a definitive decline in value added (Palma, 2005). Conversely, in the case of developing countries, the decline of the manufacturing sector in terms of employment and value added occurs before the formation of a diversified, productive and innovative industrial sector, that is, at a much earlier level of per capita income lower than in advanced economies (Tregenna, 2016). This, in turn, consistently reduces the capacity of the industrial sector to drive development (Tregenna; Andreoni, 2020).

In addition to this qualitative difference, empirical work has shown that the inflection point of the inverted U curve has been systematically lowered in recent decades. In this sense, between the 1980s and 1990s, the inflection point moved from $21,000 to just over $10,000, indicating that deindustrialization primarily affected advanced countries in the 1980s and middle-income countries in the 1990s. In other words, the phenomenon of deindustrialization has been observed to be increasingly premature. According to Tregenna and Andreoni (2020)

> Premature 6eindustrialization is a threat to low- and middle-income countries, as it shrinks their opportunities for technological development and their capacity to add value in global value chains and tradable sectors, thereby ultimately reducing their scope for cumulative increases in productivity. In order to reverse this trend, and to avoid falling behind in the global industrial landscape, appropriate packages of industrial, technological and innovation policies have to be deployed (Andreoni; Tregenna, 2020). These are essential economic policy tools for escaping the middle-income trap, increasing domestic value addition and reversing the processes of premature deindustrialization (Tregenna; Andreoni, 2020, p. 1).

The middle-income trap arises when emerging economies struggle to sustain a virtuous cycle of structural transformation, specifically the shift towards more complex, technologically intensive, and innovative activities. As suggested by Lin and Wang (2020) as well as Rekha (2022), this situation often links premature deindustrialization with the middle-income trap, as it hinders the reconfiguration of productive structures. According to Lee (2013; 2019), overcoming these challenges depends on dynamic capabilities and the domestic business structure.

To enhance the role of manufacturing in development within global value chains, industrial and technological policies must address capability and size failures, as well as the obstacle of intellectual property dominated by incumbents. Thus, they should be based on (i) building domestic technological and innovative capabilities, (ii) promoting large enterprises to address size failures, (iii) leveraging GVCs for innovative learning, and (iv) exploiting windows of opportunity during major transformations in technologies characterized by short cycles (Lee, 2013; 2019). Only in this scenario would it be possible to reorganize a dynamic of transformation of the productive structure towards permanent creative destruction, thus increasing the contribution of manufacturing to development.

3 Data and methods

The measurement and analysis of manufacturing’s contribution to development carried out in this paper is based on a structural decomposition of productivity and salary, using shift-share techniques, as in OECD (1987), Timmer and De Vries (2009); McMillan and Rodrik (2011); Haraguchi (2015) and specially De Vries, Timmer and De Vries (2015). Data were collected from the United Nations Industrial Development Organization (UNIDO) Industrial Statistics Database at the 2-digit level of ISIC (INDSTAT2), which provides disaggregated data on the manufacturing sector. This analysis is supplemented with GDP (Purchasing Power Parity, PPP) per capita in current US dollars, obtained from World Bank's DataBank. In order to provide a very brief perspective to Brazilian and Chinese manufacturing contribution to development, we also measured and analyzed these indicators for the 20 main MIC that had all data available in the period (Table 1)[4].

Table 1
MIC sample, share in world manufacturing value added and employment, manufacturing value added as proportion of GDP (%, 2019)

	Share in world manufacturing value added (%)	**Share in world manufacturing employment (%)**	**Manufacturing value added as proportion of GDP (%)**
Middle Income Countries			
Brazil	1,79%	3,21%	10,30%
China	28,01%	34,76%	27,90%
Colombia	0,24%	0,33%	11,80%
Egypt	0,34%	0,91%	15,30%
India	1,64%	7,4%	14,50%
Indonesia	1,89%	2,9%	20,30%
Iran	0,44%	0,83%	13,90%
Malaysia	0,62%	1,04%	22,20%
Mexico	1,35%	2,02%	17,10%
Morocco	0,13%	0,39%	15%
Oman	0,13%	0,04%	9,50%
Pakistan	0,27%	1,16%	12,10%
Peru	0,24%	0,34%	12,80%
Philippines	0,22%	0,64%	19,40%
Romania	0,19%	0,54%	19%
Russia	1,78%	3,15%	13,20%
South Africa	0,34%	0,54%	12,20%
Thailand	0,74%	1,89%	25,80%
Türkiye	0,70%	1,76%	16,30%
Viet Nam	0,71%	3,51%	24,20%
Total	**42%**	**67%**	

Source: Authors, based on World Bank – DataBank and UNIDO – SDG 9 Monitoring.

The value-added and salary dataset were calculated in local currencies and posteriorly deflated through World Bank's Consumer's Price Index for each country, with 2019 as the base year.

(4) Due to the lack of data, Argentina, Kazakhstan and Ukraine, which were previously among the top 20 manufacturing parks in the MIC, were excluded from the sample (see Table 1).

Following Tregenna and Andreoni (2020), manufacturing was disaggregated into 23 sub-sectors, at the 2-digit level of ISIC Rev. 3 and grouped by the technological intensity as proposed by Galindo-Rueda and Verger (2016) and UNIDO (2010), as Table 2.

Table 2
Sub-sectoral technological classification

Low-tech	**Medium-tech**	**High-tech**
Food and beverages (15) and Tobacco products (16)	Coke, refined petroleum products, nuclear fuel (23)	Chemicals and chemical products (24)
Textiles (17)	Rubber and plastics products (25)	Machinery and equipment n.e.c. (29) and Office, accounting and computing machinery (30)
Wearing apparel, fur (18) and Leather, leather products and footwear (19)	Non-metallic mineral products (26)	Electrical machinery and apparatus (31) and Radio, television and communication equipment (32)
Wood products (excl. furniture) (20)	Basic metals (27)	Medical, precision and optical instruments (33)
Paper and paper products (21)	Fabricated metal products (28)	Motor vehicles, trailers, semitrailers (34) and Other transport equipment (35)
Paper and paper products (21)		
Furniture; manufacturing n.e.c. (36) and Recycling (37)		

Source: Tregenna and Andreoni (2020), according to Galindo-Rueda and Verger (2016) and UNIDO (2010).

Labor productivity was measured by the ratio of value-added to employed population in industrial sectors. Mean salary was measured by the ratio of total salary to the number of employees. GDP at current PPP in USD was calculated as the simple average from 2000 to 2019.

3.1 The shift-share techniques

This paper employs a shift-share technique, as used by OECD (1987), Timmer and De Vries (2009), McMillan and Rodrik (2011) and Haraguchi (2015), to analyze the decomposition of productivity and salary variation. Specifically, by adopting the methodology of De Vries, Timmer and De Vries (2015), it is possible to capture the impact of sectoral productivity and salary variation through different components: intrasectoral, intersectoral (static structural change), and dynamic structural change. Accordingly, in a virtuous process of structural change, all components are expected to be positive, i.e., associated with the reconfiguration of the productive structure towards activities that increase productivity and salaries.

Formally, the applied model for productivity variation is derived as follows. The same steps apply when the observed variable is mean salary. The only modification is the use of this variable instead of labor productivity.

T = Σ of all sectors i;

S_i =participation of sector i in the total number of employed population;

$L_i =$ employed population;

$fy =$ final period;

$by =$ initial period;

Q_i = value added;

LP = labor productivity.

t = time

First, we measure the share of the respective industrial sector i in the total number of the employed population:

$$\boldsymbol{S_i = \frac{L_i}{\Sigma\, L_i}} \tag{1}$$

Next, labor productivity was measured by the ratio between the value added of industrial transformation and the employed population:

$$\boldsymbol{LP_i = \frac{Q_i}{L_i}} \tag{2}$$

$$\boldsymbol{LP_T} = \frac{\boldsymbol{Q_T}}{\boldsymbol{L_T}} = \frac{\sum_i Q_i}{\sum_i L_i} = \sum_i \left(\frac{Q_i}{L_i}\frac{L_i}{L}\right) = \sum_i LP_i S_i \tag{3}$$

Differentiating equation 1 in time (from t-k to t, where t>k), we obtain

$$\boldsymbol{LP_t} - \boldsymbol{LP_{t-k}} = \Delta LP_t = \sum_i LPP_{i,t} S_{i,t} - \sum_i LP_{i,t-k} S_{i,t-k} \tag{4}$$

The level of productivity for the years of analysis (2000, 2010 and 2019) was calculated taking into account the final and initial analysis periods.

As in De Vries, Timmer and De Vries (2015), productivity growth (4) was decomposed in 3 components, as follows:

$$\boldsymbol{\Delta(LP_T) = \frac{LP_{T,fy} - LP_{T,by}}{LP_{T,by}} = I + II + III} \tag{5}$$

Or, as in the growth-rate form, where:

$$\boldsymbol{\frac{\Sigma_{i=1}^{n} LP_{T,by}\,(S_{i,fy} - S_{i,by})}{LP_{T,by}}} \tag{6}$$

I

Equation (6) represents the first term by the right side of Equation (5), term I, and it accounts for the intersectoral, or static, component of the structural transformation. This component stands for the contribution to productivity growth from changes in the allocation of labor between the differing industrial segments. In accordance with literature, it is assumed that in a progressive development process, the relative share of employment shifts from low productivity sectors to those with above-average productivity rates, raising the overall labor productivity of the economy and making this component positive in the process (Mcmillan; Rodrik, 2011).

$$\frac{\sum_{i=1}^{n} (LP_{i,fy} - LP_{i,by})(S_{i,fy} - S_{i,by})}{LP_{T,by}} \quad (7)$$

II

Term II, the dynamic component of structural transformation is represented by Equation (7). It essentially captures the interaction between the change in labor productivity and the change in the relative share of employment across all sectors of the economy. This component is basically the internal product of productivity levels at the end of the analysis period and represents the change in the share of employment across sectors. Thus, in a virtuous process of structural transformation, the relative share of employment is expected to be positively correlated with the reallocation of resources towards industries with rapid productivity growth.

$$\frac{\sum_{i=1}^{n} (LP_{i,fy} - LP_{i,by}) S_{i,by}}{LP_{T,by}} \quad (8)$$

III

As for Term III, represented by Equation (8), it stands for the intrasectoral component of the structural transformation and captures the productivity growth within the different industrial segments, mainly through improvements in innovation, scale, or other internal variables to each sector. Similarly, if the change in this component is positive, then the contribution of this component to structural change is also expected to be positive (Mcmillan; Rodrik, 2011).

3.2 OLS Regression with Robust Standard Errors

This section details the econometric methodology used to investigate the presence of an inverse U-shaped curve, as proposed by Rodrik (2016), in middle-income countries. The regression model assesses the relationship between manufacturing productivity and salary growth across sectors of varying technological intensity and the natural logarithm of GDP per capita, while controlling for population size. Robust standard errors are utilized to ensure accurate and reliable statistical inference. The regression equation is specified as follows:

$$Y_{ij} = \alpha + \beta_1 \ln(gdppc_i) + \beta_2 \ln(gdppc_i)^2 + \beta_3 \ln(pop_i) + \epsilon_{ij} \quad (9)$$

where Y_{ij} is the total manufacturing productivity / salary growth structural decomposition according to tech intensity, where *j* is the tech intensity category for country *i*. $ln(gdppc_i)$ is natural logarithm of GDP per capita for country *i*, $ln(gdppc_i)^2$ is the squared term of natural logarithm of GDP per capita, $ln(pop_i)$ is the logarithm of the population of country *i*, α is the overall intercept, β_1, β_2, β_3 are the coefficients to be estimated, and ϵ_{ij} is the error term. To address potential heteroscedasticity, robust standard errors are applied, providing more reliable hypothesis tests and confidence intervals, even if the assumption of homoscedasticity (constant variance) is violated.

Our study utilizes annual data from the following sources. *INDSTAT from the United Nations Industrial Development Organization (UNIDO)* provides detailed industrial statistics, including manufacturing value added and employment data across various sectors. *World Bank* offers a comprehensive set of economic indicators, including per-capita income, population statistics, and other macroeconomic variables. *International Monetary Fund (IMF)* supplies data on GDP, economic growth, and other financial indicators through its *International Financial Statistics (IFS) database*.

4 Results: Manufacturing´s contribution to development in Brazil and China

4.1 Middle-income countries

In order to assess the empirical results of the contribution of manufacturing to development in Brazil and China from a comparative perspective, it is essential to briefly examine this trend among the main MICs. We replicate the empirical framework proposed by Rodrik (2016) and extended by Tregenna and Andreoni (2020), which explores the relationship between the share of manufacturing in GDP and the per capita income of a country.

Rodrik (2016) introduced an econometric model that links the share of manufacturing in GDP (MVA%) and the share of manufacturing employment in total employment (EMP%) to the per capita income (GDP/CAP), controlling for population size. Its findings reveal a U-shaped curve between manufacturing value added as a percentage of GDP and GDP per capita, as well as between the share of manufacturing employment and GDP per capita.

Tregenna and Andreoni (2020) further expanded this analysis by highlighting the heterogeneity of deindustrialization experiences at the sub-sectoral level. They identified potential cases of premature deindustrialization based on variations in the U-shaped curve, particularly noting that higher technological intensity in manufacturing leads to less concavity in the curve, evolving into a monotonically increasing or even convex pattern in high-tech sub-sectors.

Their study shows that Asian economies like South Korea, Thailand, and China, which have a higher proportion of technologically intensive products in their GDP, have successfully converged, while industrialized economies like the UK, Spain, and Canada struggle to sustain their manufacturing sector's contributions to growth. In Latin America, premature deindustrialization is a significant concern. Consequently, Tregenna and Andreoni (2020) suggest that different curves emerge depending on the technology intensity across sub-sectors, necessitating a more nuanced analysis of the traditional U-curve hypothesis.

Our paper contributes to this literature by analyzing the limits of the manufacturing's contribution to development, adding an additional perspective to the U-curve framework. We build on Rodrik's model, applying it to the sub-sectoral level as Tregenna and Andreoni proposed, to verify the relationship between per capita income in MICs and the manufacturing's ability to drive development. Unlike the earlier studies, we examine the relationship between the structural decomposition of productivity and average wages in manufacturing and the level of per capita income.

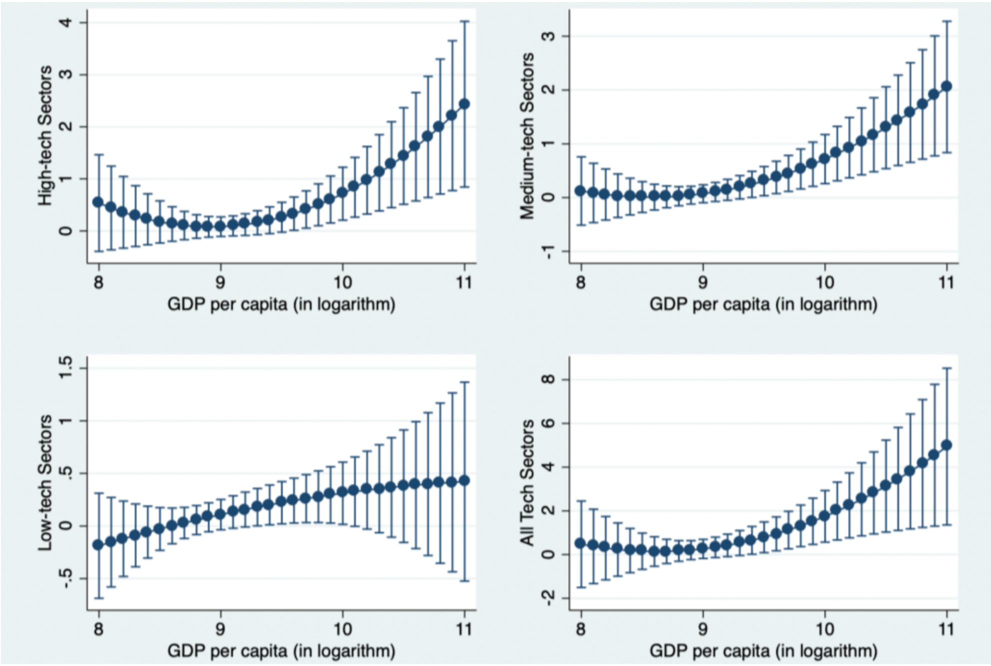
This section presents the results of our regression analysis with robust standard errors, examining the relationship between manufacturing's contribution to development across different technology intensity sectors and GDP per capita. The regression outcomes for manufacturing productivity growth are summarized in Table 3 and Figure 1, while those for manufacturing salary growth are shown in Table 4 and Figure 2. Appendix 1 contains the robustness checks, detailing previous simulations across five different model specifications for productivity and salary growth.

Table 3
Regression Results of manufacturing productivity growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components) on natural logarithm of GDP per capita in with Robust Standard Errors

	High-Tech Sectors	Medium-Tech Sectors	Low-Tech Sectors	Total
ln(gdppc)	-9.685**	-5.969*	1.086	-14.69
	-4.221	-2.841	-2.64	-9.442
ln(gdppc)²	0.543**	0.348**	-0.0465	0.851
	-0.226	-0.153	-0.142	-0.506
ln(pop)	0.122	0.167	0.157*	0.449
	-0.157	-0.106	-0.0788	-0.328
Constant	41.04*	22.55	-8.76	55.3
	-20.05	-13.32	-12.31	-44.51
Observations	20	20	20	20
R-squared	0.367	0.377	0.275	0.314

Note: Robust standard errors are in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Figure 1
The relationship between manufacturing productivity growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components) and GDP per capita, with different levels of technology intensity



Source: Drawn by the authors using Stata 15.
Notes: In accordance with Stata's default settings, ln(pop) is held constant at the mean value across all observations in the sample when drawing the figure.

The provided image illustrates the predictive margins with 95% confidence intervals for the relationship between GDP per capita and manufacturing productivity growth across different technology intensity sectors. Each graph represents a different sector: the top left for high-tech intensive (hmh) sectors, the top right for medium-tech intensive (ml) sectors, the bottom left for low-tech intensive (low) sectors, and the bottom right for all manufacturing sectors combined.

Both the high-tech and medium-tech sectors exhibit significant U-shaped relationships, indicating that productivity growth initially decreases but then increases as GDP per capita rises. Consistent with Tregenna and Andreoni (2020), our analysis shows that in high and medium-tech sectors, the manufacturing's contribution to development, measured by productivity growth, strengthens as the per capita income of MICs surpasses the US$8,000 threshold. This suggests that in these sectors, there is no observed decline in the manufacturing's contribution to development as MICs reach higher income levels.

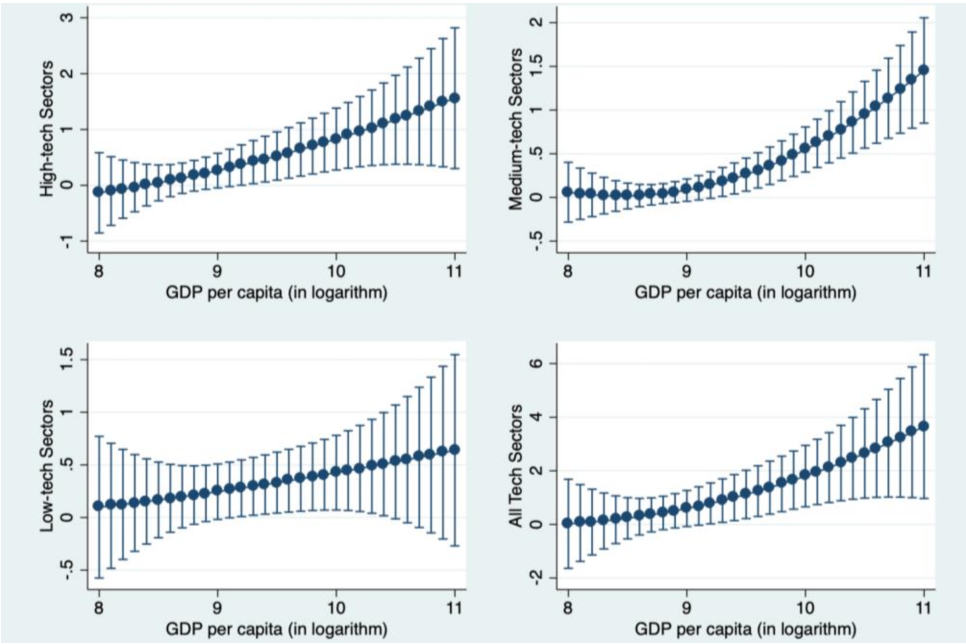
Conversely, the low-tech sectors show an insignificant inverse U-shaped relationship. The pattern for all manufacturing sectors resembles that of medium-tech sectors but with lower significance.

Table 4
Regression Results of manufacturing salary growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components) on natural logarithm of GDP per capita in with Robust Standard Errors

	High-Tech Sectors	Medium-Tech Sectors	Low-Tech Sectors	Total
ln(gdppc)	-9.685**	-5.969*	1.086	-14.69
	-4.221	-2.841	-2.64	-9.442
ln(gdppc)^2	0.543**	0.348**	-0.0465	0.851
	-0.226	-0.153	-0.142	-0.506
ln(pop)	0.122	0.167	0.157*	0.449
	-0.157	-0.106	-0.0788	-0.328
Constant	41.04*	22.55	-8.76	55.3
	-20.05	-13.32	-12.31	-44.51
Observations	20	20	20	20
R-squared	0.367	0.377	0.275	0.314

Note: Robust standard errors are in parentheses. *p<0.1, **p<0.05, ***p<0.01.

Figure 2
The relationship between manufacturing salary growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components) and GDP per capita, with different levels of technology intensity



Source: Drawn by the authors using Stata 15.
Notes: In accordance with Stata's default settings, ln(pop) is held constant at the mean value across all observations in the sample when drawing the figure.

When examining salary growth, as depicted in Table 4 and Figure 2, the predictive margins with 95% confidence intervals reveal the relationship between GDP per capita and manufacturing salary growth across different technology intensity sectors. Each graph mirrors the sectors in Figure 1.

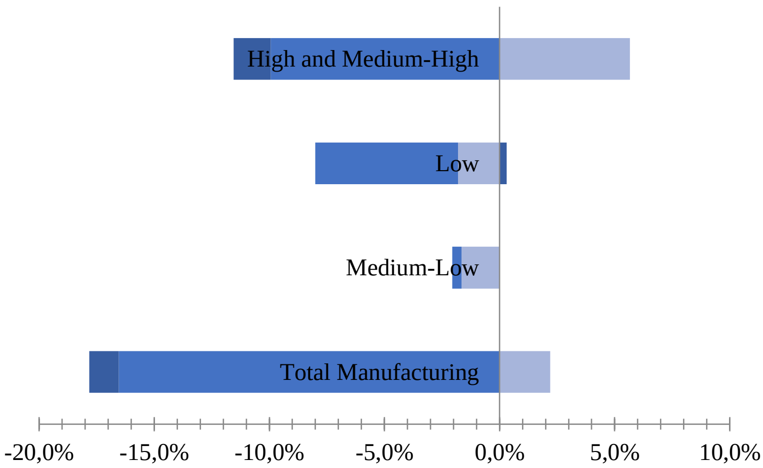
Across high, medium, and low technology sectors, as well as collectively across all sectors, wage growth in the manufacturing industry shows an upward trend with increasing per capita GDP in representative middle-income countries. The medium-tech sector, in particular, exhibits a strong significance level, achieving a two-star rating, indicating a 5% significance level.

Similar to our findings in the productivity models, the contribution of high and medium-tech sectors to development, measured by the increase in average wages in manufacturing, rises as the per capita income of MICs increases. This trend appears nearly linear for high-tech sectors and continuous for medium-tech sectors above the US$8,000 threshold. Thus, consistent with the productivity models, our empirical evidence for the top 20 MICs demonstrates that manufacturing continues to contribute to development even as these countries attain higher levels of per capita income.

4.2 Manufacturing´s contribution to development in Brazil

The first noteworthy observation is that Brazil exhibited the worst performance among the 20 MICs with the largest manufacturing structures between 2000 and 2019 (Figure 3). While the average productivity growth for these countries during this period was 107.7%, Brazil's manufacturing sector experienced a productivity decline of 15.6%. Notably, this downward trend in productivity was observed across all technological segments of Brazilian manufacturing.

Figure 3
Manufacturing productivity growth - structural decomposition according to tech intensity - Brazil (2000 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	2,20%	-1,7%	-1,8%	5,7%
Intra-sectoral component	-16,54%	-0,4%	-6,2%	-9,9%
Structural change (dynamic component)	-1,28%	0,0%	0,3%	-1,6%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Notably, the intra-sectoral component alone accounted for the entire decline in productivity in Brazilian manufacturing sector. Unlike the other components of the structural decomposition, which are affected by the dynamics of the sectoral reallocation of productive activities, the performance of the intra-sectoral component is affected by the internal dynamics of the firm or sector. In other words, the variation in productivity is conditioned by variables such as capital stock, dynamic capabilities, accumulated knowledge, degree of technological sophistication of the production process, among others (Pisano, 2017; Teece et al., 1997; Cohen; Levinthal, 1989). It is also constrained by the absorption capacity of the systemic nature of learning (Freeman, 1995; Nelson, 1993; Lundvall, 1992; 2016), the high degree of uncertainty and high financial costs for the development of disruptive innovations (Mazzucato, 2013) and the need for minimum scales of efficiency to make the budding technologies economically competitive.

Thus, in line with the literature on the recent process of Brazilian deindustrialization, this phenomenon can be understood from two sets of hypotheses.

The first refers to a more conventional interpretation of the negative effects of deindustrialization on the local capacity to promote investment and generate a virtuous cycle of productive and technological transformation. In this block, productivity decline is determined by the relatively low level of investment in machinery and equipment to replace depreciated capital goods, update them or incorporate new technologies associated with digitalization. It is also influenced by the relatively low rate of innovation in Brazilian manufacturing sector, as well as its low level of investment in R&D. (Nassif; Bresser-Pereira; Feijo 2018; Nassif; Castilho, 2020; Nassif; Feijo; Araujo, 2015; Morceiro; Guilhoto, 2023; Baltar; Hiratuka; Lima, 2016; Hiratuka; Sarti, 2017).

The second block of explanations for this decline is based on Diegues and Rossi's (2017) and Diegues's (2021) interpretations of the relationship between deindustrialization, integration into global value chains, and the reorganization of the accumulation dynamics of Brazilian manufacturing sector in the post-2000 period. According to the authors, after decades of deindustrialization, Brazil's industrial bourgeoisie reorganized the competitive and accumulation strategies of their firms. This reorganization gave rise to a phenomenon they call the Brazilian Disease.

In a scenario of deindustrialization marked by the Brazilian disease, the last two decades have seen the emergence of strategies that guarantee the profitability of capital allocated to the industrial sphere, with an increasing degree of disconnection from strictly productive performance. These strategies are based on a competitive logic oriented towards a defensive and regressive reaction, with a constant search for cost reductions - for example, in labor and taxes - that are not linked to an increase in investment, productivity and innovation. These facts, in turn, bring important elements that allow us to conclude that a domestic productive structure with a lower capacity to contribute to development seems to be increasingly consolidated.

Thus, the dynamics of competition and accumulation of the Brazilian productive structure in the 2000s, which would characterize what Diegues (2021) calls the Brazilian disease, would be based on:

i. a permanent defensive strategy on the part of local industrial agents, in which the search for competitiveness does not occur in parallel with a virtuous structural transformation, with an increase in the complexity of the production process and a consequent increase in productivity. On the contrary, this search is supported by regressive strategies based on a permanent pressure to reduce production costs. It is also worth noting that the intensification of the pressure to compress these production costs must be understood in a scenario of limited space for the use of the instrument par excellence for increasing competitiveness in industrialization strategies - a relatively devalued exchange rate. This is because devaluation would be associated with short-term negative effects on local accumulation, given the reconfiguration of the production structure towards an essentially import-oriented integration into global production.

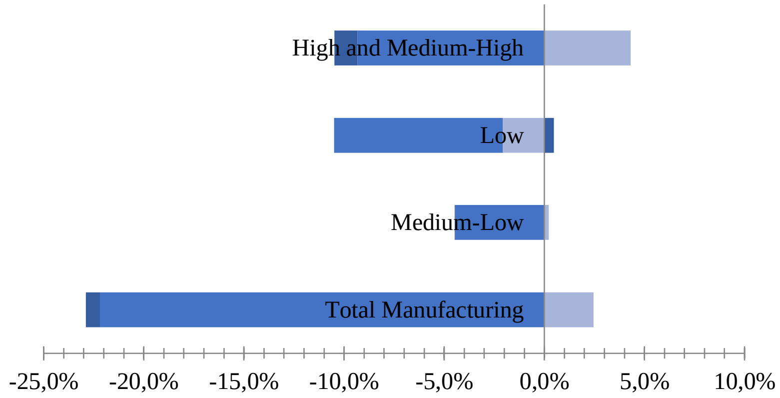
ii. a new form of complementarity with international productive capital, made possible by the reorganization of productive activities in the form of the so-called “smile curve”, in which there is an increase in the participation of the domestic productive sector in activities related to its representation (commercial, financial and marketing) and the tropicalization of imported products;

iii. the search for increasing competitiveness and accumulation through constant pressure for fiscal and tax incentives of various kinds. These include benefits associated with the Manaus Free Trade Zone and other special sectoral or regional tax regimes, pressure to reduce wage costs, state and municipal incentives, among others. In other words, the drive to increase competitiveness and boost accumulation focuses on static elements and shifts away from a dynamic cycle resulting from investments linked to technological and innovative learning, as seen in the successful catch-up strategies of countries like Japan and Korea.

According to this interpretation, the decline in productivity in Brazilian manufacturing sector, even in terms of the intra-sectoral component, could be explained by the growing specialization of local industrial firms in activities not linked to production dynamics, with an emphasis on integration into global value chains through imports of parts and components. This, in turn, would contribute to a reduction in the local value added of production, with implications for productivity. In addition, the fall in productivity could be understood as the result of the reorganization of the dynamics of accumulation towards a logic of commercial complementarity with international capital, where local industrial companies would increasingly concentrate their accumulation on activities based on the trinomial of financialization, commercial representation and distribution of products of large local brands, and on a kind of introverted maquila (MORCEIRO, 2018) based on the tropicalization of imported products in order to meet the requirements necessary to obtain local tax benefits and circumvent trade restrictions.

If we analyze the downward trend in Brazilian industrial productivity by subperiods (Figure 4 and Figure 5), we see that the entire trend is explained by the decline between 2000 and 2010. This result is interesting for at least two reasons.

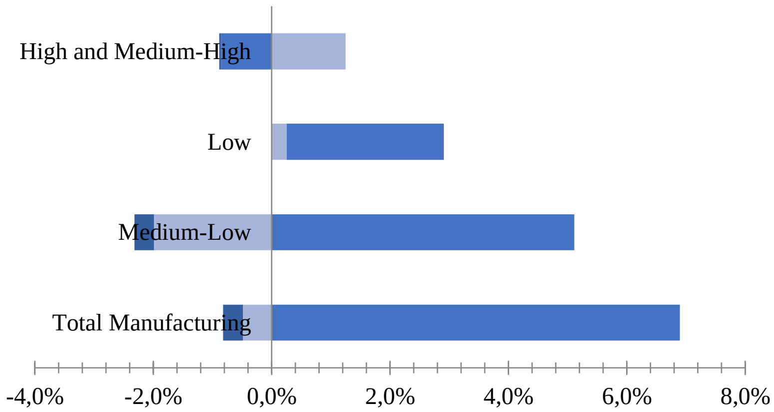
Figure 4
Manufacturing productivity growth - structural decomposition according to tech intensity - Brazil (2000 to 2010)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	2,45%	0,2%	-2,1%	4,3%
Intra-sectoral component	-22,20%	-4,4%	-8,4%	-9,3%
Structural change (dynamic component)	-0,70%	0,0%	0,5%	-1,2%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Figure 5
Manufacturing productivity growth - structural decomposition according to tech intensity - Brazil (2010 to 2019)



	Total Manufac turing	Medium-Low	Low	High and Medium-High
Structural change (static component)	-0,49%	-2,0%	0,3%	1,3%
Intra-sectoral component	6,89%	5,1%	2,6%	-0,9%
Structural change (dynamic component)	-0,34%	-0,3%	0,0%	0,0%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

The first is that most Latin American MICs perform worse in this subperiod compared to 2010 to 2019. For Asian countries, the dominant trend seems to be the opposite.

The second factor is that it is precisely during this period that the Brazilian economy experienced its highest growth rates since at least the early 1980s. In other words, the local manufacturing sector was not able to benefit from the growth of domestic demand (and also from the commodity boom) in a way that would allow an investment cycle that would promote a structural transformation towards more technologically intensive and more productive activities. On the contrary, what was observed was the accentuation of a regressive specialization movement, with an increase in the relative participation of natural resource-intensive and less technologically sophisticated sectors, in parallel with a generalized lack of density in medium- and high-technology intensity sectors (Araujo; Peres; Araujo, 2023; Rossi; Mello; Bastos, 2020; Nassif; Castilho, 2020; De Negri; Cavalcante, 2015).

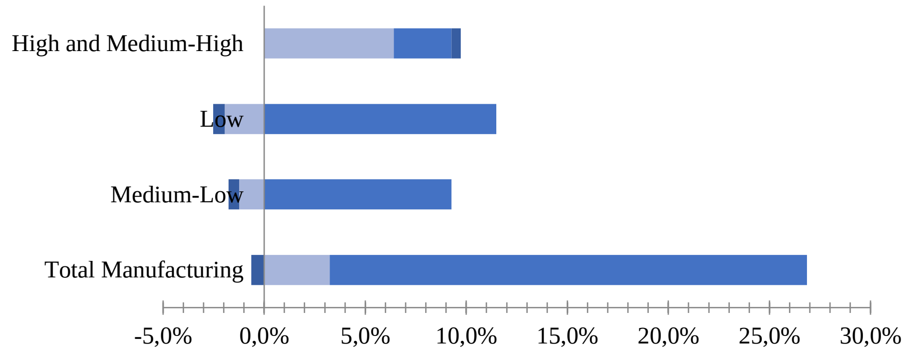
According to Nassif et al. (2018), this move toward deindustrialization could be explained by the existence of false macroeconomic prices during this period. Thus, with an appreciated exchange rate, relatively high interest rates, and wage growth exceeding productivity, there was an increase in relative profitability and a consequent shift in investment toward natural resource-intensive sectors.

In terms of the sectoral dimension, medium-intensity technology sectors showed the smallest productivity losses, while low-intensity sectors showed the worst performance. Perhaps these sectors were more affected (especially between 2000 and 2010) by the substantial increase in productive integration between Brazil and China after the latter joined the WTO. On the other hand, the greater resilience of the medium technological intensity sectors can be explained by the large representation of the oil and gas extraction sector, which saw exponential investment growth during this period (Bastos et al, 2015).

Despite the premature deindustrialization movement and the fact that Brazilian manufacturing sector had the worst performance among the MICs in terms of productivity growth between 2000 and 2019, it can be seen that this movement was not associated with a reduction in average wages. Nevertheless, the growth of local industrial wages was significantly lower than the average among MICs (150% versus 26.2%) (Figure 6).

Figure 6

Manufacturing mean salary growth - structural decomposition according to tech intensity - Brazil (2000 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	3,24%	-1,2%	-1,9%	6,4%
Intra-sectoral component	23,61%	9,3%	11,5%	2,9%
Structural change (dynamic component)	-0,64%	-0,5%	-0,6%	0,5%

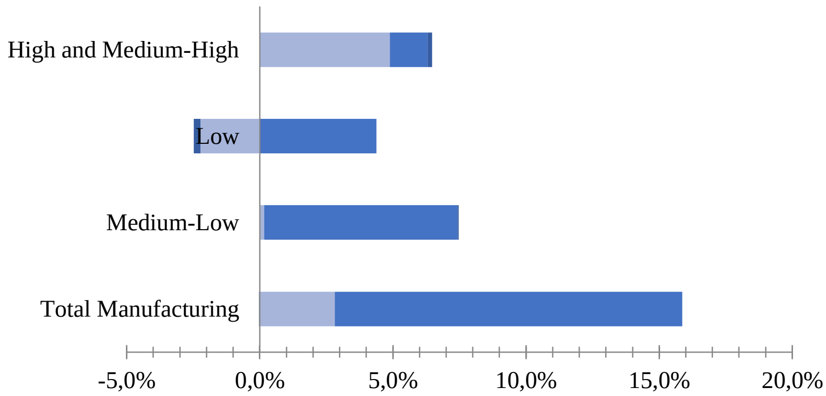
Source: Authors, based on Indstat-Unido, World Bank and IMF.

Another factor worth highlighting when analyzing the behavior of average industrial wages in Brazil is that their growth is widespread and relatively similar according to different technological intensities. Thus, even the segments that showed a strong decline in productivity, such as the high and medium-high tech and low-tech sectors, showed a real growth in average wages.

Thus, the increase in the average wage was not the result of sectoral restructuring, with workers moving towards sectors with greater technological sophistication and, therefore, higher wage levels, as would be expected in a virtuous trajectory of industry's contribution to development. This movement seems to have stemmed more from the persistence over most of the period observed (between 2003 and 2018) of a deliberate policy of increasing the real minimum wage by Brazilian policy makers. From 2006 onwards, in line with a growth strategy based on eliminating extreme poverty, reducing inequality and expanding the local consumer market, a regulation was established by the Worker´s Party national government´s that the minimum wage should be readjusted annually by the amount of inflation observed in the immediately preceding year plus the GDP growth observed in the previous two years. Thus, between 2003 and 2019 alone, the real growth of the minimum wage was 97%.

Since the minimum wage in the Brazilian economy has historically had an indirect impact on the construction of the wage pyramid among different occupations, there has been upward pressure on wages in occupations at the bottom of the manufacturing sector occupation pyramid, even in a deindustrialization scenario (Arestis and Baltar, 2021; Calixtre and Fagnani, 2018; Singer, 2015) (Figure 7 and Figure 8).

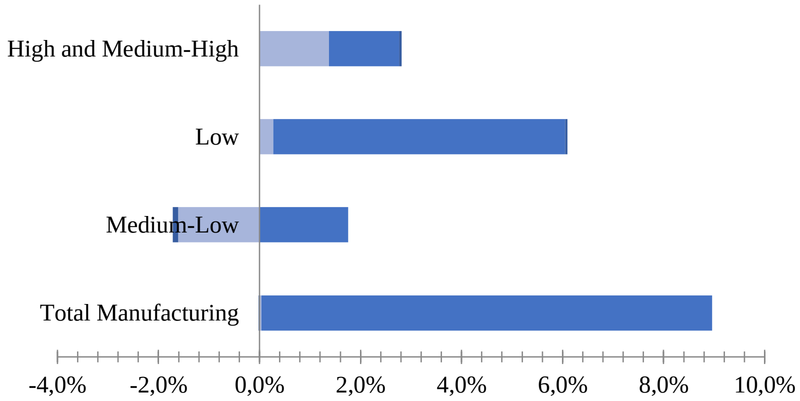
Figure 7
Manufacturing mean salary growth – structural decomposition according to tech intensity – Brazil (2000 to 2010)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	2,8%	0,2%	-2,2%	4,9%
Intra-sectoral component	13,1%	7,3%	4,4%	1,4%
Structural change (dynamic component)	0,0%	0,1%	-0,3%	0,2%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Figure 8
Manufacturing mean salary growth – structural decomposition according to tech intensity – Brazil (2010 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	0,0%	-1,6%	0,3%	1,4%
Intra-sectoral component	8,9%	1,8%	5,8%	1,4%
Structural change (dynamic component)	0,0%	-0,1%	0,0%	0,0%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Thus, it can be seen that in the period of slowdown of the Brazilian economy (after 2010), the sectors that show the best dynamics in terms of wage growth are precisely the low-tech sectors. This is because these are the sectors where the presence of occupations with salaries close to the minimum wage is highest.

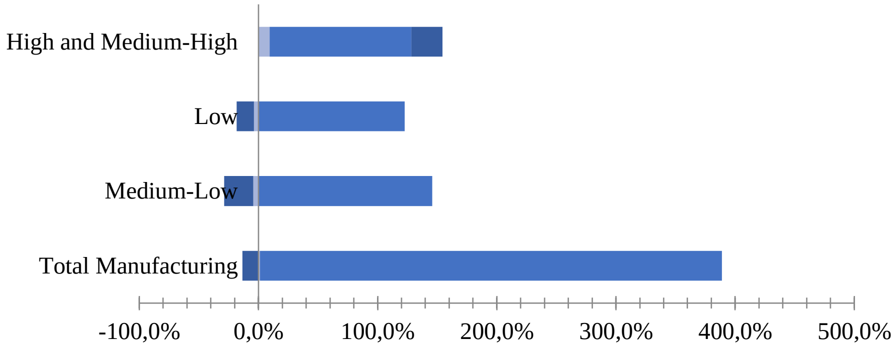
On the other hand, the high and medium-high tech sectors showed greater dynamism precisely during the period of relative boom of the Brazilian economy between 2000 and 2010, due to the fact that they are relatively less labor-intensive and their workers have higher skill levels (and therefore higher wages). As a result, the labor market heated up considerably and there was a relative shortage of professionals in many occupations, especially those related to STEM (science, technology, engineering and mathematics).

4.3 Manufacturing´s contribution to development in China

The growth dynamics of China's industrial productivity between 2000 and 2019 align closely with what classical authors suggest for a virtuous development path (Hamilton, 1791; List, 1841; Rosenstein-Rodan, 1943; Hirschmann, 1958; Furtado, 1961; Gerschenkron, 1962) And By The Empirical Structural Decomposition Literature (Haraguchi, 2015; Mcmillan; Rodik, 2011; Oecd, 1987; Timmer; De Vries, 2009; De Vries; Timmer; De Vries, 2015). The same movement, as will be shown below, is also observed when analyzing the growth dynamics of industrial wages.

The first observation is that China's industrial productivity growth (357%) is the highest among the MICs over the period. This growth of about 7.3% per year even stands out among the other BRICS countries (Brazil with a decline of 15.6%, Russia with a growth of 243%, India with 33.6% and South Africa with 55.8%). As shown in the previous section, the main component responsible for productivity growth was intra-sectoral at all different levels of technological intensity (Figure 9).

Figure 9
Manufacturing productivity growth – structural decomposition according to tech intensity – China (2000 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	1,21%	-4,3%	-3,8%	9,3%
Intra-sectoral component	387,75%	145,8%	122,7%	119,2%
Structural change (dynamic component)	-13,38%	-24,5%	-14,7%	25,8%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

The dominance of this component can be explained by the intensity of the catching-up process of China's productive structure, which is materializing in manufacturing through the incorporation of technological progress into production processes, increased spending on R&D, and improved performance related to patenting and innovation, all of which contribute decisively to productivity growth. As Mao et al (2021) empirically aims to demonstrate that

> the success of industrial policy (in China) is not entirely about following the static or even latent comparative advantages, as Lin and his colleagues have advocated (Lin, 2012). Instead, by targeting emerging industries in which firms in developed countries also face greater uncertainty about technological direction, developing countries like China with considerable R&D capacities can indeed facilitate rapid technological catch-up by their domestic firms (Mao et al., 2021, p. 14).

In contrast to Brazil, China's productivity growth is significantly bolstered by the components of structural change. It's worth noting that the contributions of the static and dynamic components of structural change are completely in line with what would be expected from the classical logical circuit of manufacturing's contribution to development.

For the high and medium-high tech sectors, the sum of the structural change components accounts for 22.5% of total productivity growth over the period, which means that around ¼ of this growth is explained by the reallocation of workers to activities with higher productivity levels and/or to activities with a productivity growth rate higher than the manufacturing average. In other words, both movements would be in line with a reorientation of China's development strategy roughly since the Medium- and Long-term Science & Technology Plan (2006), and a subsequent implementation of a wide range of industrial policies such as the Strategic Emerging Industries Development Plan (2010), Made in China (2015), Innovation-driven Development Strategy (2016), among others. As suggested by Mao et al. (2021), industrial and S&T policies have been a key driver behind China's economic miracle.

According to Li and Feng (2022) and Chen (2018), what we are witnessing is a relative exhaustion of the paradigm based on attracting FDI and recognizing the limits of the market for technology strategy, where technological learning was sought primarily through the establishment of joint ventures with transnational corporations. According to Li and Feng (2022),

> Recognizing the role of innovative enterprise in the transition to indigenous innovation should propel the rethinking of China's industrial policy. Since the 1980s, the Chinese government has acted as a developmental state, mobilizing a massive amount of resources to invest in strategic industries (…) The government's emphasis on rapid catch-up might have actually hampered indigenous innovation at the firm level: in chasing the "latest" technologies, local firms have been under the pressure to constantly import new equipment and blueprints for upgrading, undermining the accumulative process of technological learning required for indigenous innovation (Li; Feng, 2022, p. 33).

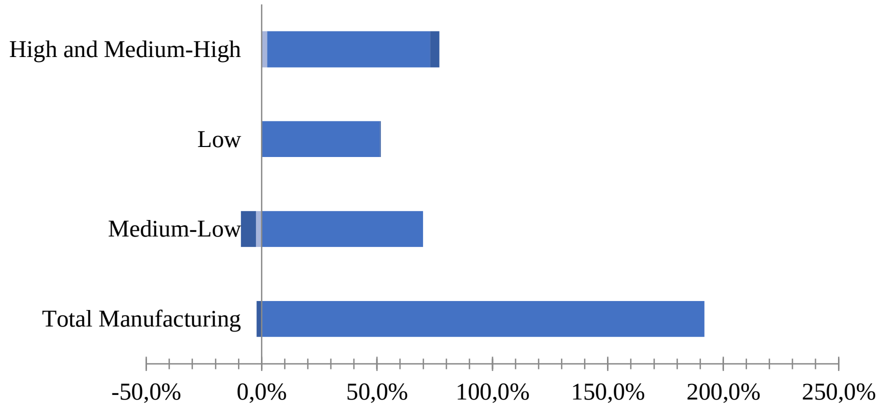
This shift in power has moved towards institutions linked to the national innovation system, such as the Ministry of Science and Technology, away from the previously dominant Ministry of Commerce. The combination of these elements was based on structuring a top-down market and competition regulation logic, in which techno-nationalism configures a key vector to build productive and technological capacities in the Chinese economy (Chen; Naughton, 2016; Naughton, 2021).

In recent years, China has developed a "New National System", concentrating efforts and resources on key technological innovations and major industrial projects. This is a national development model that prioritizes key technological innovations and major industrial projects, driven by highly centralized policy implementation approaches and strategic optimizations of national resources. It features government leadership (usually via industry guidance and support), strategic planning (encompassing five-year plans and medium- to long-term plans formulated by central and local governments), academia-manufacturing-research collaboration (through national initiatives engaging universities and research institutes with enterprises), and significant national capital investments (such as the National Strategic Emerging Industries Development Fund). China's high-tech giants such as Huawei and ZTE in telecommunications equipment and BYD in new energy vehicles, are representative successful cases of this "New National System". This national development model fosters enterprise growth and expansion through diverse mechanisms, including market access, government procurement, financial support, and government collaboration, and provides crucial assistance to businesses during economic crises. (Schaefer, 2020; Kwan, 2019; Yeung, 2019). For example, Huawei, as the national pride of China, is often the preferred supplier for major communication projects by the government and state-owned enterprises, providing Huawei with a substantial domestic market base. Similarly, ZTE benefits from the backing of the Ministry of Science and Technology and local governments when it builds extensive network of R&D centers and international collaborative projects. Additionally, BYD partners with several provincial governments to advance electric buses and taxis, and receives substantial local fiscal subsidies and policy support

Complementarily, and also in line with the IDDS guidelines, the static and dynamic structural change components are negative for the medium-low and low technological intensity sectors. This means that the representativeness of these sectors in total industrial employment decreased over the period. In other words, again in line with a virtuous circle of manufacturing's contribution to development, there has been productivity growth due to the intra-sectoral component even in the less technologically intensive sectors, but a reduction in the relative importance of these sectors in China's overall productive structure.

With regard to the two sub-periods of analysis, as shown in Figure 10 and Figure 11, it is worth noting that, although this movement is generalized, the contribution of the structural change components is significantly higher after 2010, precisely the period in which the policy of reorienting China's development strategy towards building an innovation-oriented economy was strengthened.

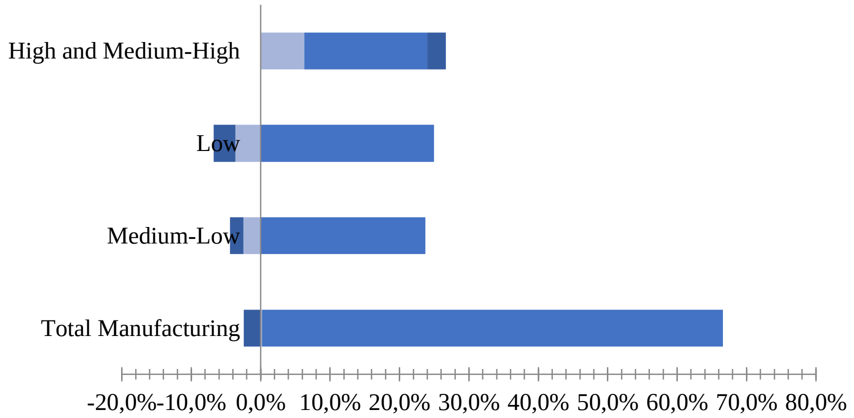
Figure 10
Manufacturing productivity growth – structural decomposition according to tech intensity – China (2000 to 2010)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	0,23%	-2,4%	0,2%	2,4%
Intra-sectoral component	191,61%	70,0%	51,0%	70,6%
Structural change (dynamic component)	-2,20%	-6,5%	0,4%	4,0%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Figure 11
Manufacturing productivity growth – structural decomposition according to tech intensity – China (2010 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	0,21%	-2,5%	-3,6%	6,3%
Intra-sectoral component	66,39%	23,7%	25,0%	17,7%
Structural change (dynamic component)	-2,41%	-2,0%	-3,1%	2,7%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

However, although it is possible to observe that manufacturing's contribution to development is moving in a direction that is seen as virtuous by the classic corollary of developmental policies (Jhonson, 1982; Wade, 1990; Amsden, 1989; 2001; Chang, 1994), it is worth noting that this process has some characteristics that are distinct from the broader logic of the Asian first-generation tigers.

This is because the coexistence of a movement of continued intense productivity growth (and also wages, as will be shown below) in the low and medium-low sectors, even in a scenario of gradual reduction of their representativeness in the local economy, reinforces the perception that maintaining China as the world's factory continues to be one of the constituent elements of the long-term objective of national rejuvenation.

It is also worth noting that this strong presence as the world's factory since the beginning of 2000 has occurred in parallel with the permanent transformation of local manufacturing towards more technologically complex activities. This metamorphosis does not necessarily mean that, as happened in Japan, Korea and Taiwan, low-tech sectors would be replaced by medium- and high-tech ones, but that even in these less complex sectors one could verify that, although manufacturing the same goods, there has been and increasing and steady process of technological sophistication of their features and production process.

Contrary to what a linear reading of the transition between different stages of development might suggest, the continued strength of manufacturing exports is not inconsistent with an ongoing movement to avoid the middle-income trap. As Diegues et al. (2023) point out, there is a pervasive movement towards sophistication in China's production structure, even in the low- and medium-low-tech segments, which makes it possible to combine productivity and wage increases with maintaining international competitiveness. In other terms, Mao et al. (2021) empirically shows that:

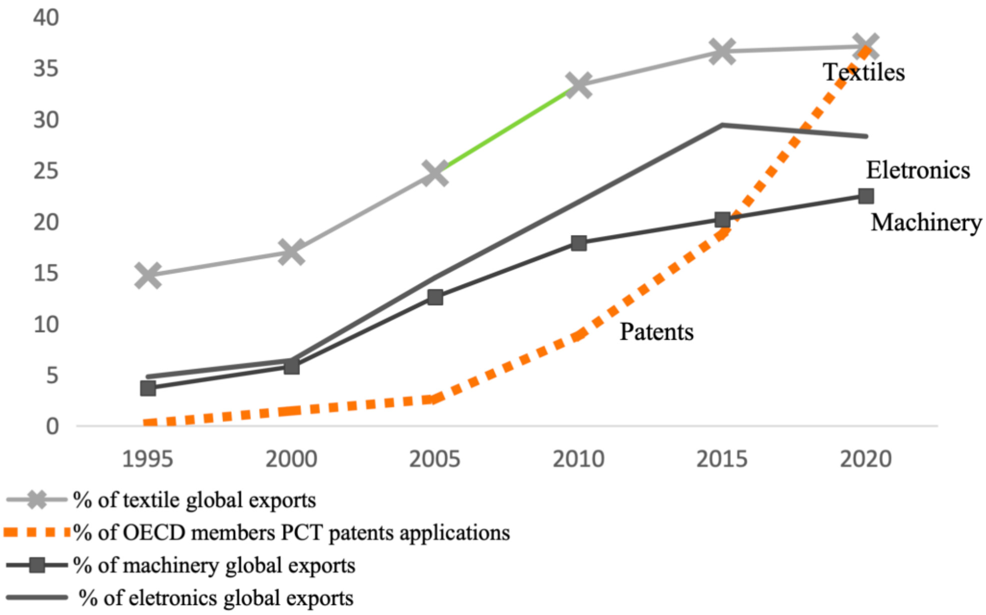
> Thus, although a country's overall industrial policy should be comparative-advantage-following, well-crafted industrial policies that target selected emerging industries can work even though these policies defy comparative advantage (Mao et al, 2021, p. 14).

The logic of this process is based on the perception that China's productive, technological, regional, and social heterogeneity, coupled with its enormous geographic and population size, give the Chinese development process unique characteristics compared to those of the other Asian tigers. In this way, the authors suggest that this unique character would distance the Chinese strategy from an emulation of the historical experiences of countries such as South Korea and Taiwan under the flying geese paradigm (Akamatsu, 1962; Palma, 2009). This is because, in these experiences, the virtuous process of manufacturing's contribution to development was essentially characterized by specialization in activities of high technological complexity and the virtual elimination of medium- and low-technology products. Therefore, replicating this strategy has obvious limits in terms of universalizing, incorporating and extending the fruits of technological progress to the huge Chinese population.

Thus, according to Diegues et al (2023), the process of structural transformation of the Chinese economy would be accompanied by what the authors call the *"the coexistence of characteristics of different stages of development, which combine qualitatively distinct productive policies and institutions according to different regions of the country, sectors and technologies* *(as) the orientation of the Chinese economy toward an innovation-driven strategy does not necessarily eliminate the country's strength as the factory of the World including in low and medium-low tech industries"*

In empirical terms, this movement towards the coexistence of different stages of development in the production structure could be illustrated by the fact that, as shown in Figure 12, an increase in China's market share in world exports of electronics, machinery and transport equipment does not go hand in hand with a decrease in the market share of labor-intensive sectors. This movement, in turn, is accompanied by an equally significant increase in Chinese patent applications under the PCT (Figure 12).

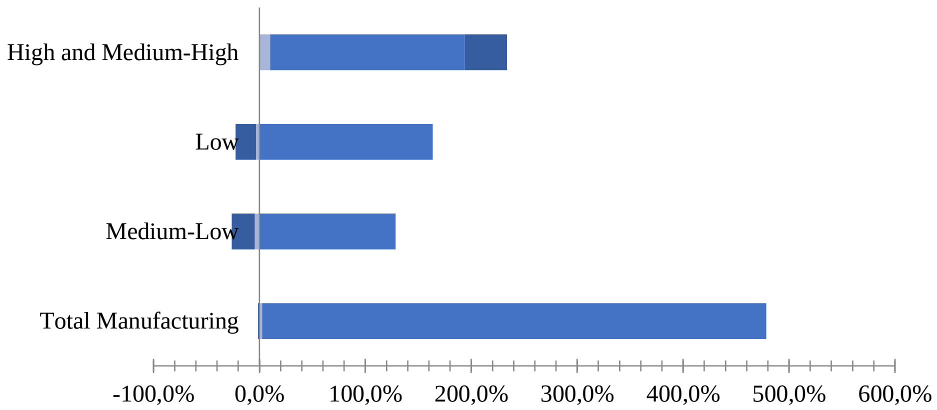
Figure 12
Chinese Productive Indicators - Selected years - in %



Source: Atlas of Economic Complexity - Growth lab at Harvard University (% of exports) and OECD-Stats (% of patents).

Following the logic of China's structural transformation model, the same outstanding pattern can be observed for industrial wages as for productivity. With a growth of 476% over the period (Figure 13), or more than 9% per year, China showed the best performance of all the MICs.

Figure 13
Manufacturing mean salary growth – structural decomposition according to tech intensity – China (2010 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	2,63%	-4,5%	-3,1%	10,2%
Intra-sectoral component	476,03%	128,6%	163,8%	183,6%
Structural change (dynamic component)	-1,43%	-21,6%	-19,6%	39,8%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

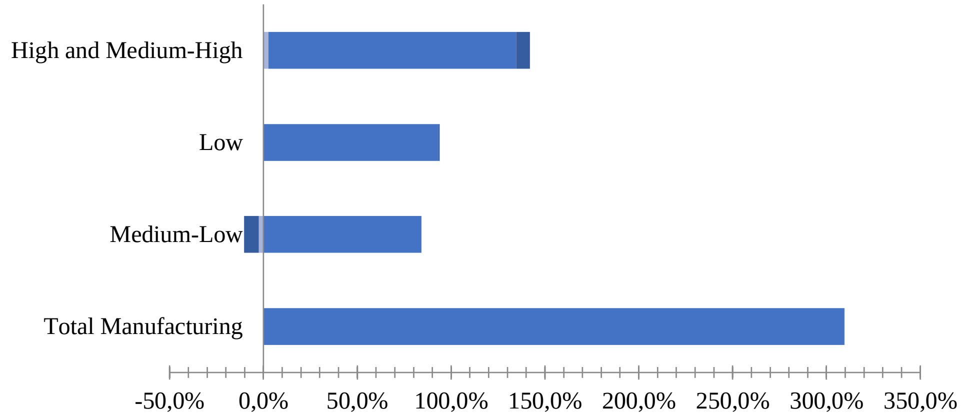
Wage growth is evident across all levels of technological intensity, aligning with the broader transformation of China's productive structure. However, in the high and medium high-tech sectors, this growth is about 65% higher than in the medium low-tech sectors and 128% higher than in the low-tech sectors.

This movement could be understood as part of a broader process of avoiding the middle-income trap. This is because, on the one hand, the stronger growth of high and medium-high technology sectors would be associated with a greater representation of these sectors in the economy (as shown by the positive variations in the static and dynamic components of structural change), in parallel with the accumulation of technological and innovative capacities in these sectors (Lee, 2019; Andreoni and Tregenna, 2020). In other words, according to Feng et al. (2022)

> Innovation in China has occurred not only in industries chasing technological frontiers but also by making use of the massive Chinese market to innovate in traditional manufacturing (and) this variety of innovation models means that innovation in China is about generating not only high-tech gadgets but also increasing employment, improving productivity, and bringing prosperity to broad segments of the economy (Feng et al., 2022, p.4-5)

On the other hand, we can see that the strategy of avoiding the middle-income trap is also present when we observe that the components of structural change are negative for the medium-low and low-tech sectors. In other words, although wages in these segments have increased due to the intra-sectoral component (which is also a virtuous element in the development strategy of countries threatened by the middle-income trap), their representativeness in the economy has decreased. Thus, there is a negative contribution from the structural change components, as suggested by the policy guidelines aimed at avoiding the middle-income trap. This contribution is accentuated in the subperiod after 2010 (Figure 14 and Figure 15).

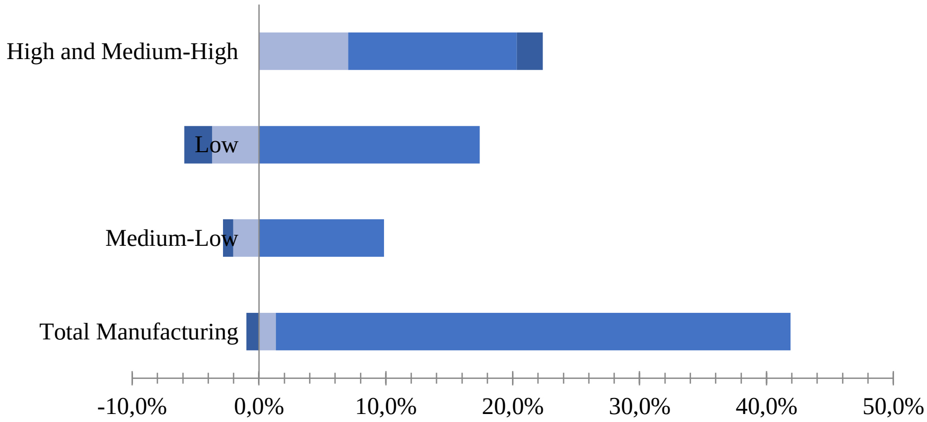
Figure 14
Manufacturing mean salary growth - structural decomposition according to tech intensity - China (2000 to 2010)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	0,33%	-2,5%	0,2%	2,6%
Intra-sectoral component	309,10%	84,1%	93,0%	132,0%
Structural change (dynamic component)	0,22%	-7,8%	0,7%	7,4%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Figure 15
Manufacturing mean salary growth - structural decomposition according to tech intensity - China (2010 to 2019)



	Total Manufacturing	Medium-Low	Low	High and Medium-High
Structural change (static component)	1,32%	-2,0%	-3,7%	7,0%
Intra-sectoral component	40,57%	9,9%	17,4%	13,3%
Structural change (dynamic component)	-0,98%	-0,8%	-2,2%	2,0%

Source: Authors, based on Indstat-Unido, World Bank and IMF.

Thus, very similar to the dynamics observed in relation to productivity growth, we see a greater contribution of structural change components to the variation in industrial wages in the second subperiod analyzed in this article. As an illustration, for the high and medium-high intensity sectors, the structural change components are responsible for 2/3 of the wage growth in this period. It is during this period that the need to reorganize domestic growth dynamics becomes increasingly clear, with a transition from a growth model based on a combination of investment-led and export-led elements to an economy in which China is still the factory of the world, but moving to hierarchically superior positions in global value chains in order to avoid the middle-income trap.

Besides, China's informal institutional arrangements, exemplified by '"*Te Shi Te Ban*", are crucial in maintaining its status as the world's factory while advancing in the global value chain.

The concept of "*Te Shi Te Ban*" is actually a series of special dealings in the form of informal institutional arrangement, where local governments facilitate the growth of private businesses by helping them navigate through or bypass formal institutional barriers. Special dealings occur in various forms, such as breaking through regulatory constraints, offering land at preferential prices, easing credit constraints, blocking competitors' entry etc. (Li and Zhou, 2005; Xu, 2011; Hallward-Driemeier and Pritchett, 2015; Jia et al., 2015; Bai et al., 2020)

"*Te Shi Te Ban*" is, to a great extent, a product of local governments competing in a GDP championship. The competitive dynamics among local governments to attract and support businesses, ensures that businesses across different regions have the opportunity to grow and integrate into the global value chain, thus collectively raising China's position. More crucially, "*Te Shi Te Ban*" is usually extended to industries that have strategic importance for China's ascent in the value chain, such as technology and manufacturing, aligning closely with the national policy direction.

According to Bai et al. (2020),

> The period between the early 1990s and 2008, before the onset of the global financial crisis, was the highest growth episode in recent Chinese history, with GDP growth averaging 11% per year. We suggest that this growth was driven by the emergence of a special deal regime best characterized as a "high capacity and private benefits" regime. (...) Local governments also provide land at below market costs to favored firms. Using the power of eminent domain, local governments obtain land from farmers, urban residents, and other channels, and resell the land to developers and firms. (...) We argue that special deals in China are provided by local governments, and part of the deal is that competitors of the favored firms are blocked from the local market. For example, Shanghai-GM, one of the favored car companies in Shanghai, is supposedly protected by the Shanghai municipal government, which blocks non-local car companies (such as Chery) from the market. However, if Chery produces better cars, it would outcompete Shanghai-GM in markets where Shanghai-GM is not protected. As the largest car manufacturer in China in 2007, Shanghai-GM's export was negligible. In contrast, although Chery only accounted for 5% of domestic car sales, 20% of cars exported from China were produced by Chery (Bai et al., 2020, p. 355, p. 364, p. 366).

While this approach may seem to perpetuate inefficiencies by favoring certain enterprises, it also drives substantial innovation. Businesses that receive support can invest more in research and development, ultimately contributing to China's move from being a low-end manufacturer to a creator of higher-value products and technologies.

5 Concluding remarks: a comparative of manufacturing´s contribution to development in China and Brazil

This paper contrasts the industrial development paths of China and Brazil, two representative middle-income countries, to highlight the critical role of industrial policy in overcoming the middle-income trap. China has pursued proactive policy interventions, emphasizing high-tech industries through "Made in China 2025," along with substantial investments in R&D, infrastructure, and innovation-promoting policies. These efforts have sustained high productivity growth in the industrial sector and facilitated integration into the global high-tech market. Significant investments in ICT and transportation networks have supported China's digital and intelligent industrial transformation, enhancing efficiency and connectivity. Various incentives, including tax breaks, subsidies, and preferential government procurement, have further accelerated international technology exchange, boosting the global competitiveness of Chinese enterprises.

In contrast, Brazil's industrial development has been hampered by political instability and frequent policy shifts, undermining long-term industrial strategies and eroding investor confidence. Infrastructure challenges, such as unreliable transportation and energy supplies, coupled with outdated ICT, have escalated production costs and deterred investment. Brazil's reliance on raw material exports, like iron ore and soybeans, makes its economy vulnerable to global price fluctuations, stifling diversification and industrial growth. Additionally, high industrial taxes and uncertain macroeconomic policies have increased operational risks, stifling innovation and industrial expansion.

However, the distinct industrial policy paths of China and Brazil reveal both challenges in China and potential advantages in Brazil.

China's proactive policy interventions have promoted rapid economic development and helped enterprises overcome institutional barriers. However, they have also led to resource allocation distortions, with resources often skewed towards government-favored enterprises rather than the most efficient users. Such biased policies harm the market's fair competition environment and disadvantage those enterprises that do not receive government favoritism. Additionally, when enterprises rely on political connections to gain advantages rather than through innovation, the motivation to invest in R&D and new technologies may decrease. Simultaneously, informal institutions may undermine the formal legal environment, weakening the rule of law, damaging social trust, and potentially fostering corruption, leading to the misuse of public resources. This economic vulnerability may amplify its impact in the face of crises, as overly protected enterprises may lack the resilience to adapt to market changes. The government's continuous support for specific industries may lead to rigidity in the industrial structure, hindering the natural upgrading and structural adjustment of the economy, causing the economy to over-rely on old industries that have lost competitiveness. Moreover, excessive government intervention in the criticized domestic market protection measures may conflict with international trade rules, potentially causing international relations tensions and trade disputes. Therefore, to ensure the long-term health and sustainable development of China's economy, gradually establishing and improving market mechanisms, reducing the negative impact of informal institutions, strengthening the construction of the rule of law, are key for current and future development.

Brazil, in the current period, having abundant natural resources and a vast agricultural base provides unique advantages for developing high-value-added industries such as biotechnology and renewable energy. To fully leverage these potential advantages, Brazil needs to implement appropriate industrial policies, improve infrastructure, strengthen education and skills training, promote innovation and R&D, and optimize its industrial structure. First, substantial investment in infrastructure, especially in transportation, electricity, and communication technology, will reduce production costs, improve overall economic efficiency, and attract foreign direct investment. Next, by investing in education and skills training that align with manufacturing needs, particularly in the fields of science, technology, engineering, and mathematics (STEM), Brazil can enhance the competitiveness of its labor market. Additionally, the government should provide tax incentives and subsidies to encourage enterprises to adopt new technologies and innovate, and strengthen cooperation with higher education institutions and research centers to accelerate the commercialization of scientific and technological achievements. Supporting the development of small and medium-sized enterprises is also crucial, as these enterprises are usually more adaptable to market changes. Finally, maintaining policy coherence and macroeconomic stability, especially controlling inflation and maintaining currency stability, is key to attracting investment and promoting industrial development. By implementing these strategies, Brazil can leverage its potential advantages, develop new competitive strengths in the global market, achieve sustainable economic growth, and avoid the middle-income trap.

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Appendix
Robustness checks: simulations according to different model specifications

Dependent variable: Productivity growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components)

Variables	(1) hmh	(2) ml	(3) low	(4) total	(5) hmh	(6) ml	(7) low	(8) total	(9) hmh	(10) ml	(11) low	(12) total	(13) hmh	(14) ml	(15) low	(16) total
ln_gdppc	-8.574**	-4.443*	2.518	-10.59	-9.685**	-5.969*	1.086	-14.69	2.602	-0.543	5.755*	7.773	-13.77	-16.90	5.080	-25.68
	(3.977)	(2.365)	(2.165)	(8.214)	(4.221)	(2.841)	(2.640)	(9.442)	(4.184)	(4.532)	(2.848)	(10.80)	(10.51)	(15.69)	(10.64)	(34.02)
c.ln_gdppc#c.ln_gdppc	0.475**	0.254*	-0.134	0.600	0.543**	0.348**	-0.0465	0.851	-0.132	0.0500	-0.303*	-0.382	0.373	0.554	-0.282	0.649
	(0.214)	(0.127)	(0.117)	(0.443)	(0.226)	(0.153)	(0.142)	(0.506)	(0.226)	(0.255)	(0.156)	(0.594)	(0.339)	(0.560)	(0.351)	(1.152)
ln_pop					0.122	0.167	0.157*	0.449	-5.377***	-2.261	-1.933*	-9.602**	-11.62**	-8.496*	-2.190	-22.36*
					(0.157)	(0.106)	(0.0788)	(0.328)	(1.585)	(1.985)	(1.072)	(4.405)	(4.209)	(4.270)	(3.948)	(11.64)
c.ln_pop#c.ln_pop									0.146***	0.0647	0.0556*	0.268**	0.219***	0.137**	0.0586	0.415**
									(0.0435)	(0.0520)	(0.0287)	(0.118)	(0.0542)	(0.0475)	(0.0497)	(0.143)
c.ln_pop#c.ln_gdppc													0.386	0.386	0.0159	0.789
													(0.255)	(0.310)	(0.246)	(0.754)
Constant	38.84**	19.53*	-11.60	47.17	41.04*	22.55	-8.760	55.30	36.69**	20.63	-10.41	47.35	169.5*	153.3	-4.939	318.7
	(18.38)	(10.98)	(9.900)	(37.84)	(20.05)	(13.32)	(12.31)	(44.51)	(15.09)	(11.78)	(11.23)	(37.12)	(84.36)	(107.8)	(82.74)	(254.9)
Observations	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
R-squared	0.309	0.236	0.036	0.159	0.367	0.377	0.275	0.314	0.668	0.452	0.381	0.508	0.723	0.522	0.381	0.552

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Dependent variable: Salary growth according to shift-share structural decomposition (sum of static, dynamic and intrasectoral components)

Variables	(1) High and Medium-High	(2) Medium-Low	(3) Low	(4) Total Manufac-turing	(5) High and Medium-High	(6) Medium-Low	(7) Low	(8) Total Manufac-turing	(9) High and Medium-High	(10) Medium-Low	(11) Low	(12) Total Manufacturing	(13) High and Medium-High	(14) Medium-Low	(15) Low	(16) Total Manufac-turing
ln_gdppc	1.192	-2.706	0.797	-0.720	-0.946	-3.710**	-0.162	-4.821	12.39	2.304	7.796	22.48	-14.62	-7.619	-2.043	-24.28
	(3.624)	(1.595)	(2.440)	(7.487)	(3.718)	(1.701)	(2.831)	(8.156)	(9.140)	(3.988)	(6.227)	(19.13)	(20.04)	(8.767)	(15.79)	(43.62)
c.ln_gdppc#c.ln_gdppc	-0.0513	0.158*	-0.0409	0.0661	0.0798	0.220**	0.0179	0.318	-0.653	-0.111	-0.419	-1.182	0.180	0.195	-0.116	0.259
	(0.192)	(0.0847)	(0.128)	(0.396)	(0.196)	(0.0899)	(0.149)	(0.430)	(0.497)	(0.217)	(0.337)	(1.038)	(0.765)	(0.330)	(0.563)	(1.625)
ln_pop					0.234	0.110	0.105	0.449	-5.734*	-2.581*	-3.456	-11.77*	-16.03**	-6.364**	-7.207	-29.59**
					(0.211)	(0.0935)	(0.141)	(0.441)	(3.031)	(1.352)	(1.977)	(6.270)	(5.686)	(2.690)	(5.541)	(13.71)
c.ln_pop#c.ln_pop									0.159*	0.0717*	0.0948*	0.325*	0.278***	0.116***	0.138*	0.532**
									(0.0803)	(0.0358)	(0.0526)	(0.166)	(0.0784)	(0.0377)	(0.0754)	(0.189)
c.ln_pop#c.ln_gdppc													0.637	0.234	0.232	1.102
													(0.369)	(0.170)	(0.332)	(0.853)
Constant	-6.196	11.68	-3.566	1.935	-1.959	13.67	-1.665	10.06	-6.677	11.54	-4.481	0.401	212.4	92.01	75.32	379.6
	(16.91)	(7.425)	(11.56)	(35.04)	(16.98)	(7.872)	(12.85)	(37.23)	(21.60)	(9.539)	(15.51)	(46.20)	(133.0)	(59.65)	(116.5)	(302.6)
Observations	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
R-squared	0.042	0.243	0.003	0.047	0.168	0.356	0.059	0.153	0.374	0.525	0.219	0.349	0.461	0.572	0.244	0.409

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1